Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal

Proceedings of 2nd National Workshop
22-23 May 2017, Dhulikhel

Editors
Bal Krishna Joshi
Hari Bahadur KC
Anil Kumar Acharya

2017

NAGRC

FDD
DoA
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***Theme**: Agrobiodiversity for securing our lives*

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Bal Krishna Joshi
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Anil Kumar Acharya

National Genebank, NARC	Fruit Development Directorate	Department of Agriculture	Ministry of Agricultural Development

Kathmandu, Nepal
2017

NAGRC (Khumaltar, Lalitpur; http://narc.gov.np)
The National Agriculture Genetic Resources Center (NAGRC) was established in 2010 under NARC for conservation and utilization of all agricultural genetic resources including domesticated, crop wild relatives and wild edible plants. Agricultural plant genetic resources (APGRs) have been managed through ex-situ, on-farm and in-situ conservation and breeding strategies by establishing seed bank, tissue bank, DNA bank, field genebank and community genebank.

FDD (Kirtipur, Kathmandu; http://fdd.gov.np)
Fruit Development Directorate (FDD) is one of the directorates under the Department of Agriculture of Nepal. This directorate deals with the program planning and implementation of the technologies related to fruits sector of Nepal. Moreover, this directorate also deals with plantation crops and flowers. There are 13 farms under this department distributed in different localities of the country. This directorate works on technical backstopping on the extension activities related to fruit development in districts and in the farm centres.

DoA (Hariharbhawan, Lalitpur; http://www.doanepal.gov.np)
Department of Agriculture (DoA) is one of the departments under the Ministry of Agricultural Development. This department deals with the overall agricultural service delivery activities in the country. There are 5 regional directorates and 12 program directorates under this department. This department is responsible for coordinating and facilitating the different agricultural extension programs implemented by District Agriculture Development Offices in the country.

MoAD (Singhadurbar, Kathmandu, Nepal; http://www.moad.gov.np)
The Ministry of Agricultural Development (MoAD) is the central body of the Government of Nepal responsible for agriculture and allied fields. The ministry consists of five divisions, three central bodies (two centres and one research and development fund) two departments, and autonomous bodies, consisting of a research council, one development boards, two companies, and four development committees. The Honorable Minister for Agricultural Development is in charge of the ministry; the secretary is the administrative head and chief advisor to the minister.

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Cover photo: Immature seeds of common buckwheat (Mithe Phaper, Fagopyrum esculentum Moench.) from Humla.
Background: Farming land in Samibhanjyang, Lamjung
Cover design: Dr Bal K. Joshi

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Foreword

YR Pandey, PhD

Executive Director
Nepal Agricultural Research Council, Kathmandu
15 June 2017

Agricultural plant genetic resources (APGRs) always come first in agricultural research. However, crop diversity in the fields is decreasing rapidly and there is a necessity of high degree of diversity for breeders and growers for developing suitable varieties and securing harvest. Poor knowledge on the Nepalese APGRs is one of the main reasons of not using local crop landraces in breeding and research in the past. After the first workshop on the management of APGRs in 1994, there are many research findings and advances made on conservation and utilization of APGRs by different organizations. This 2^{nd} national workshop on conservation and utilization of agricultural plant genetic resources (CUAPGR) held on 22-23 May 2017, become a milestone for sharing updates, documenting achievements, planning future program and identifying gaps. The efforts made by national committee, technical committee, and financial and logistic committee are highly appreciated. I would like to thank all the team members for their hard work and esteem the team spirit they have demonstrated.

The NARC, mainly National Agriculture Genetic Resource Center (NAGRC), also known as National Genebank, has initiated a number of methods and approaches for management of agricultural plant genetic resources. As part of strengthening management of APGRs in the country, this workshop became fruitful. The lead role played and achievements made by NAGRC in the field APGRs conservation are rewarding. Sharing of these progresses through proceedings will have great impact at grassroots to national to global levels and contributions to other organizations for better management of APGRs.

Documenting scientific information that were lacking in the past is painstaking work. The team representing from National Agriculture Genetic Resources Center, Ministry of Agricultural Development and Vegetable Development Directorate were very efficient on organizing and editing the papers, and timely publishing this proceedings. I am very pleased with this updated information and would like express sincere thanks to the Editors, Dr Bal K. Joshi, Dr Hari B. KC and Mr Anil K. Acharya.

NARC feel happy to be a part of this initiative and believe it is a great contribution to the nation mainly in the field of agrobiodiversity conservation, utilization and policy reform aiming at improving food and nutrition security through increasing access to APGRs and enhancing community resilience to climate change. On behalf of the NARC, I would like to thank Fruit Development Directorate, Department of Agriculture and Ministry of Agricultural Development for jointly organizing this workshop in the coordination of National Genebank. I believe this proceedings will be read widely and used as a valuable reference in the field of agrobiodiversity conservation, use, management both within the country and outside.

Foreword

Suroj Pokhrel, PhD

Secretary
Ministry of Agricultural Development
Kathmandu, Nepal

Nepal is ranked 10^{th} position for biodiversity richness in Asia. Agrobiodiversity, a main component of biodiversity is the livelihoods of about 65% Nepalese people. However, this rich agrobiodiversity has been poorly understood, documented and used in research. There is gap in quantitative information of agricultural plant genetic resources of Nepal and questions arise like how many cultivated species, how many varieties or landraces, how many introduced species, etc. I found this 2^{nd} national workshop has done its best to fill these gaps inviting different national experts.

With deep satisfaction, I am very pleased with this workshop and the Proceedings of 2^{nd} National Workshop on Conservation and Utilization of Agricultural Plant Genetic Resources (CUAPGR) held in Dhulikhel, Nepal from 22-23 May 2017. The workshop continued a tradition of bringing together researchers, academics and professionals from across the country, experts in agrobiodiversity conservation and utilization. Their contributions helped to make the workshop outstanding. The papers contributed the most recent scientific knowledge known in the field of agrobiodiversity. On behalf of the MoAD, I would like to congratulate and thank organizing team from National Genebank, Fruit Development Directorate, Department of Agriculture and Ministry of Agricultural Development.

This proceedings is filled with updated information covering the status of conservation, diversity, utilization and distribution of APGRs in the country. It has listed the existing agrobiodiversity particularly English name, Nepali name and scientific name of most of the crop species including crop wild relatives. In addition, action matrix including group recommendations will help guide the nation for future works on agrobiodiversity. This proceedings will serve the agricultural scientists, farmers, students, researchers and development workers with valuable reference resources. I am also confident that this document will be an impetus of further study and research in all areas.

My thanks go to all the authors, editors and participants who contributed from their parts. I would specially like to thank Dr Bal K. Joshi and Mr Anil K. Acharya for their tireless effort to make the workshop successful and bring out this publication.

Comments and suggestions are welcome.

Preface

Big altitudinal range of crop cultivation ie from 60 m to 4700 m in Nepal has created and maintained about more than 30,000 landraces of 484 crop species. These diversities are the basis of Nepalese people' life and need to conserve and use sustainably. More than 100 organizations are working on agricultural plant genetic resources (APGRs). Many progresses and milestones have been achieved on conservation and utilization of APGRs in Nepal. However, all these progresses were not shared each other and documented. We realized in 2015 that Nepal should organize a national workshop in this area so that horizon of APGRs management will be increased and effectively conserved and used. NAGRC and MoAD proposed budget to GoN for jointly organizing a workshop in 2016. Later, DoA and FDD joined for organizing this workshop and contributed both financially and technically. First workshop in this area was held in 1994 and proceedings are available from www.narc.gov.np.

We identified gaps in conservation and utilization of APGRs based on the literatures and progresses made by different organizations. Technical team sit together many round for selecting paper titles based on these gaps and authors based on the expertise available in the country. General guidelines were developed. On the behalf of organizing committee, MoAD requested principle authors to write a full paper and to present summary in workshop. The potential co-authors were also provided to main authors, though main authors were given authority to edit the list. Main documents related to APGRs were shared among the authors to ease the writing process. After the workshop, MoAD formed an editorial team for publication of the proceedings.

We, the editors, organized four days long editshop after first round of editing papers for finalization in Potato Seed Production Farm, Nigale, Sindhuplachowk. Our special thanks go to Krishna P. Paudel, Chief of this farm for providing congenial environment to accelerate the editing works. Scientific names were verified through published literatures and websites, mainly http://www.theplantlist.org/, http://www.ipni.org/ and http://www.efloras.org/flora_page.aspx?flora_id=110. There were 29 papers and 6 posters in the list. Two papers could not be presented because of unable of Indian and Chinese scientists to attend the workshop. One poster was later added in the list and was hanged on during the workshop.

We requested authors of posters to convert poster in full paper and total we have 34 papers in this proceedings. These papers were grouped in five sections (i. conservation and utilization; ii. Accelerators for APGRs management; iii. Status of agronomic crops; iv. Status of horticultural crops, forages and crop wild relatives and v. Poster section). Authors have tried to quantify the agrobiodiversity, conservation and utilization status. Each question, comment and suggestion is documented for each technical discussion session. Group recommendations along with action matrix were presented in this proceedings. Action matrix was developed from group and individual's recommendation and way forward of each paper.

We are very pleased to mention here the financial support from NAGRC; FDD; DoA and MoAD for organizing the workshop and publishing this proceedings. Sincere thanks go to all authors who made this proceedings very informative and scientific. We are thankful to Dr YR Pandey, ED, NARC; Suresh B. Tiwari, Joint Secretary, MoAD; Dr Suroj Pokhrel, Secretary, MoAD for their support and guidance.

The Editors

Uncommon Abbreviations and Abbreviations not Spelled out in the Text

2n	Diploid generation
ABD	Agrobiodiversity
ADS	Agriculture development strategy
AFU	Agriculture and Forestry University
AGDP	Agriculture gross domestic product
AI	Agrobidiversity index
APGR	Agricultural plant genetic resource
ARA	Agrobiodiversity rich area
ARF	Agrobiodiversity rich farmer
BI	Bioversity international
BP	Before present
BS	Bikram sambat
CAC	Collection acceptance committee
CAT	Climate analog tool
CBR	Community biodiversity register
CF	Custodian farmer
CFGB	Community field genebank
CGB	Community genebank
CSB	Community seed bank
CSPB	Climate smart plant breeding
CTC	Crush tear curl
cv.	Cultivar
CWR	Crop wild relative
DADS	Diversifying Availability of Diverse Seeds
DNA	Date not available
DOI	Digital object identifier
f.	Filius, son
FR	Farmers' right
GI	Geographical indicator
GM	Green manuring
GP	Gene pool
GRPI	Genetic resource policy initiative
HFGB	Household field genebank
HSB	Household seed bank
IAPS	Invasive alien plant species
IJO	International Jute Organization
IMISAP	ITPGRFA-MLS Implementation Strategy and Action Plan
IP	Intellectual property
LEC	Landrace enhancement and conservation
MDG	Millennium development goal
MLS	Multilateral system
NA	Not available
NAA	Nepal agricultural association
NBSAP	National Biodiversity Strategy and Action Plan
ODAP	Oxalyldiaminopropionic acid
OP	Open pollinated
ORCID	Open researcher and contributor identifier
PDO	Protected Designation of Origin
PGI	Protected geographical indication
PMAMP	Prime minister agriculture modernization program
PVP	Plant variety protection
SDG	Sustainable development goal
SMTA	Standard material transfer agreement
sp.	Species (singular)
spp.	Species (plural)
SPS	Sanitary and phytosanitary
ssp.	Subspecies
subsp.	Subspecies
Syn.	Synonym
TSG	Traditional speciality guaranteed
TSLC	Technical school leaving certificate
TVET	Technical and vocational education and training
var.	Variety
veg	Vegetable
WEP	Wild edible plant
WSV	World seed vault
x	Placed after a genus name and before a specific epithet, indicating hybrid origin

Glossary

Term	Definition
Access to genetic resources	The arrangement made to collect, acquire, or receive genetic materials, resources, or traditional knowledge from the owner for the use of others
Accession	A distinct uniquely identifiable sample of seeds representing a cultivar (variety or landrace), breeding line or a population which is maintained in storage for conservation and use. Accessions of the same species or landraces may differ by collection sites, collection year, local name or donor.
Agricultural genetic resources	Any genetic material of actual or potential value for food and agriculture
Agricultural plant genetic resources	All cultivated plant landraces and varieties, wild edible plants, and wild relatives of crops
Agrobiodiversity	Includes four components of agrobiodiversity (plant and crop genetic resources, animal genetic resources, aqua genetic resources and associated genetic resources) and four sub-components in each component ie domesticated, semi-domesticated, wild edible and wild relative species
Alternate host	A plant, other than the main host, on which a pathogen or pest can live. Alternate hosts, often weeds can provide a means for the pathogen to survive when its main host is not available
Angiosperm	A plant that has flowers and produces seeds enclosed within a carpel
Animal farm genebank	Rearing of domesticated local and indigenous animals as well as improved breeds on-farm maintaining different species and breeds available around the command areas of research station or public farms for conservation, use and research
Aquaculture	Farming of fish, crustaceans, mollusks, aquatic plants, algae, and other aquatic organisms
Associated biodiversity	Includes micro-organisms including bacteria, viruses and protists, and fungi; invertebrates, including insects, spiders, worms, and all other invertebrates; vertebrates, including amphibians, reptiles, and wild (non-domesticated) birds and mammals, including wild relatives, of importance to crop, animal, fish and forest production as pests, predators, pollinators or in other ways, and wild and cultivated terrestrial and aquatic plants other than crops and crop wild relatives
Authorities	The authors of plant names
Base broadening	Increasing the amount of genetic diversity used to produce new varieties or breeds used in agricultural production
Benefit-sharing	Sharing monetary or non-monetary benefit acquired by accessing and using genetic material, resources, or traditional knowledge as per an agreement between provider and receiver
Biennials	Need 2 growing seasons to complete life cycle
Biodiversity for food and agriculture	Includes the variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain the ecosystem structures, functions and processes in and around production systems, and that provide food and non-food agriculture products
Biological diversity or biodiversity	The richness and variety of living beings from all sources including, *inter alia*, terrestrial, marine and freshwater ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
Biological Resources	Includes genetic resources, organisms or parts thereof, populations or any other biotic component of ecosystems with actual or potential use or value for humanity
Biopiracy	Take away biological resources and indigenous knowledge for profit without any discussion, interaction, nor formal or informal agreement with local custodians or users of biological resources
Biotechnology	Any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify biological products or processes for specific use
Black box	A system for depositing samples that does not constitute a legal transfer of genetic resources; the repository gene bank does not claim ownership over the deposited samples and that ownership remains with the depositor, who has sole right of access to the materials. The repository genebank is not entitled to the use or distribute the germplasm. It is the depositor's responsibility to ensure that the deposited material is of high quality, to monitor seed viability over time, and to use their own base collection to regenerate the collection when it begins to lose viability.
Boreal	At least one month with monthly mean temperatures, corrected to sea level, below 5 °C and more than one but less than four months above 10°C
Breeders' rights	An exclusive right on the breeder or his successor or his agent or licensee to produce, sell, market, distribute, import or export of the variety
Catalog	A list or record of variety and landraces for identification, sharing knowledge and information

Term	Definition
	which is systematically arranged and often including descriptive material
Clone	A genetically identical plant derived from a single mother plant by asexual propagation (cuttings or tissue culture)
Common	Found in relatively large numbers, the most widespread, grown in large areas and by many farmers; not rare
Community biodiversity register	A register maintained by a local community to record APGRs
Community gene bank	A community storage facility for seeds of orthodox types and a one or more fields where farmer communities grow recalcitrant types of crops and maintain them over time, managed and owned by community for themselves giving due emphasis to local crops
Community seed banks	Locally used seed storage structure and institutions managed by local community with collective action for strengthening local seed system of orthodox crops and conserving them
Conservation	Careful preservation and protection of APGRs on-farm, in-situ or ex-situ for use of current and future generations
Cover crop	Grown to protect soil from erosion
Crop	Cultivated angiosperm plant species, either for sale or for subsistence
Crop wild relative	A non cultivated species which is more or less closely related to a crop species (usually in the same genus) and occur in agro-ecosystems
Cultigen	A taxon believed to have originated in cultivation
Cultivar	Any distinct genotype under cultivation, including both landraces and varieties
Culton	Cultivated taxon
Determinate Crops	Flowering is confined to a specific period of time in these crops, at the end of vegetative growth
Distribution	Fair and equitable distribution of acquired benefit from the access to genetic material, resources, or traditional knowledge between farmers and stakeholders
Diversity field school	A community based knowledge and action platform that facilitates the use and maintenance of diversity in the production system both as a way of risk minimization (from pest & disease damage or climate variability) as well as providing farmers access to knowledge, planting materials, credit and networks. Crop diversity is major subject of discussion similar to farmers field school
Domesticated or cultivated species	Species in which the evolutionary process has been influenced by humans to meet their needs and they grow in the management system of human
Domestication	The development of new crop, aquatic, forest and animal species through deliberate breeding programmes or the continued selection and improvement of existing species from their wild progenitors
Ecosystem diversity	Comprises the variety of habitats, the dynamic complexes of plant, animal and microorganism communities and their nonliving environment, which interact as a functional unit and their change over time
Ecotype	A distinct form or race of a plant or animal species occupying a particular habitat
Elite line	Any genotype that possess at least one useful trait or superior line for at least one trait. In breeding phase, elite line is generally first identified, then promising and pipeline variety.
Endangered	A species or landrace which has been categorized as likely to become extinct. Population size of that species or landrace is in decreasing order due to several factors
Endemic species	Organisms found only on particular geographical location and habitat
Energy Crops	Harvested for energy production –includes oil seed crops for biodiesel, corn and others for bioethanol, and biomass crops
Ethnobotany	Dealing with the folklore and knowledge of plants and crops
Exotic	Of foreign origin; not native; introduced from abroad, but not fully naturalized or acclimatized
Ex-situ	Outside, off site, or away from the natural location, or in case of crop landrace, away from local farming areas
Ex-situ conservation	Conservation off-site. Conservation of genetic resources outside of its original or natural habitat eg in a genebank, botanical garde, field genebank
Farmer	The people and communities, who identify, conserve, preserve, develop, produce or use genetic material, resources, and traditional knowledge.
Farmers field school	A platform for learning and sharing agricultural practices in farmers' fields. Though it was originally used for implementation of IPM but now it is used as an extension tool for holistic management of agricultural production system covering soil, water and nutrients and diversity
Farmers' rights	The privilege of farmers and their right to protect varieties developed or conserved by them. A farmer can save, use, re-sow, exchange, share and sell farm produce of a protected variety, and protection of innocent infringement

Term	Definition
Floriculture	Dealing with the production of field-grown or greenhouse-grown plants for their flowers or showy leaves
Fodder	Any agricultural foodstuff used specifically to feed domesticated livestock
Forma (f., plural formae)	The rank below varietas (variety) in the taxonomic hierarchy, often Informally referred to as form
Gene	The functional unit of heredity
Genebank	Facility where germplasm is stored or maintained for research and use for long time
Geneflow	The exchange of genetic materials between populations including introduction of new varieties
Genepool	The total amount of genetic diversity present in a particular population
Genetic diversity	The genetic variation present in a population or species. Refers to the variation of genes and/or genomes within living organisms, that is, the genetic differences between populations of a single species and between individuals within a population
Genetic erosion	Loss of genetic diversity (specific trait, particular cultivar) between and within populations of the same species over time or reduction of the genetic base of a species
Genetic material	All or part of the functional units of heredity consisting of the genetic characteristics of domestic or wild animals, plants, microbial organisms, viruses, or other origin. Germplasm of plants, animals or other organisms containing useful characters of actual or potential value
Genotype	Genetic composition of a plant, comprised of heritable traits
Germplasm	Living tissue (seed or another plant part – a leaf, a piece of stem, pollen or even just a few cells) from which new plants can be grown
Global Annex 1 crops	Also called IT Annex 1 crops. Crop species that are included under the multilateral system, listed in Annex 1 of the ITPGRFA, and accessible to all contracting parties through a Standard Material Transfer Agreement
Global crop gene pool	Agricultural plant genetic resources that are necessary to secure food and nutrition for the global community and they are available through MLS
Green Manure Crop	A crop grown to be incorporated into the soil so as to provide fertilizer nutrients
Habitat	Place or type of site where an organism or population naturally occurs, local areas in case of crop landraces
Habitat provisioning	Role of ecosystems in creating and maintaining habitats for a wide variety of organisms. Providing diverse and suitable habitats for species; nursery function for migratory species and as breeding areas
Hay crops	Are cut and dried in the field, baled, and stored for later use
Herbarium	A collection of dried plants or parts of plants
High yielding variety	Crop variety developed by educated plant breeders, designed to maximize yields at the expense of diversity and generally promoted by agricultural development organizations
Home garden	A traditional land use practice carried out around a homestead consisting of several species of plants that are grown and maintained by the family members with the primary objective of fulfilling the family's food and nutrition needs.
Host	A plant upon which an organism (such as an insect or mildew) lodges and subsists
Hybrid swarm	A population of hybrids that has survived beyond the initial hybrid generation, with interbreeding between hybrid individuals and backcrossing with its parent types
Image bank	Record of photos (printed or electronic form) of each accession of crops with some information that are used for identification and reference samples, similar to herbarium
Indeterminate Crops	Flowering is continuous and not confined to a specific period in these crops, as flowering overlaps with vegetative growth
Indigenous	Native, developed or created naturally within country , all APGRs that have been existed before 1950
In-situ	In the natural or original position or place
In-situ conservation	On-site conservation. The conservation of genetic resources in their original ecosystem and natural habitat. Conservation of genetic resources in areas where they developed their distinctive properties ie in the wild. Both active (growing) and dormancy (after seed matures) periods occur in the same place
In-situ conservation on-farm	Conservation in the surroundings or farmers fields where they have developed their distinctive properties (with at least one allele originating there). Active (growing) period is in the field and dormancy (after seed matures) period occur in nearby household or storage structure
Integrated Pest Management	A broad-based approach aims to suppress pest populations below the economic injury level (EIL). It is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment
Intellectual property	Laws that grant monopoly rights to those who create ideas or knowledge

Term	Definition
right	
Introduced varieties/ species	Exotic, brought from outside the country
Invasive species	A species that is not native and causes economic harm to a new environment
Inventory	A complete list of varieties, landraces or genotypes with some basic information
Irrigated crops	Irrigated crops in areas purposely provided with water, including land irrigated by controlled flooding
Kitchen garden	A garden or area near to homestead, where vegetables, fruit, or herbs are grown for domestic or kitchen use
Landrace	Genotype not altered by breeders but grown continuously by farmers over years. It may be local or introduced
Landscape approach	Planning and management of natural resources means a comprehensive, ecosystem-based approach, which takes into account living resources and includes local people and their wellbeing within the context of their physical environment and in harmony with natural cycles and processes
Line	Refers to any group of genetically uniform individuals formed from the selfing of a common parent
Livestock	Domesticated animals raised in an agricultural setting to produce commodities such as food, fiber and labor
Local landrace	Crop landraces available before 1950 in Nepal and grown continuously in particular location for at least over 60 years in same location
Local variety	Crop variety grown continuously in particular location for at least over 60 years in same location
Major crops	Main food crops, form a major part of the daily diet in relatively large quantities as a source of energy, grown commonly and available widely
Management	Conservation and utilization of APGRs
Minor crops	Refers to crops that may be high in value but that are not widely grown and not commonly available
Modern variety	Crop variety developed by educated plant breeders. Syn. High yielding variety
Multilateral access	An arrangement made under the provisions of the ITPGRFA to access and use plant genetic resources for food and agriculture by national governments and international organizations working in the area of agriculture and food security for the welfare of human kind
Multilateral system	Under the ITPGRFA, the multilateral system (MLS) comprises a pool of 64 selected crops that are made accessible. On ratifying the treaty, countries agree to make their genetic diversity and related information about the crops stored in their gene banks available to all through the MLS.
National crop gene pool	Agricultural plant genetic resources that are necessary to secure food and nutrition for human kind.
National list	List of notified crops' varieties that have got approval by the National Seed Board and published in the Nepal Gazette. There are two categories, released varieties and registered varieties in the National list.
Native or indigenous	Entity has always been in the place where they are, rather than being brought there from somewhere else. Native and indigenous are similar meaning words that refer to naturally growing plants, living animals, and even original inhabitants of a particular region
Nepal Annex 1 crops	List of accessions of crops from Nepal included in the MLS
Non-timber forest products	Non-timber forest products (NTFP) are any product or service other than timber that is produced in forests. They include fruits and nuts, vegetables, fish and game, medicinal plants, resins, essences and a range of barks and fibres such as bamboo, rattans, and a host of other palms and grasses.
Olericulture	Dealing with the production of vegetables and herbs
On-farm	Farming areas or cultivated areas
On-farm conservation	The conservation of agrobiodiversity in farmers' fields and/or in community gene banks (seed bank and field gene bank), where new traits or alleles have not originated, but have been cultivated over a period of time. Active life (growing period) remains in the field and dormancy period (after harvest) remains in the manmade structure nearby field
Organic farming	Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity and prohibits use of agrochemicals
Origin of landrace	Area where farming communities have been growing a landrace for more than 60 years or the location where a landrace was collected
Origin of variety	Location where a distinct form of genotype is developed either by crossing or selection

Term	Definition
Pasture	Land covered with grass or herbage and grazed by or suitable for grazing by livestock
Pasture crops	Used directly in grazing
Phytoplankton	Single-celled organisms of aquatic habitats that capable of making their own food by photosynthesis. Phytoplankton occurs almost anywhere there is water and sunlight
Pipeline variety	Variety at the end of breeding stage, outperformed in all breeding trials including on-farm trials and ready to release or register. Genotypes at the state of development, and will be released soon
Plant	Uncultivated and wild flowering (angiosperm) plant species
Pomology	Dealing with fruit and tree nut production
Population	A group of individual of the same group or species, which live in a particular geographical area, and have the capability of interbreeding
Production systems	Include the livestock, crop, fisheries and aquaculture and forest sectors
Promising variety or line	Fixed genotypes that show the signs of future success
Protected area	A geographically defined area that is regulated and managed to achieve specific conservation objectives
Public domain	Space containing genetic materials that are not protected by intellectual property rights.
Rainfed crop	Agricultural practice relying exclusively on rainfall as its source of water
Rank	The position of a taxonomic entity or its level in the taxonomic hierarchy
Rare	Not found in large numbers, grown by few farmers in small areas, localized landraces not commonly available, population size remain constant
Registered	Variety after testing one season or two seasons in target environment and listed in Nepal Gazette
Released	Variety after testing in different breeding trials and at least in three multi-location yield trials and listed in Nepal Gazette
Repatriation	The return of crop landraces to their original sites or country
Rescue mission	Collection target of rare and endangered landraces from particular areas to save from danger or harm or loss
Researchers' rights	Access to protected varieties for bona fide research purpose
Safety backup	Safety duplication of accessions at one or more sites and/or using an alternative conservation method or strategy, such as in-vitro or cryopreservation or field gene bank. Both depositor and repository gene banks can use and distribute the germplasm.
Safety duplication	The duplication of genetically identical subsamples of an accession to mitigate the risk of its partial or total loss caused by natural or man-made catastrophes. Safety duplicates are genetically identical to the accessions in the base collection and are referred to as the second-most original samples. Safety duplicates include both the duplicated material and its related information and are deposited in a base collection at a different location from the originals, usually in another country. Safety duplication is generally organized under a black-box agreement.
Selection	Any process, natural or artificial which permits an increase in the population of certain genotypes or groups of genotypes in succeeding generations
Silage crops	Are cut, but not dried, and are then fermented under anaerobic conditions
Species	A taxon comprising one or more population of individuals capable of interbreeding to produce fertile offspring
Species diversity	Refers to the frequency and variety of species (wild or domesticated) within a geographical area
Specimen	An individual animal, plant, piece of a mineral, etc, used as an example of its species or type for scientific study or display
Subspecies	A category in biological classification that ranks immediately below a species and designates a population of a particular geographic region genetically distinguishable from other such populations of the same species and capable of interbreeding successfully with them where its range overlaps theirs
Subtropics	One or more months with monthly mean temperatures, corrected to sea level, below 18°C but above 5°C
Sui generis system	Of its own kind. Any unique form of system designed to meet certain alternative legal system
Sustainable use	The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations
Swidden and shifting cultivation agriculture	Rotation of plots from intensive cultivation to extended fallow periods for the replenishment of soil fertility

Term	Definition
Synonym	A valid name for a taxon that is not currently accepted, usually through application of the principle of priority
Taxon	A group or category at any level in a system for classifying plants (eg an entity at a species level, a genus level, a family level, etc; all may be called a taxon
Temperate	At least one month with monthly mean temperatures, corrected to sea level, below 5°C and four or more months above 10°C
Traditional knowledge	Knowledge, skills, technology, or practices used by farmers from generation to generation to identify, manage, conserve, develop, or use genetic material or resources
Tropics	All months with monthly mean temperature, corrected to sea level, above 18°C.
Variant	An informal term for a plant or group of plants which shows some character differences from others in the same taxon
Variety	Genotype developed by breeders. It may be under cultivation or in the process of development
Voucher	Specimen kept as a reference for a plant which has been used for other purposes

2nd National Workshop on Conservation and Utilization of Agricultural Plant Genetic Resources (CUAPGR) in Nepal

Workshop Summary

The 2nd National Workshop (after 23 years of the first workshop which was held in 1994) on Conservation and Utilization of Agricultural Plant Genetic Resources (CUAPGR) was held from 22 to 23 May 2017 in Mirabel Hotel and Resort, Dhulikhel. This workshop, inaugurated by Honorable Minister of Agricultural Development, Gauri Shankar Chaudhary, was organized jointly by National Agriculture Genetic Resources Center, Fruit Development Directorate, Department of Agriculture and Ministry of Agricultural Development. Theme of the workshop was agrobiodiversity for securing our lives with the scope of diversity and utilization status, agrobiodiversity conservation and utilization, angiosperms, agricultural plant genetic resources (APGRs) and national and international policies. The workshop date was chosen as 22 May is the International Biodiversity Day with the theme of biodiversity and sustainable tourism. Joint Secretary of MoAD, Suresh Babu Tiwari highlighted the following rational of organizing the workshop and explained the workshop objectives.

- Update and share on conservation and use of APGRs, status of diversity and policy on APGRs in Nepal
- Prepare list of i. Existing APGRs including cultivated, wild relatives and wild edible plants, ii. Lost APGRs, iii. Agrobiodiversity rich farmers (custodian farmers) and hotspots of agrobiodiversity, iv. Rare, endangered and unique APGRs, v. APGRs originated in the regions, vi. Organizations involved in the APGRs conservation
- Enhance the capacity of agriculturists on management, conservation and utilization of APGRs
- Establish linkage among diverse sectors and stakeholders for the management of APGRs
- Accelerate the conservation and utilization of APGRs
- Sharing and collecting feedbacks on ITPGRFA-MLS Implementation Strategy and Action Plan (IMISAP)

Opening session was chaired by the Secretary, MoAD, Dr Suroj Pokhrel. Dr YR Pandey, ED, NARC; Dilaram Bhandari, DG, DoA; Representative from FAO Dr. Binod Saha and Dr Balaram Thapa, ED, LIBIRD shared opening remarks, giving due emphasis on the importance of workshop for conservation and utilization of agricultural plant genetic resources (APGRs). There were 75 participants, consisting of 6 female and 69 male, representing from 57 different governmental organizations, 16 non-governmental organizations and 2 freelancers. A total of 27 papers were presented by 24 experts who represented 5 NGOs, 17 GOs and 2 freelancers. At least three experts were coauthor in each paper. These papers were divided into four technical sessions, i. Conservation and utilization session chaired by Suresh Babu Tiwari, ii. Accelerators for APGRs management session chaired by Dr YR Pandey, iii. Status of agronomic crops session chaired by Dr YR Pandey and iv. Status of horticultural crops, forges and CWR session chaired by Dilaram Bhandari. Six posters were presented. As a side event, publications from NAGRC and LIBIRD were displayed. Presentations were very informative and updated. Many comments and suggestions were raised during discussion session. Three groups were formed for making recommendation on future agendas for conservation, utilization of APGRs and access and benefit sharing. The first day program was facilitated by Deepa Singh and second day was by Krishna Hari Ghimire.

Closing session was chaired by Joint Secretary, Suresh Babu Tiwari who briefly expressed the success of the workshop and planning of publishing proceedings. Active participations of all experts were highly appreciated. Closing remarks were made by Dharma Datta Baral, Chief, SQCC; Dilaram Bhandari, DG, DoA; Dr Mina Nath Paudel, Chief, NAGRC; Dr Ramita Manandhar, FDD, Kirtipur and IUCN representative Dr Pralhad Thapa. Technical committee members, Dr Bal K. Joshi, Dr Devendra Gauchan, Dr Dharma Raj Dongol and Anil K. Acharya and the invitee, Dr Hari Bahadur KC edited and shared the abstract book, which is available at www.goo.gl/9oc9LI. All presentations and posters are uploaded at www.goo.gl/z2l9ol.

A total of Rs 12,50,000 were spent for this workshop and publication of proceedings. The main headings of expenses were lodging and fooding, per diem, authors and presenters' incentives, and stationery. NAGRC contributed Rs 3,50,000; FDD contributed Rs 300,0000; DoA Rs 100,000 and MoAD Rs 5,00,000.

Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal (BK Joshi, HB KC and AK Acharya, eds). Proceedings of 2nd National Workshop, 22-23 May 2017 Dhulikhel; NAGRC, FDD, DoA and MoAD; Kathmandu, Nepal

Notes on Plant and Crop Classification

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ABSTRACT

Diverse plant and crop genetic resources should be grouped for easy handling, research and study and proper management. NAGRC has followed three kingdom systems of classification (fungi, plantae and animalia), with four phylum under kingdom plantae (bryophyta, pteridophyta, gymnosperms and angiosperms). Angiosperm has two classes, monocots and dicots. APGRs under the angiosperms include cultivated, semi-domesticated, crop wild relatives and wild edible plants. Crops are grouped under agronomic, horticultural and forages and they were further sub-grouped based on the economic and use values. This system of classification will be widely used at national level for common understanding and management of APGRs.

Keywords: APGRs, classification, crop, plant, taxonomy

INTRODUCTION

Plant and crop classification are important for research, conservation and utilization, which are based on the traits differences and similarity including reproductive behavior among the organisms. There are many systems of classifications proposed by different taxonomists (Linnaeus 1735, Woese et al 1990, Whittaker 1969, Cavalier-Smith 2004) and many ways of crop classification. Here plant taxonomy and crop classification followed by National Genebank of Nepal is described.

PLANT TAXONOMY

Plant taxonomy is the science that finds, identifies, describes, classifies, and names plants on the basis of shared characteristics. Organisms are grouped together into taxa and are given a taxonomic rank; thus creating a taxonomic hierarchy (**Figure** 1). The Swedish botanist Carl Linnaeus is the father of taxonomy, as he developed a system known as Linnaean taxonomy for categorization of organisms and binomial nomenclature for naming organisms. National Genebank has followed the three-domain system for a biological classification (Woese et al 1990).

Kingdom: Plantae or Metaphyta

The Plantae includes all types of eukaryotic, multicellular, photosynthetic plants found in this biosphere, eg non flowering plants (mosses, ferns) and flowering plants (conifers, dicot, monocot). Most of the organisms are photo-autotrophs and the cell walls are comprised of cellulose. They are anchored to the substratum and thus are sedentary (non-motile).

Phylum of Plantae

Plantae has been divided into four phylum based on the presence or absence of vascular tissue and seed (**Table** 1). Vascular tissue helps in transporting substances (water, minerals and sugars) throughout the plant. Seeds are the most evolved reproductive structures which contains an embryo and the stored food for early growth of seedlings after germination.

Table 1. Features of four phylum of Plantae

Phylum: Bryophyta	Phylum: Pteridophyta	Phylum: Gymnosperms	Phylum: Angiosperms
• Non-vascular plants, which do not contain any vascular tissues • Reproduction process is carried by vegetative method as well as spores	• Seedless vascular plants • The reproduction process is carried by vegetative method as well as spores • Example: Horsetails,	• Flowering plants with naked seeds; true fruit is thus absent • The main veins of their leaves are usually unbranched • Example: Pines,	• Flowering plants, which develops the seeds within a protective structure • They develop their seeds within an ovary, which itself is embedded in a flower

• Non flowering small plant and are found mainly growing on the moist ground, on other plants and on rocks • Example: Liverworts, mosses	ferns	cycads, ginkgo, yews	• Leaf consists of a single, branched, main vein, which originates from the base of the leaf blade • Example: Sal, sissoo, soya bean, rice

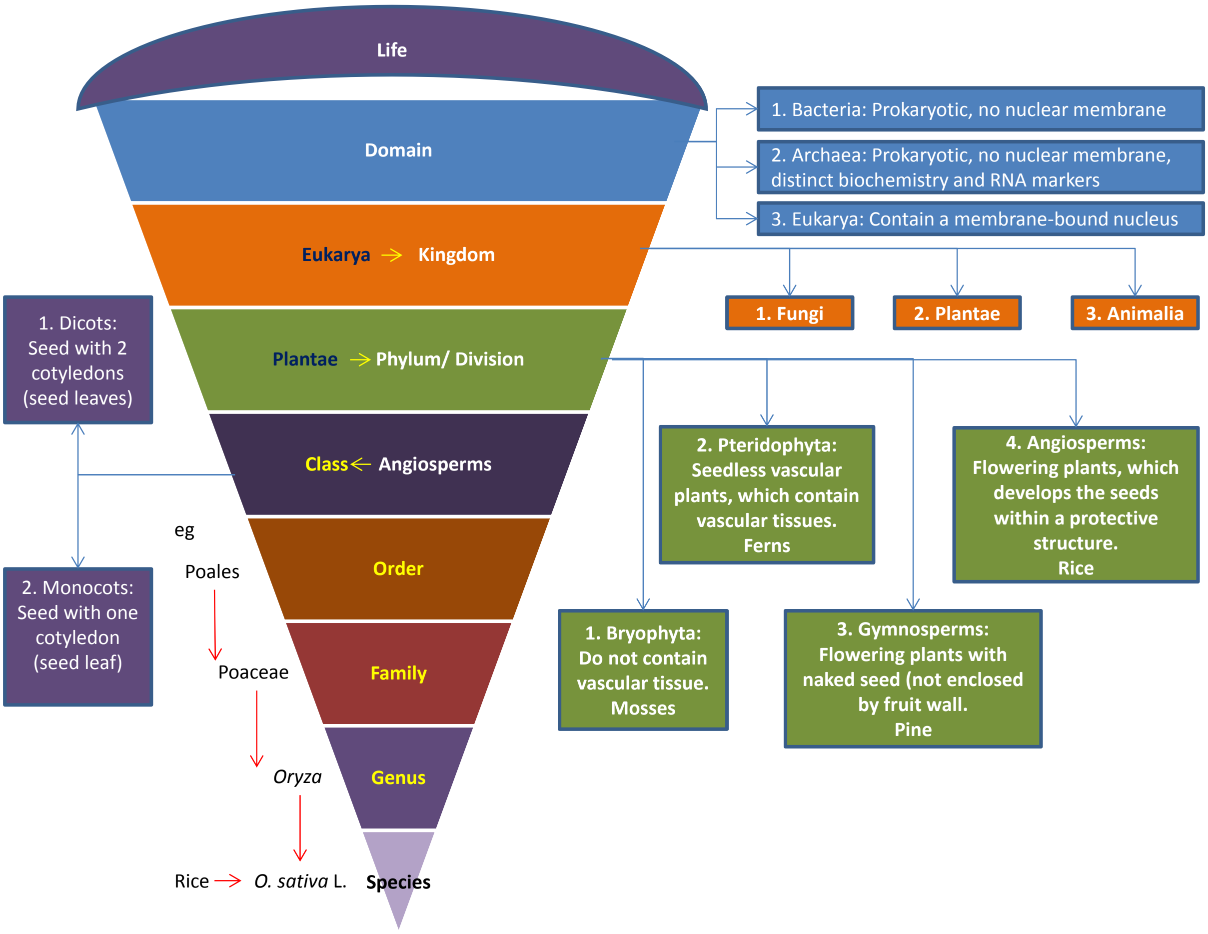

Figure 1. A hierarchical classification of living things (taxonomic levels). Taxonomy of rice is given as an example.
Source: Woese et al 1990, http://www.gbif.org/

Table 2. Characters of two classes of angiosperms (anthophyta, angiospermae or Magnoliophyta)

Monocots or Monocotyledonae, Liliopsida	Dicots or Dicotyledonae, Magnoliopsida
• Seed with one cotyledon (seed leaf)	• Seed with two cotyledons (seed leaves)
• Leaves with parallel veins	• Leaves with a network of veins
• Lateral meristems rarely occur	• Lateral meristems (cambia) present
• Flower parts mostly in 3 or multiples of 3	• Flower parts mostly in 4 or 5 or in their multiples
• Example: Rice, wheat, corn, ginger, onion, taro	• Example: Bean, tomato, eggplant, apple, yam

Source: http://www.mhhe.com/biosci/genbio/tlw3/eBridge/Chp16/16_5.pdf

CROP CLASSIFICATION

Crops are domesticated and cultivated plant species. They are main component of agricultural plant genetic resources (APGRs). APGRs include all species under Plantae kingdom that have food and agricultural values. National Genebank in Nepal has currently considered cultivated crops, crop wild relatives and wild edible plant as working plant species (**Table** 3). All these species belong to angiosperms division and this Proceedings has covered only angiosperms. National Genebank groups these APGRs based on the economic importance and use values as described in **Figure** 2 for facilitating conservation and utilization activities in the country.

Table 3. Description of economic groups of agricultural plant genetic resources

Crop group	**Description**
Agronomic crops	Crops often harvested mature, has low moisture content of harvested product and consumed processed in living state or dried. Food crops that form a major part of the daily diet in relatively large quantities as a source of energy
Beverages and narcotics	Crops for the production of beverages (agreeable liquors for drinking) including narcotic plants containing substances that cause unusual excitation, as stimulant and may have medial properties
Cereals	Annual crops, mainly members of the grass family and are grown for the edible larger seed
Crop wild relatives	Wild plants closely related to a domesticated plant, whose geographic origins can be traced to regions known as Vavilov Centers. It may be a wild ancestor of the domesticated plant, or another closely related taxon.
Fiber crops	Harvested for fibers used for clothing, industrial applications, etc
Forages	Grasses and other plants that are eaten by animals
Fruit crops	Plants from which a more or less succulent fruit (edible part of a plant that consists of the seeds and surrounding tissues or closely related botanical structure is commonly eaten fresh or raw as a dessert or snack with little preparation; have a sweet or tart taste; generally consumed as breakfast beverages, breakfast and lunch side-dishes
Fruit vegetables	Plants of which the fruits are used as food, but does not include plants with sweet or fleshy fruits that are eaten raw and does not include plants that are grown for their grains
Grass forages	Monocotyledonous flowering herbaceous plants with stems that are hollow except at the nodes and narrow alternate leaves borne in two ranks. The lower part of each leaf encloses the stem, forming a leaf-sheath
Horticultural crops	Crops harvested at different states, have high moisture content of harvested product, often consumed fresh, some cooked or processed, some for aesthetic purpose.
Leafy and stem vegetables	Includes plants of which the leaves, stem and flowers are used as food
Legume forages	Dicotyledonous herbs, shrubs, and trees having fruits that are legumes (dry dehiscent one-celled fruit developed from a simple superior ovary) or loments, bearing nodules on the roots that contain nitrogen-fixing bacteria and use as forage
Legume vegetables	Legumes plants of which shoot, immature seeds and pods are used as food
Millets	The small seeded grained cereals which are of minor importance as food
Oilseed crops	Includes crops which are grown to extract oils that are used in cooking (edible oil), for fuel, for cosmetics, for medical purposes, or for industrial purposes
Ornamental plants	Plants that are grown for decorative, aesthetic purposes in gardens and landscape design projects, as houseplants, for cut flowers and specimen display, targeted to eye satisfaction
Pseudo cereals	Includes plants that are used in much the same way as cereals, but which do not belong to the grasses
Pulses	Also known as grain legumes. Large-seeded legumes which are harvested for the edible seed as food (dal)
Root and tuber vegetable	Includes plants of which the under ground storage organs, the roots (including swollen roots), tubers (modified plant structures, usually roots or stems) are used as food
Semi domesticated plants	A kind of plant species that is in the state between wild plants and domesticated crops. They are mostly in or around the farm and are under human intervention to care and maintain them
Spices	Includes plants that are not grown for their food value but rather are used in small amounts as a food additive to add flavor or color, taste and some spices as food preservatives
Starch crops	Grown for the production of starch
Sub tropical fruits	Fruit crops that can tolerate some freezing temperatures, but not extended periods of cold
Sugar crops	Crops for production of sugar
Temperate fruits	Fruit crops grow well in cool climate
Tree forages	A perennial plant with an elongated woody stem, or trunk, supporting branches and leaves that regularly renews its growth and use as forage
Tropical fruits	Fruit crops grow well in warm and hot climate
Vegetables	Herbaceous plants of which some portion is eaten raw or cooked during the main part of a meal, in a mixed dish, as an appetizer or in a salad. Includes edible plants that are grown as a food crop for their leaves, stems, roots, tubers, bulbs, corms, pods or flowers, but plants that are only grown for their sweet fruit or for seeds or grains are not included
Wild edible plants	Wild plants that whole plants or its parts are used as food in fresh or after processed

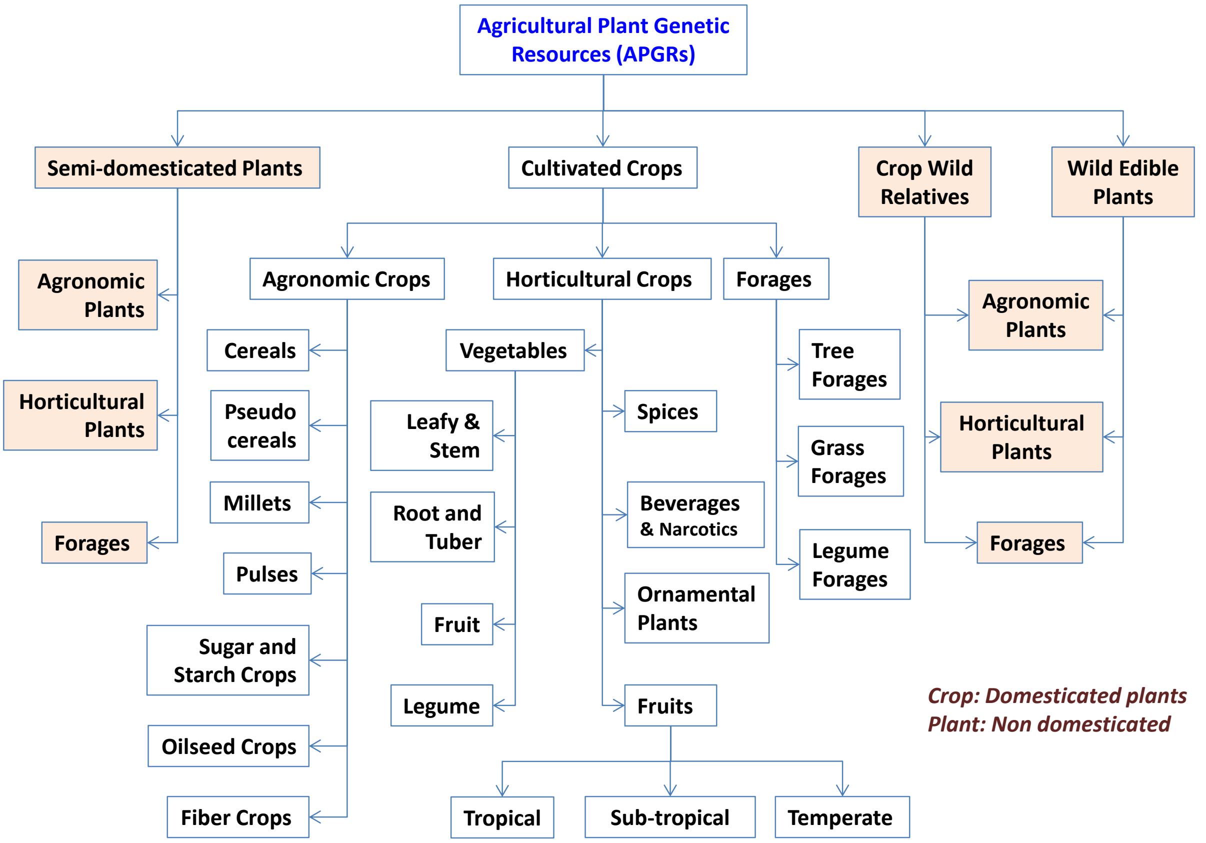

Figure 2. Classification of agricultural plant genetic resources on the basis of economic importance (uses).
This is working groups of APGRs in National Genebank, Nepal. Source: Joshi 2017, Joshi et al 2017.

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Agrobiodiversity Status and Conservation Options and Methods

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ABSTRACT
Nepal is tenth in position in term of flowering plant diversity in Asia and the 31st on a world scale. The numbers of food value plant species are 790 and cultivated are 577 including forage species. Among 577 cultivated species; 484 are indigenous and 93 are introduced species. About 224 wild species are closely related to crops (called crop wild relatives). The estimated numbers of crop landraces are 30,000. Crop cultivation ranges from 60 m (Kechana Kalan, Jhapa) to 4700 m (Khumbu, Solukhumbu) altitude. Eight agro-ecosystems available in the country are rainfed High Hill, rainfed Mid Hill, rainfed Tarai, irrigated High Hill, irrigated Mid Hill, irrigated Tarai, wetland agriculture and rangeland agriculture. Agriculture research has been started since 1950 in Nepal. APGRs (agricultural plant genetic resources) exploration, collection and conservation activities have been initiated since 1984 by the Agriculture Botany Division, NARC in Khumaltar. Three broad groups of APGRs are agronomic crops, horticultural crops and forages and numbers of known species under these groups are 64, 145 and 275 respectively. Total released, registered and denotified varieties are 250, 373 and 35 respectively and among them only 7% of the total varieties were developed using 41 local landraces of 20 crops. Loss of about 50% of traditional varieties from farmers' field demands immediate action to conserve existing landraces. Community seed banks were, therefore initiated at the community level for conserving local crop varieties by different organizations, the first being established in 1994 in Lalitpur. At the national level, the Government of Nepal has established the National Agriculture Genetic Resources Center (NAGRC) ie National Genebank in 2010. NAGRC currently holds 11053 accessions of 70 crop species. A total of 2045 accessions are safety duplicated and backed up in 7 foreign genebanks. More than 12 countries have conserved more than 23,600 Nepalese accessions of different crop species. Based on the conservation strategy, APGRs are grouped as orthodox seeds, recalcitrant seeds and vegetatively propagated crops. Orthodox seeds are conserved in medium and long term storages of Seed Bank, whereas, non-orthodox are conserved through the Field Genebank and the Tissue Bank. Four conservation strategies are ex-situ, on-farm and in-situ and breeding. Conservation options and methods available in the country are Seed Bank, Tissue Bank, DNA Bank, Field Genebank, Household Genebank (Household Seed Bank and Household Field Genebank), Community Genebank (Community Seed Bank and Community Field Genebank), Himalayan Seed Bank, Botanical Garden and Park, Community Forest, National Park, Conservation Areas, Wildlife Reserves, Hunting Reserve, World heritage sites, Ramsar sites, Religious Places, Svalbard Global Seed Vault, World Seed Vault and CGIAR Banks. These options complement each other and therefore need to collaborate with different stakeholders for effective and efficient conservation of APGRs.

Keywords: Agrobiodiversity, APGRs, conservation strategy, ex-situ, genebank, in-situ, on-farm

INTRODUCTION

The plant products account for the majority portion of the global food supply. Globally, over 84% of human diet and nutrition comes from plants. In Asia and the Pacific, the Near East and Africa plants provide around 90% of the average human diet (FAO 2011). However, human beings are dangerously relying on only a few different crops. Out of the 10,000 to 12,000 known edible plant species, only 150 to 200 are used by humans and three of them alone ie rice, wheat and maize contribute nearly 60% of calories and proteins that humans obtain from plants (FAO 2011).

Diverse genetic resources are the foundation for sustainable development of agriculture. The availability of agricultural plant genetic resources (APGRs) is a fundamental requirement for achieving further increase in productivity and higher nutritional values through breeding. About half of the average global production increase in cereals that were achieved under the Green Revolution was attributable to plant breeding utilizing plant genetic resources (FAO 2011). The role of crop diversity and plant breeding will become even more important and needs more diversity. However, genetic erosion is increasingly becoming main issue in most of the crop species across the world. To make the agrobiodiversity available forever to researchers and farmers, more than 1,750 genebanks have been established in the world. Many countries have adopted ex-situ, on-farm and in-situ conservation strategies. Different methods and tools are in practice within this each strategy.

Currently, there are about 7.4 million PGRFA (plant genetic resources for food and agriculture) accessions conserved in over 1,750 genebanks (FAO 2012). More than 2,500 botanical gardens grow over 80,000 plant species (FAO 2012). Nepal is riche in biodiversity (**Figure** 1).

Nepal is tenth in position in term of flowering plant diversity in Asia and 31st on a world scale (MoFSC 2014). This diversity is mainly created and maintained due to variation in climate (**Figure** 2). However, Nepal's dependency is about 95-100% on foreign germplasm in some agricultural crop species for research, breeding and production (Joshi et al 2016a). Additionally, loss of local crop landraces are accelerated by climate changes (**Figure** 3). After coming CBD (Convention on Biological Diversity 1992) in force, restriction imposed on germplasm flows among the countries. Nepal realized the necessity of National Genebank for managing agrobiodiversity within a country and become member of ITPGRFA (international treaty on plant genetic resources for food and agriculture 2004) for facilitated access to global crop gene pools. National Genebank has developed and followed many methods and tools for conservation of APGRs across the country (Sthapit et al 2006).

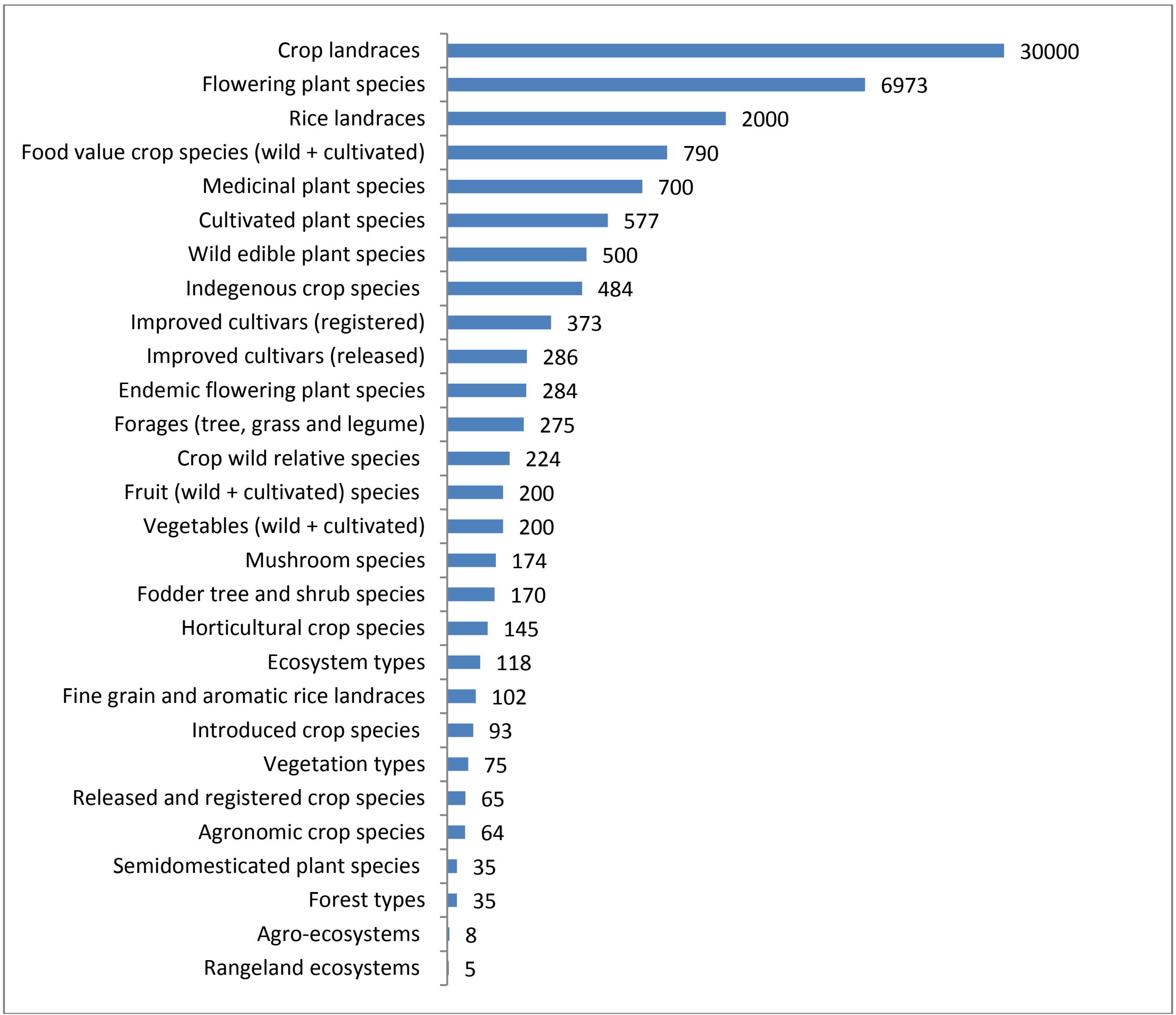

Figure 1. Indicators of plant biodiversity (diversity indices in number) in Nepal.
Adopted from Joshi 2017.

AGROBIODIVERSITY IN NEPAL

Nepal is mountainous agricultural country, where crop cultivation ranges from 60 m (in Kechana Kalan, Jhapa where rice is grown) to 4700 m (in Khumbu, Solukhumbu where potato is grown) altitude. Rice is grown at an altitude of 3050 m in Chhumjul, Jumla, which is the highest elevation of rice growing areas in the world (Mallick 1981, Upadhyay and Joshi 2003). Nepal represents 3.2% of global angiosperm and flora diversity. This biodiversity is mainly because of prevailing climatic variation ranging from tropical to alpine cold semi desert. Main four components of agrobiodiversity are plant and crop genetic resources, animal genetic resources, aqua genetic resources and associated genetic resources (**Figure** 4). For each component, there are four sub-components ie domesticated, semi-domesticated, wild edible and wild relative species.

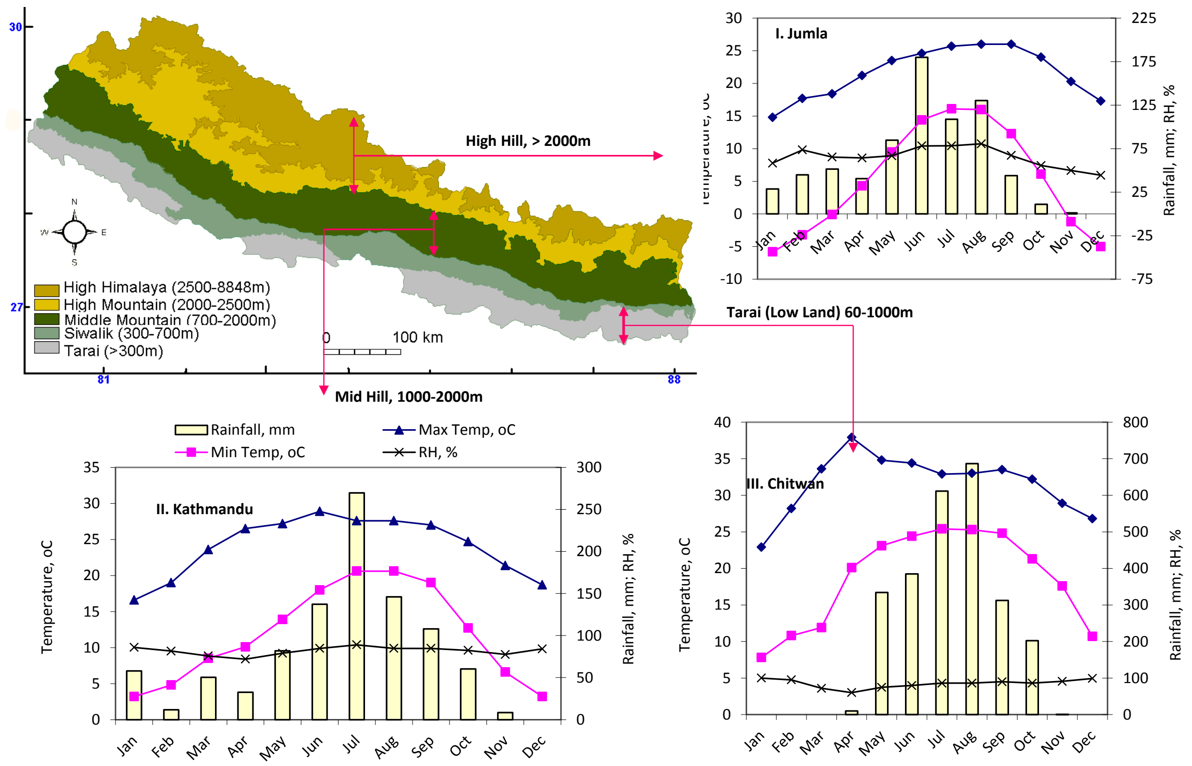

Figure 2. Three agro-ecozones in Nepal and climatic pattern in each zone.

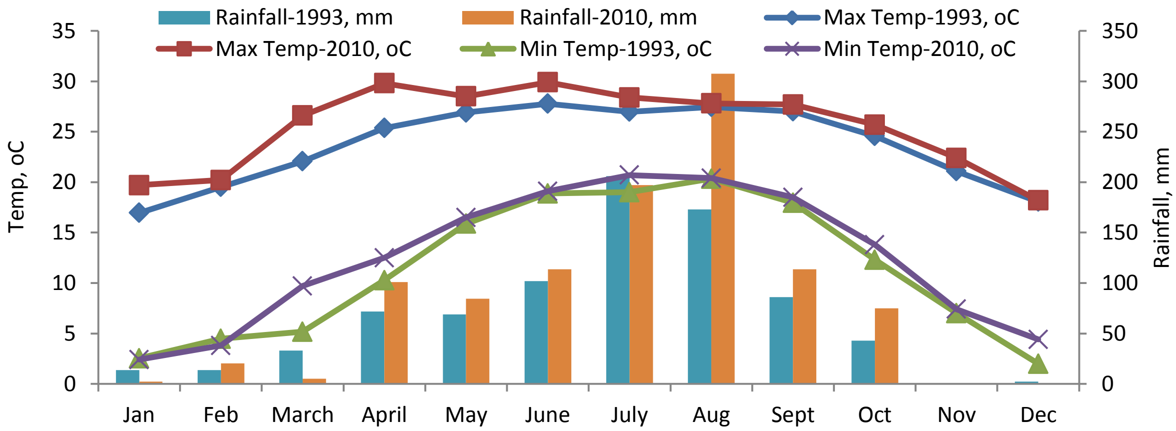

Figure 3. Comparative climatic patterns in 1993 and 2010 in Khumaltar, Lalitpur.

Indicators of biodiversity focusing on agrobiodiversity are given in **Figure** 1. There are 6973 flowering plant species, 790 food value plant species and 577 cultivated plant species including forage species. Eight agro-ecosystems available in the country are rainfed High Hill, rainfed Mid Hill, rainfed Tarai, irrigated High Hill, irrigated Mid Hill, irrigated Tarai, wetland agriculture and rangeland agriculture. Among 577 cultivated species; 484 species are indigenous and 93 are introduced species including forage species (**Figure** 5). About 224 wild species are closely related to crops (called crop wild relatives). Three broad groups of APGRs are agronomic crops, horticultural crops and forages and number of known species under these groups are 64, 145 and 275 respectively (**Figure** 6). The highest numbers of species are of tree forages followed by grass forages and spices. The numbers of species under different economic crop groups are given in **Figure** 6.

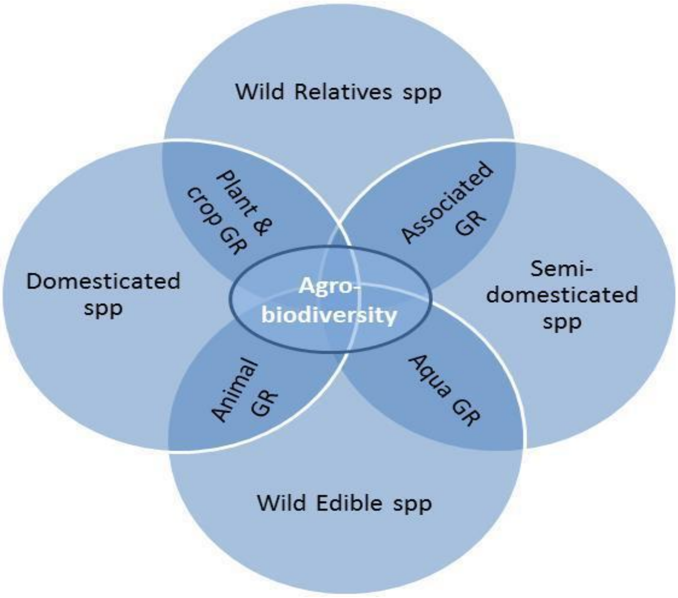

Figure 4. Components of agrobiodiversity in Nepal (GR, Genetic Resources).
Adopted from Joshi 2017.

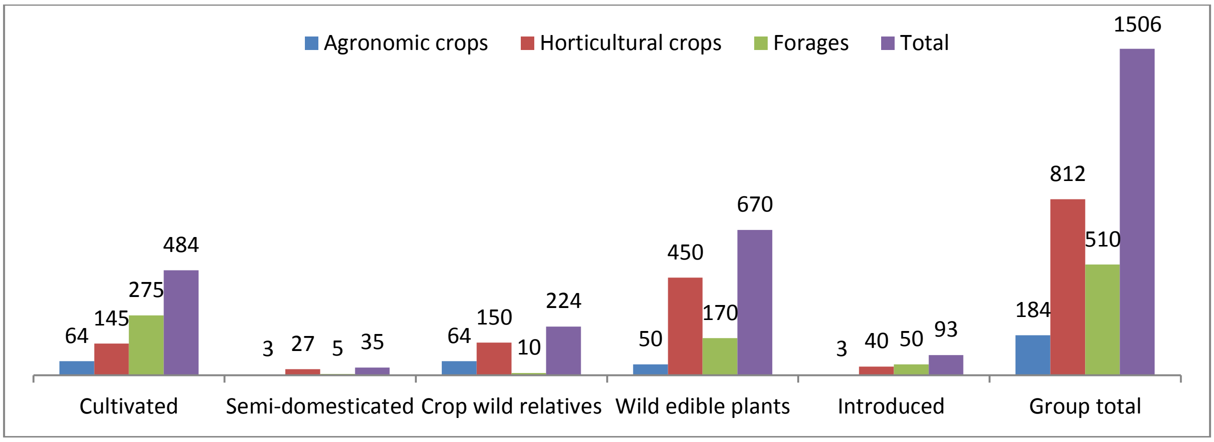

Figure 5. Number of crop species under different groups (wild edible plants also include 170 wild forage species and ornamental plants are not included).
Adopted from Joshi 2017.

CONSERVATION INITIATIVES

Collection of Nepalese specimens was begun in 1802 by Buchanan Hamilton and was continued by N. Wallich during 1820-21 (MoFSC 2002). Since then, many parts of Nepal have been well explored and different APGRs were collected and conserved in both national and international genebanks. There are more than 100 organizations working on APGRs in Nepal. Nepal Agricultural Research Council (NARC) is the main organization for conservation of APGRs and managing agrobiodiversity thorough commodity programs and National Agriculture Genetic Resources Center (NAGRC).

First collection and evaluation of indigenous plants materials by the then His Majesty's Government was started in 1940 in Nepal (Genebank 2014). Collections were more focused by establishing Vegetable Development Division in 1972 and Plant Genetic Resource Section in the Agriculture Botany Division of the NARC in 1984. Later NAGRC was established in 2010 for APGRs management. First community seed bank was established in Lalitpur in 1994. Agrobiodiversity conservation and utilization programs were planned in 10th Plan 2003 and many national documents have given priority to APGRs management (MoAD 2004, 2015a, 2015b, SQCC 2013, MoFSC 2014). Community Biodiversity Registration was piloted and community seed bank was established by MoAD and NAGRC and other many NGOs.

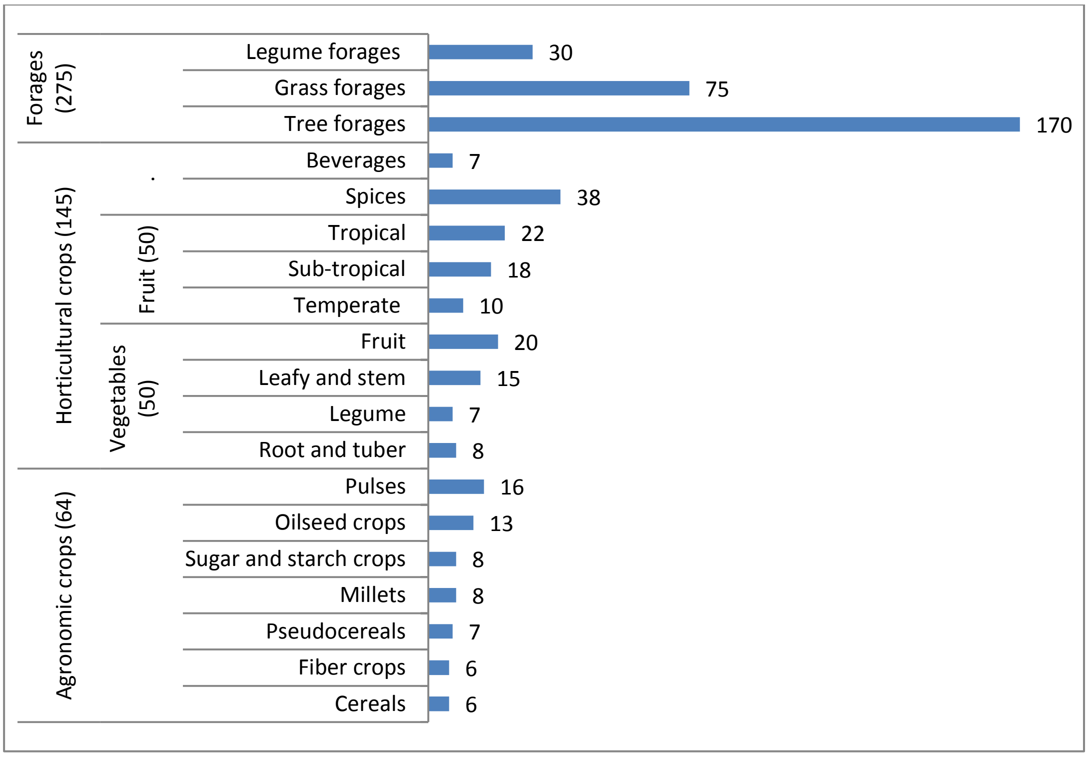

Figure 6. Number of available species under different economic groups of crops in Nepal (excluding ornamental plant species).
Adopted from Joshi 2017.

The history of conservation initiatives are tabulated in **Table** 1. The Government of Nepal has established the National Agriculture Genetic Resources Center (NAGRC, also called Genebank) under NARC in 2010 for conservation and utilization of agrobiodiversity. After the establishment of the National Genebank in 2010, APGRs are systematically managed, conserved and utilized in Nepal (Genebank 2014, Joshi et al 2013a). NAGRC has considered landraces, modern varieties, obsolete varieties, breeding lines, RILs (recombinant inbred lines), genetic stocks, NILs (near isogenic lines), differential lines, exotic genetic resources, crop wild relatives and wild edible plants for conservation. Biotechnology tools, Geographical Information System (GIS) and Climate Analogue Tool (CAT) have been applied by NAGRC for better management of APGRs (Joshi et al 2008). National Genebank is working at local, national and international levels and has established different methods and conserved Nepalese APGRs at different levels (**Figure** 7).

Table 1. Initiatives and milestones on conservation of agrobiodiversity in Nepal

SN	Initiative	Start date	Breeder/ organization	Crop	Remarks/ Reference
1.	Introduction	1850	Rana Dynasty	Fruits	Acharya and Atreya 2012
2.	Plant exploration	1937	Herrlich (Germany)	Wheat, barley	Upadhyay and Joshi 2003
3.	First collection and evaluation of indigenous plant materials	1940	By the then His Majesty's Government	Multi crops	Genebank 2016
4.	First breeder in Nepal	1951	Netra B. Basnyat	Rice	Primary introduction of rice from Japan; Mallick 1981
5.	Rice collection and evaluation	1951	Netra B. Basnyat	Rice	Mallick 1981
6.	First introduced recommended variety and crop	1958	Netra B. Basnyat	CH-45, rice	From India; Mallick 1981
7.	Variety recommendation	1959	Parwanipur Agriculture Station	Rice (CH-45)	NARC 1997, Mallick 1981
8.	First hybridization	1964	Gopal R. Rajbhandary	Potato	Kamlesh L. Rajbhandry (Pers. Comm.)
9.	Start of crop breeding	1966	Agriculture Botany Division	Rice	Basnyat 1999
10.	Establishment of Vegetable	1972	By the then His	Vegetable	Genebank 2016

SN	Initiative	Start date	Breeder/ organization	Crop	Remarks/ Reference
	Development Division		Majesty's Government	landraces	
11.	Establishment of Plant Genetic Resource Section in Agriculture Botany Division	1984	NARC	Orthodox crops	ABD 2003
12.	Genebank (medium term ex-situ conservation)	1986	Bharat R. Adhikary	Cereals	Madhusudhan P. Upadhyay (Pers. Comm.)
13.	Member of Convention on Biological Diversity	1993	MoFSC	Biodiversity	www.mfsc.gov.np
14.	Community seed bank	1994	Bal K. Joshi	Cereals and vegetables	Dalchowki, Lalitpur; Joshi 2013
15.	National workshop on PGR conservation	1994	Madhusudan P. Upadhyay	Plants	Upadhyay et al 1995
16.	Establishment of Community Seed Bank	2003	ABD, LIBIR, BI	Rice	Kchorwa, Bara; Joshi 2013
17.	Diversity kit	2003	Bhuwon Sthapit	Rice, sponge gourd	Bara, Kaski; Sthapit et al 2006
18.	Diversity block	2003	NARC, LIBIRD, BI	Rice, taro, finger millet	Kaski, Bara, Jumla; Tiwari et al 2006
19.	Isozyme fingerprint	2003	Bal K. Joshi	Rice	Joshi and Bimb 2004
20.	Diversity fair	2003	NARC, LIBIRD, BI	Multi crops	Kaski, Bara, Jumla; Adhikary et al 2006
21.	Red listing APGRs	2003	NARC, LIBIRD, BI	Rice	Joshi et al 2004
22.	DNA fingerprint	2004	Jwala Bajracharya	Rice	Bajracharya et al 2006
23.	Agrobiodiversity policy	2007	MoAD, NARC	Crops	MoAD 2016, www.moad.gov.np
24.	Member of ITPGRFA	2009	MoAD	Global annex-1 crops	http://www.fao.org/plant-treaty/en/
25.	National genebank	2010	Madhusudan P. Upadhyay	Cereals	Genebank 2014
26.	Protected variety and royalty system	2010	Horticulture Research Division	Tomato (parental lines of Srijana F_1 hybrid)	Dhruba Bhattarai (Pers. Comm.)
27.	Taro Park	2012	Bal K. Joshi and Ram B. KC	Taro	ARS Malepatan
28.	Use of GIS and CAT	2012	Bal K. Joshi	Rice	Chaudhary et al 2016, Joshi et al 2008
29.	Conservation Biotechnology	2012	Bal K. Joshi	Rice, chayote, finger millet, maize, wheat, potato, sugarcane	Joshi 2017, Genebank 2013
30.	Field genebank and community field genebank	2012	Bal K. Joshi	Taro, ginger, chayote, mango	Genebank 2014
31.	Unique landrace identification	2012	Bal K. Joshi	Chayote, rice, chili pepper, buckwheat	Joshi et al 2015a
32.	Pre-breeding	2012	Bal K. Joshi	Rice	Joshi et al 2013b
33.	Safety backup	2013	NAGRC	Maize, wheat, grass pea, lentil, barley, chickpea, finger millet, rice	CIMMYT, IRRI, ICARDA, ICRISAT; 1,796 accessions; Genebank 2014
34.	Accessioning System	2013	Bal K. Joshi	Multi crops	Different NARC research stations
35.	DNA Bank and Tissue Bank	2013	Bal K. Joshi	Potato, chayote, rice, wheat	Genebank 2014
36.	Base Collection Room	2014	Bal K. Joshi	Orthodox crops	Genebank 2015
37.	School Field Genebank and Village Level Field Genebank	2014	Bal K. Joshi, Dinesh Shrestha	Vegetatively propagated and recalcitrant crops	Lamjung, Hetauda and Kathmandu
38.	Safely duplication	2014	NAGRC	Barley	World Seed Vault, Korea; 69

SN	Initiative	Start date	Breeder/ organization	Crop	Remarks/ Reference
					accessions; Genebank 2015
39.	Seed Herbaria	2014	Bal K. Joshi	Rice, maize, wheat	For identification and selection in NAGRC
40.	Registration of local landrace	2014	Bal K. Joshi and Mohan B. Hamal	Broad leaf mustard	Gujmujje Rayo and Dunde Rayo from Dalchowki; Joshi et al 2017
41.	Germplasm rescue mission	2015	Bal K. Joshi	Rice tatary buckwheat	Dolpa; Joshi and Ghimire 2016
42.	Potato Park, Sugarcane Park, Ginger and Turmeric Park	2015	Bal K. Joshi	Potato, sugarcane, ginger and turmeric	Genebank 2016
43.	Rejuvenation of mango orchard	2016	Mohan B. Hamal and Bal K. Joshi	Mango	Lamjung; Joshi et al 2016b
44.	Short term storage	2016	Bal K. Joshi	Vegetatively propagated and recalcitrant crops	Genebnk 2016
45.	Aqua Pond Genebank and Livestock Farm Genebank	2016	Bal K. Joshi	Fish, cow and buffalo	Nepalgunj and Khumaltar
46.	Household Genebank (Household Seed Bank and Household Field Genebank)	2016	Bal K. Joshi	Multi crops	Joshi et al 2016b
47.	Conservation Ladder	2016	Bal K. Joshi	Multi crops	Joshi et al 2016b
48.	Genebank operational manual	2016	NAGRC	Multi crops	Joshi et al 2015b
49.	20 conservation action plans	2016	Bal K. Joshi	Multi crops	Joshi et al 2016b
50.	Diversity field school	2016	Bhuwon Sthapit	Multi crops	Dolakha, Lamjung, Humla, Jumla; Sthapit et al 2016
51.	Nepal Annex-1 Crops in MLS	2017	MoAD, NARC	13 food crops and 7 forage crops	Contribution of GRPI-2 team, http://www.fao.org/plant-treaty/en/

BI, Bioversity International; LIBIRD, Local Initiatives for Biodiversity, Research and Development; MoAD, Ministry of Agricultural Development; MoFSC, Ministry of Forest and Soil Conservation; NARC, Nepal Agricultural Research Council. Adopted from Joshi 2017.

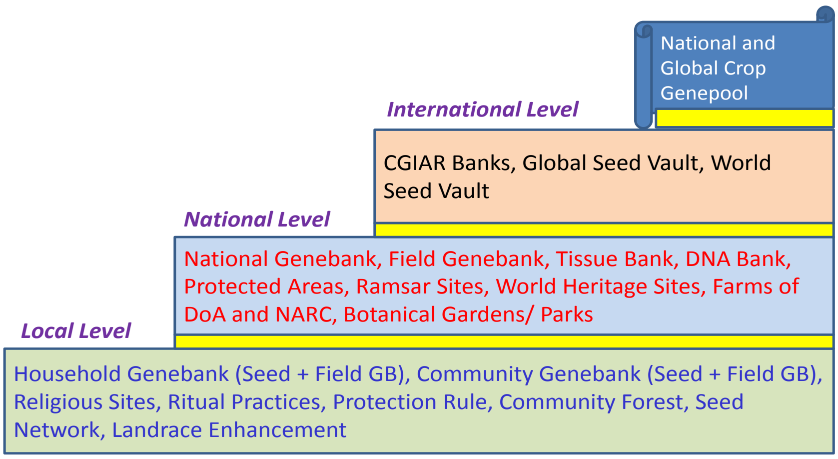

Figure 7. Conservation stair adopted by NAGRC for management of APGRs in Nepal.

National Genebank (NAGRC)

NAGRC has short term storage for seed materials harvested from field genebank, medium and long term storage for orthodox crop species. Each new collection should pass collection acceptance check. Seed quality, quantity and information are major features during check (**Figure** 8). NAGRC has five units and within unit they have specific regular activities (**Figure** 9). In addition to these regular activities, NAGRC organizes many activities in collaboration with other organizations. The stepwise activities and mechanism of seeds and information flows are depicted in **Figure** 9 and 10. Genebank standards are also reported in **Figure** 10.

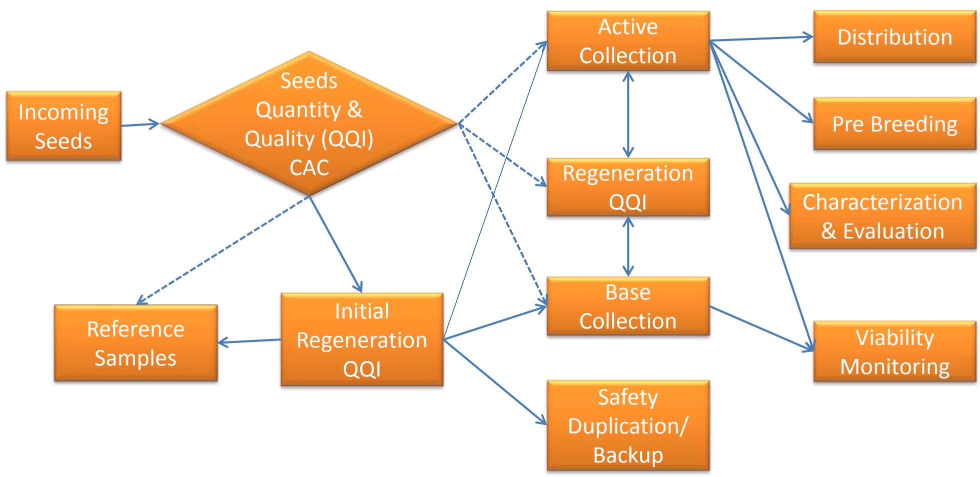

Figure 8. General system of seed flows in National Genebank.

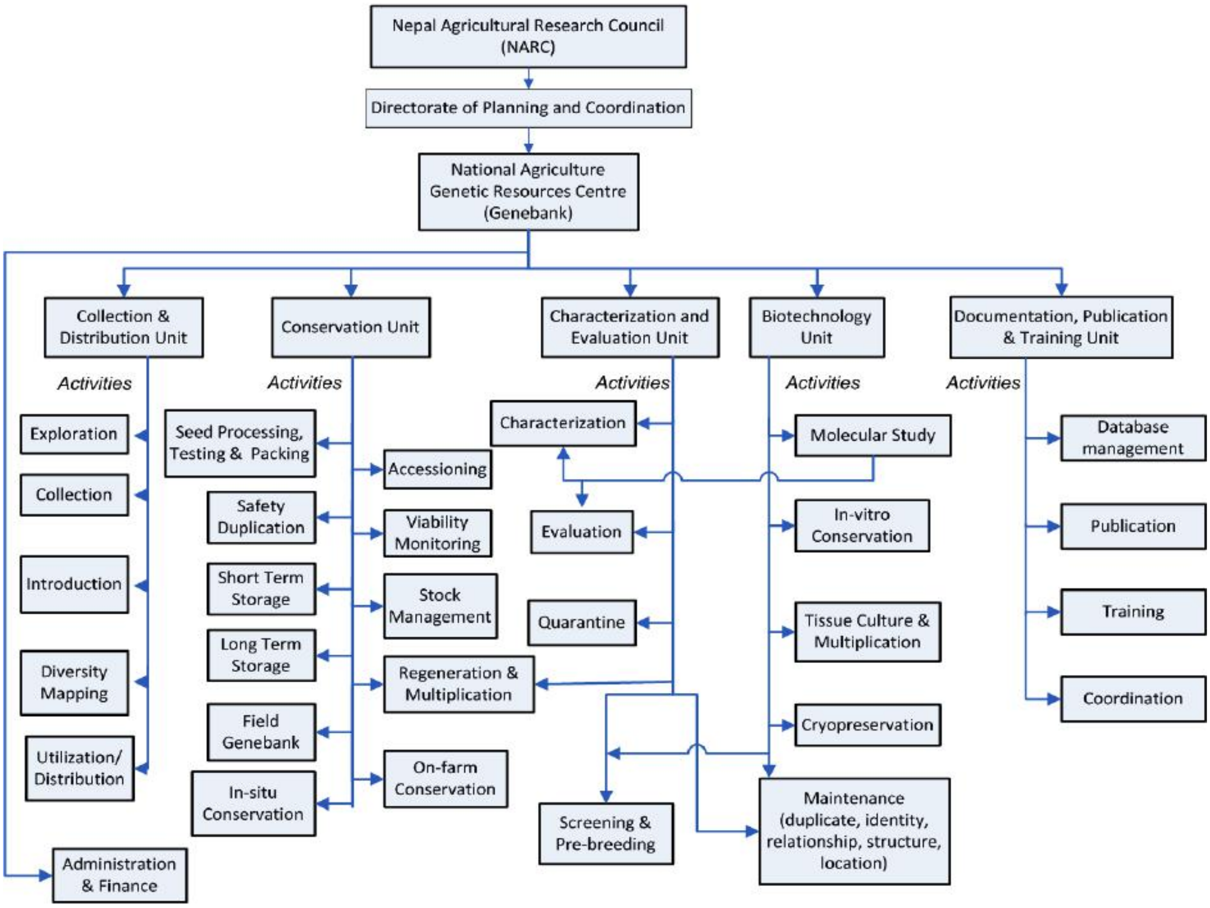

Figure 9. Organization structure and regular activities in NAGRC.

CONSERVATION STATUS

Within Country

More than 10,000 accessions of 60 orthodox crop species are conserved in National Genebank. About 200 accessions of non-orthodox crop species are maintained in different field genebanks.

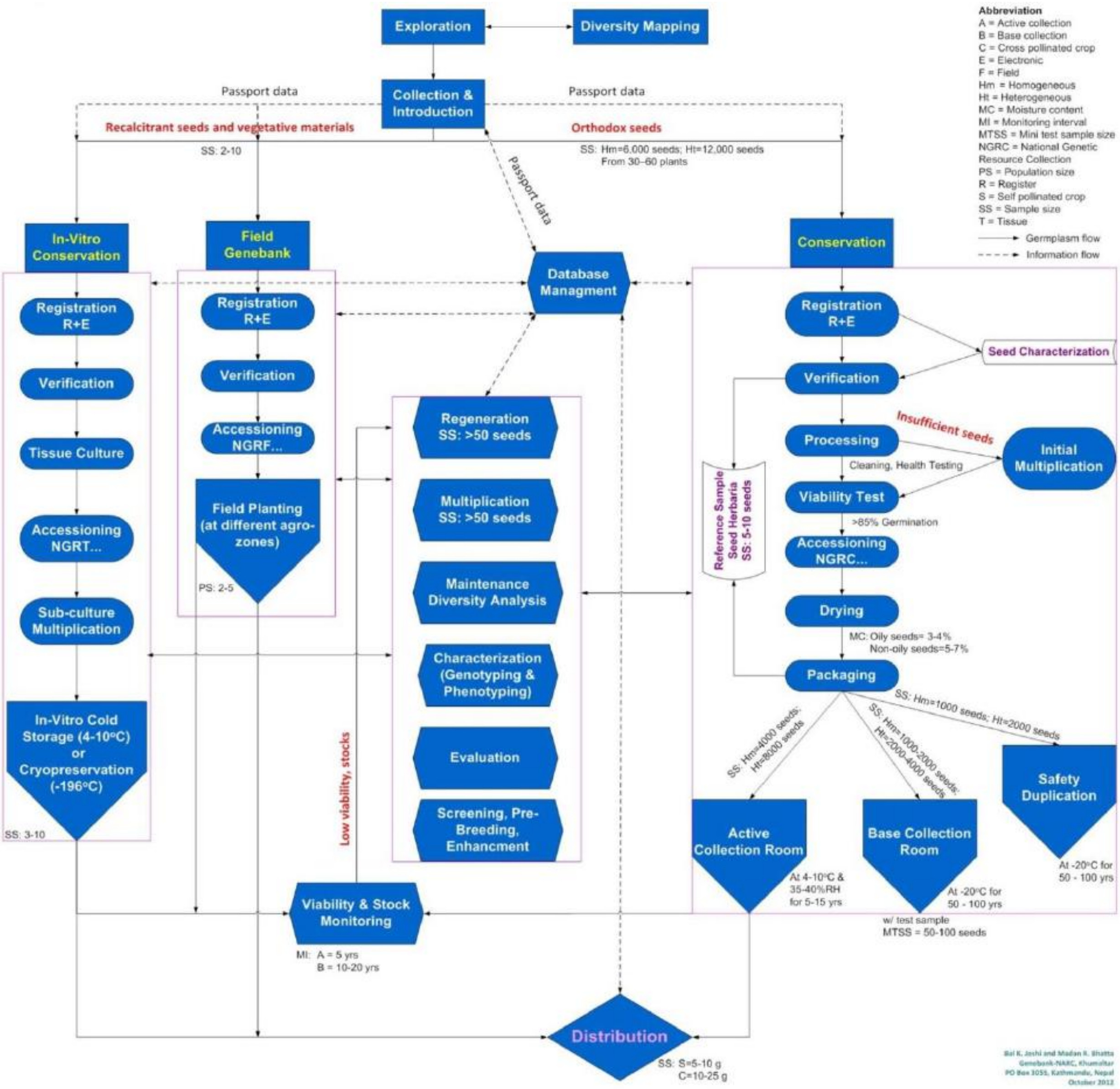

Figure 10. Stepwise activities for APGRs management (including germplasm and information flows system) in NAGRC.

Outside Country

More than 21 countries (USA, Japan, UK, Sweden, Germany, Italy, Syria, India, China, Philippines, Australia, Mexico, etc) have conserved seeds of Nepalese APGRs totaling about more than 23,600 accessions. Nepalese accessions under the Global Crop Gene Pool are 12489 in GeneSys, 11702 in CG Banks, 850 in AVRDC, 4136 in NIAS, 3510 in URISCO and some in GRIN-USDA (Figure 11). National Genebank has safety backed up 1987 accessions of maize, rice, wheat, chickpea, finger millet, barley, grass pea and lentil in different CG banks eg CIMMYT, IRRI, ICRISAT and ICARDA in 2013. Recently 69 accessions of barley are conserved in World Seed Vault, Korea in black box system. A total of 3980 accessions of rice from Nepal have been genebanked in national and foreign genebanks. Nepal genebank has 1141, IRRI genebank 2672, Vavilov Institute 49, USDA 121 and West African Rice 6 accessions of Nepalese rice. They have been collected from all over the cultivating areas of Nepal (Figure 12). Both cultivated and wild species are being conserved in these banks.

CONSERVATION STRATEGIES AND APGR

Different conservation strategies should be considered so that they complement each other and help to conserve maximum diversity as much as possible (FAO 2009, 2010, 2012). NAGRC has adopted four strategies, namely ex-situ, on-farm, in-situ conservation and plant breeding (Joshi et al 2016b). These strategies can be grouped into two strategies, as static and dynamic (Figure 13). The technical differences among these strategies are described by Joshi (2017).

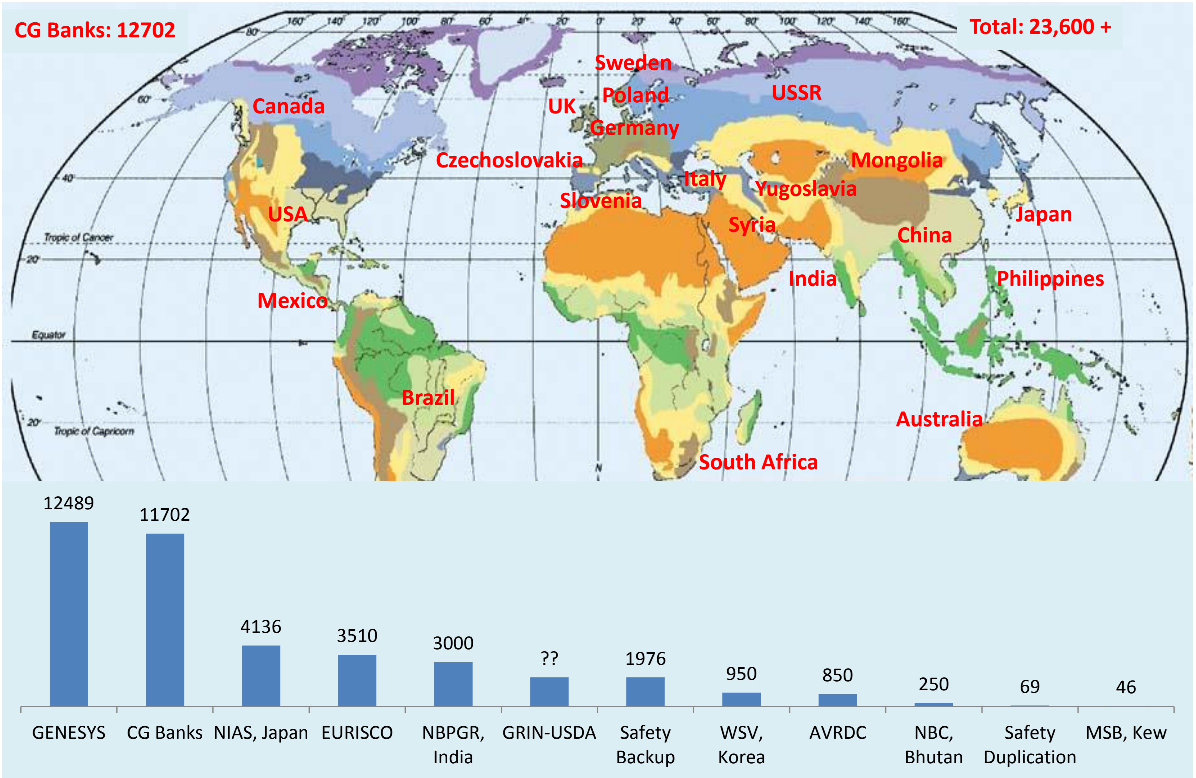

Figure 11. Nepalese crop accessions conserved in different foreign genebanks and countries.

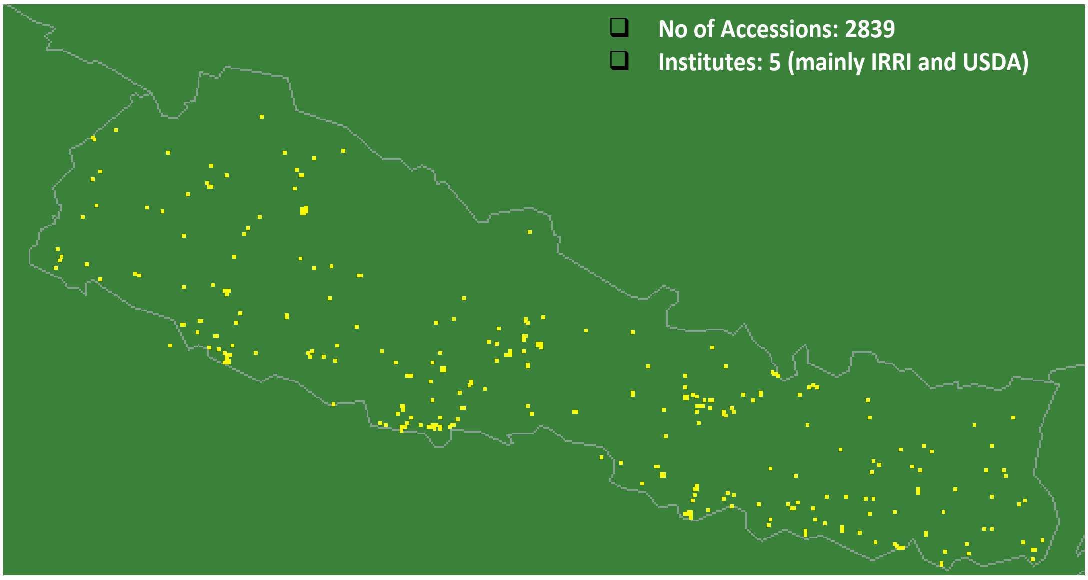

Figure 12. Collection map of Nepalese rice accessions maintained under GENESYS.

Ex-situ Conservation

It is the conservation of APGRs outside their natural habitats and farming areas (Plucknett et al 1987, FAO 2009). Ex-situ conservation is usually carried out in genebanks, field genebanks and botanical gardens. Different types of genebanks have been established for the storage of plant diversity, depending on the type of plant material conserved. Most common methods under ex-situ conservation are Seed Bank for orthodox seeds, Tissue Bank, Cryo Bank, DNA Bank and Field Genebank/ Botanical Gardens/ Farms/Parks for recalcitrant seeds and vegetatively propagated crops.

On-farm Conservation

It is a dynamic conservation of traditional and locally adopted varieties and landraces in farming community. The continuous cultivation and management of a diverse set of populations by farmers in the agro-ecosystems is the technique of on-farm conservation. In this type of conservation, APGRs grow in the farming land and seeds are stored in human made storage located nearby growing sites. Local landraces can be conserved by establishing community genebank (community seed bank and community field genebank), by strengthening household genebank (household seed bank and household field genebank), by enhancing landraces and by strengthening seed networks.

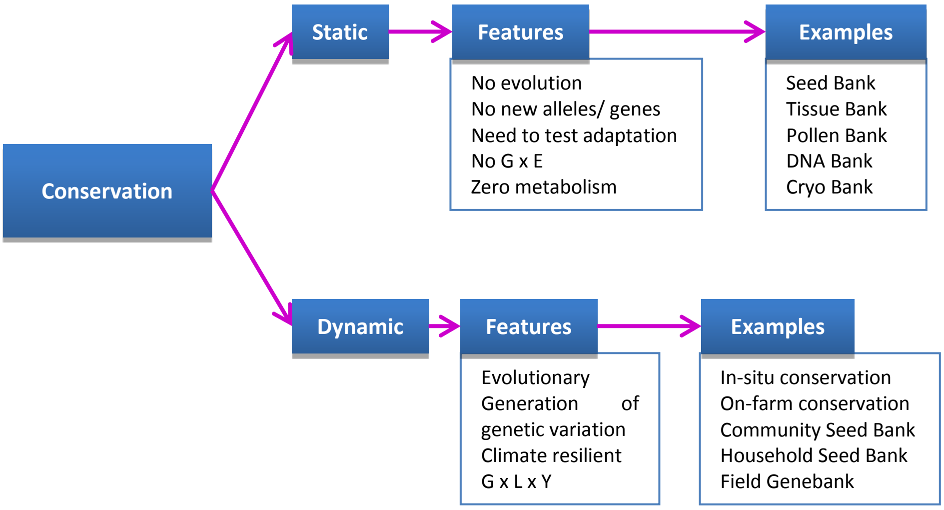

Figure 13. Conservation approaches and their features with examples.

In-situ Conservation

It is the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings (Collins and Hawtin 1999, FAO 2009) and in the case of domesticated or cultivated plant species, in the surroundings where they have developed their distinctive properties. Typical in-situ conservation is the method where active and dormant life (growing period and seed storage period) of APGRs remains on the same location.

Breeding Ctrategy

Conservation plant breeding helps to increase production maintaining diversity and creating diversity within plots. Some successful methods under this strategy are evolutionary plant breeding, participatory plant breeding, landrace enhancement, cultivar mixture etc.

Classification of APGRs

Conservation method is applied based on the types of APGR eg Field Genebank is for recalcitrant type of crop species. Based on the conservation strategy, all APGRs are grouped as a. Orthodox seeds (can dry up to 3-7% moisture depending upon crop species eg rice, maize, bean), b. Recalcitrant seeds (can't dry lower than 12-31% moisture eg mango, coffee) and c. Vegetatively propagated crops and apomictic plants eg banana, potato, citrus, etc. There are 60% orthodox crops in Nepal.

CONSERVATION OPTIONS AND METODS IN NEPAL

Seed Bank

Orthodox seeds are stored in controlled environment for medium and long terms, and such type of storage is called seed bank. Medium term storage is called active (core or working collections) and long term storage called base (original) collections. Active collections are the collections stored at 5 to 10^{o}C with a relative humidity 30 to 40% for 5 to 10 years. This is a medium term storage system with an accession size of about 1 to 5 kg seeds. Core collections are used to characterize, evaluate, multiply and distribute. Base collections are the collections stored at -18^{o}C for 50 to 100 years. Seed moisture is lowered to 3 to 7%. This is called long term storage system. Size of accession is about 2000 seeds for self-pollinated crops and 4000 seeds for cross pollinated crops. Frost free deep-freezers or temperature and RH adjustable room can be used with different types of seed containers. Under the ex-situ conservation of orthodox seeds, more than 9,000 accessions are conserved in seed bank along with their passport and characterization data in NAGRC. One of the seed rack is allocated for conserving breeders' materials in black box system. Breeder who has good materials and could not store for longer period themselves and could not regenerate annually can use this space.

Tissue Bank (In-vitro conservation)

In-vitro conservation is very effective for long term storage and economically applicable to those crop species, which either produce recalcitrant seeds or does not produce any seeds. Materials to be kept in conservation are small in size and conserved materials develop very slowly mainly due to nutrient depletion and low temperature. Such type of materials can be multiplied rapidly and can easily be kept free from viruses, insect parasites, fungi or bacteria. Cultures can be kept in test tubes on nutrient medium for indefinite periods of time by transferring at regular interval. Such type of conservation is called Tissue Bank which is medium term storage system. Cryo Bank is for long term storage for non-orthodox crop species. Many tissue culture lab in the country can initiate Tissue Bank. To conserve the recalcitrant types of crop species and vegetatively propagated crop species, Tissue Bank has been established in NAGRC. Currently 11 accessions of potato, cardamom, sugarcane both local and improved are being conserved as plantlets in tube using MS media.

DNA Bank

DNA Bank, as a part of the Genebank is a repository of DNA, usually for research. The DNA Bank is conserving the different kinds of DNA extracted from the genetic resources (rice, wheat, chayote, maize, buckwheat, etc) in tubes at -40°C. DNA conserved in DNA Bank is used for studies and research at molecular levels. DNA banking is the secure, long term storage of an individual's genetic material (de Vicente 2006).

Field Genebank

Field genebank is essential for those crop species having recalcitrant seeds for conservation, characterization, evaluation and utilization. In addition to such type of crop, vegetatively propagated and apomictic crop species are also conserved. Listing and prioritizing the crop species is the initial step for establishing the field genebank. Climatically suitable crop species should be identified for a particular site. Instead of allocating separate field, government's farm, around the road and office buildings, community farms, botanical garden, parks, culturally protected and heritage sites can be used. There are about 286 accessions of different crops in Khumal field genebank. NARC has started establishing sub field genebanks in its all research stations across the country (**Figure** 14). As a sub field genebank, there are 29 accessions of taro in Agricultural Research Station (ARS), Pokhara; 54 mango in RARS (Regional ARS), Tarahara and 61 ginger in ARS, Kapurkot. Technical support for establishing and managing field genebank has been provided to different organizations including some schools (school field genebank).

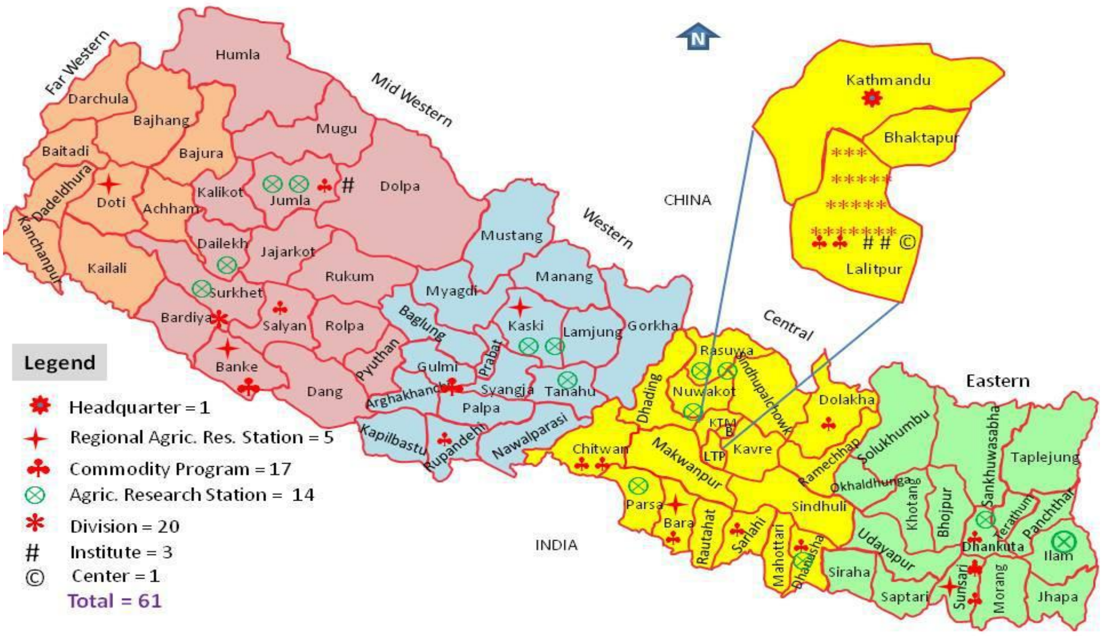

Figure 14. Country map showing NARC stations where Field Genebank is planned to establish.

Community Genebank

Agricultural biodiversity can't be conserved without supporting farming communities, and conversely, farming communities can't be saved without saving agricultural diversity. Farmers are the key players for sustaining diversity which can be effectively conserved through Community Genebank. Community Genebank is of two types, Community seed bank (CSB) and community field genebank (CFGB). As a part of conservation, NARC has been supporting on-farm conservation since 2001 by involving farmers and their genetic resources in research system. This resulted in the establishment of CSB in Kachorwa, Bara and Simariya, Sunsari. CSB is the system of conservation and utilization of local genetic resources, operated at local levels and run by the community (Joshi 2013). The purpose of CSB is to make available the seeds of all locally growing crop varieties to all farmers, which ultimately helps to conserve genetic resources in an evolutionary way along with associated traditional knowledge. The options of planting materials provided by CSB to the farmers are considered important to increase the total production at the household level. Diversity fairs, Community Biodiversity Register (CBR), and diversity blocks are the major activities to collect and maintain the varieties in CSBs. These are also the experimental units where, selection can be imposed to identify the better genotypes. CSB is considered an economical way of conserving genetic resources; therefore, this center is helping community genebanks (CGB) involved in conservation activities through training, material support, involving in different Genebank activities, etc. There are 120 community seed banks (**Figure** 15) in the country and Dalchowki CSB in Lalitpur is the first of its kind in Nepal established in 1994 (Joshi 2013).

On-farm conservation strategy has been discussed with Parivartan Nepal and their working group. Parivartan Nepal has also established CSB in Ranibas, Sindhuli; School Field GB in Phaparbari, Makawanpur and Pattharkot, Sarlahi; Field GB in Chattiwan, Makawanpur and Narayankhola Sarlahi. The community in Gadhariya, Kailali has established CFGB with 76 accessions of mango in 5.5 ha of land. Similar kind of work has also been started in Kachorwa and Dalchowki. Communities in Lamjung have initiated working on old mango orchard in the same way as community forest. They have rejuvenated some mango landraces and managed in the same field called community mango orchard (community field genebank).

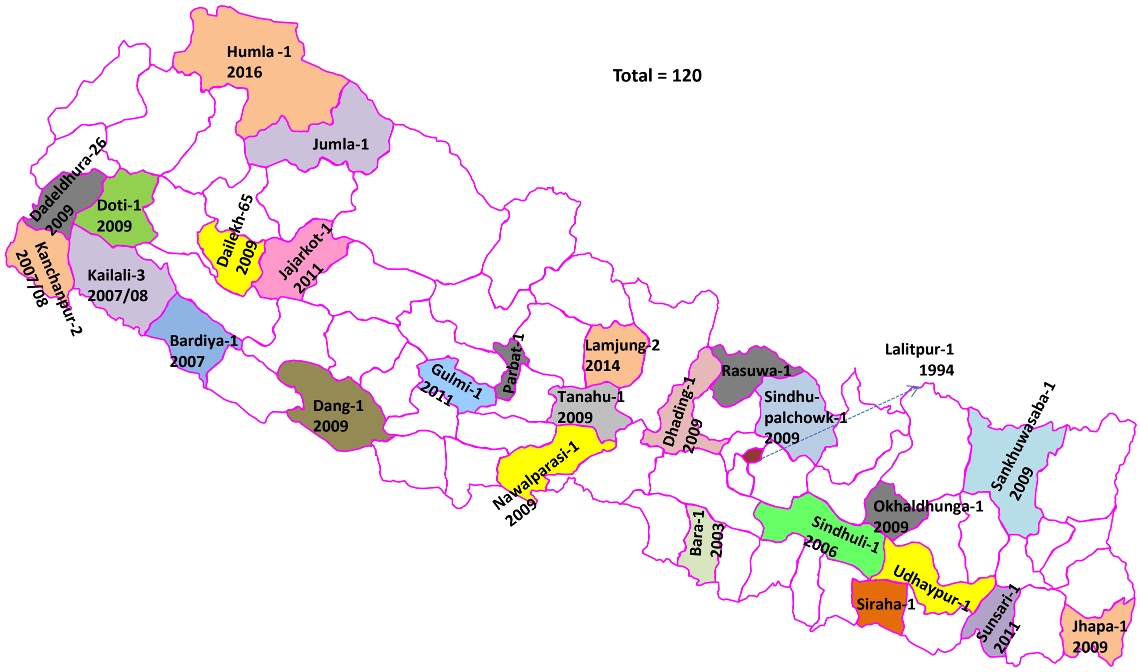

Figure 15. Location of community seed bank in Nepal.

Household Genebank

Identification of agrobiodiversity rich farmers (also called custodian farmer) is the initial step to strengthen the Household Genebank (HGB). Farmers with Genebank mind have been identified and such farmers are maintaining crop genetic resources as seed bank and field genebank, collectively called Household Genebank (Household seed bank + Household field genebank). All genetic resources, in this system are maintained in their private land and house. Such farmer should be identified at least one in each agro-eco-zone and supported technically and financially.

Himalayan Seed Bank

This is first seed bank of Himalayan plants established in 2011 in NAST to preserve alpine flora. Base collection of medicinal plants is maintained in deep fridge ie at -20°C in Khumaltar.

Protected Areas

There are 10 National Parks, 6 Conservation Areas, 3 Wildlife Reserves and a Hunting Reserve (**Figure** 16). These sites are, where, important CWR (crop wild relatives) and WEP (wild edible plants) exist, should be considered as in-situ conservation for these plant species. Some rare plant species can also be repatriated or relocated from other unsafe sites to these protected areas. There are many wild species and wild relatives of cultivated species distributed across the protected areas. These are the reservoir for different important genes and evolution continuously takes places interacting with nature. It is necessary to locate species that needs to be conserved on-site and develop strategies to protect their habitat collaborating with relevant stakeholders.

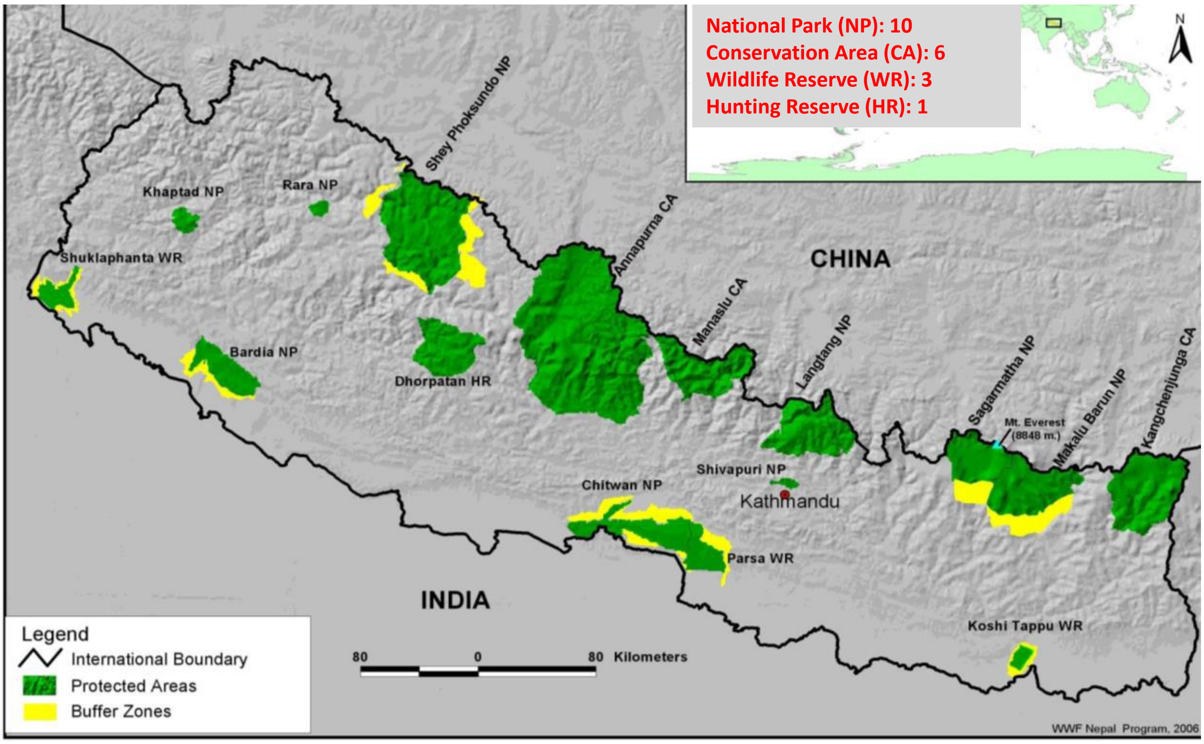

Figure 16. 20 protected areas including buffer zones in Nepal that support for in-situ conservation.

Ramsar Sites

There are nine Wetland Sites in Nepal located across the country (**Figure** 17), where agrobiodiversity can be efficiently conserved in-situ in the similar way as in protected areas.

World Heritage Sites

Natural World Heritage Sites are Everest National Park and Royal Chitwan National Park; Cultural World Heritage Sites are Kathmandu Valley (Swayambhu, Bouddha, Bhaktapur, Changunarayan, Pashupatinath, Kathmandu Durbar Square, Patan Durbar Square) and Lumbini. These sites are very useful to conserve CWR and WEP. Even cultivated rare crop species can be conserved in such areas.

Svalbard Global Seed Vault

It is opened in 2008 in permafrost zone (-17°C) of Norway. It is also called Arctic Seed Vault or Doomsday Vault. It has capacity of 1.5 million accessions with black box safety duplication system. Currently it has 7,50,000 accessions of 3286 species originated from 204 countries. Nepal should also use this facility for securing country agrobiodiversity.

World Seed Vault

National Agrobiodiversity Center in Korea is used as World Safety Duplication Center since 2008 and called World Seed Vault (WSV). Its holding capacity is 500,000 accessions for medium and long-term storage with facility for black box system of safety duplication. NAGRC has safety duplication of 69 accessions of barely in WSV.

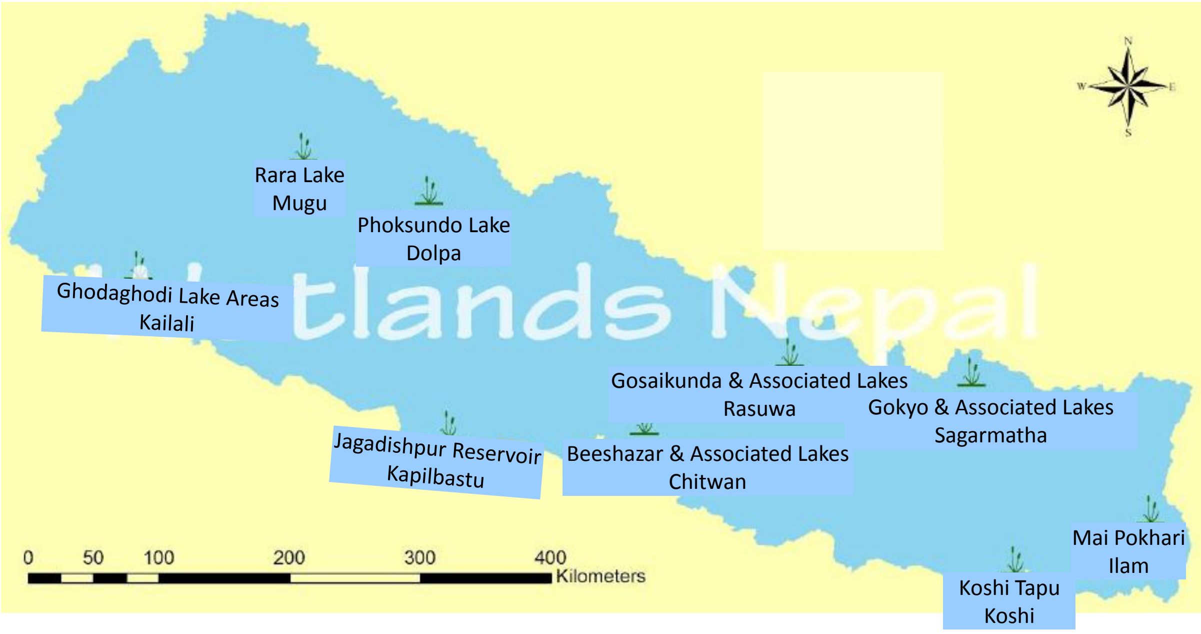

Figure 17. Nine Ramsar sites in Nepal that can be effective and low cost sites for in-situ conservation.

CG Banks

From the outset, CGIAR (consultative group on international agricultural research) institutes have been involved in studying and preserving the agrobiodiversity of their respective mandate crops. Some 710,000 accessions of cereals, legumes, roots and tubers, trees and other essential staple crops are stored in 11 genebanks of CGIAR (CG Banks, **Figure** 18). All accessions within these collections are international public goods, available under the terms and conditions negotiated by ITPGRFA. These Banks have collectively 11702 accessions of Nepalese crops.

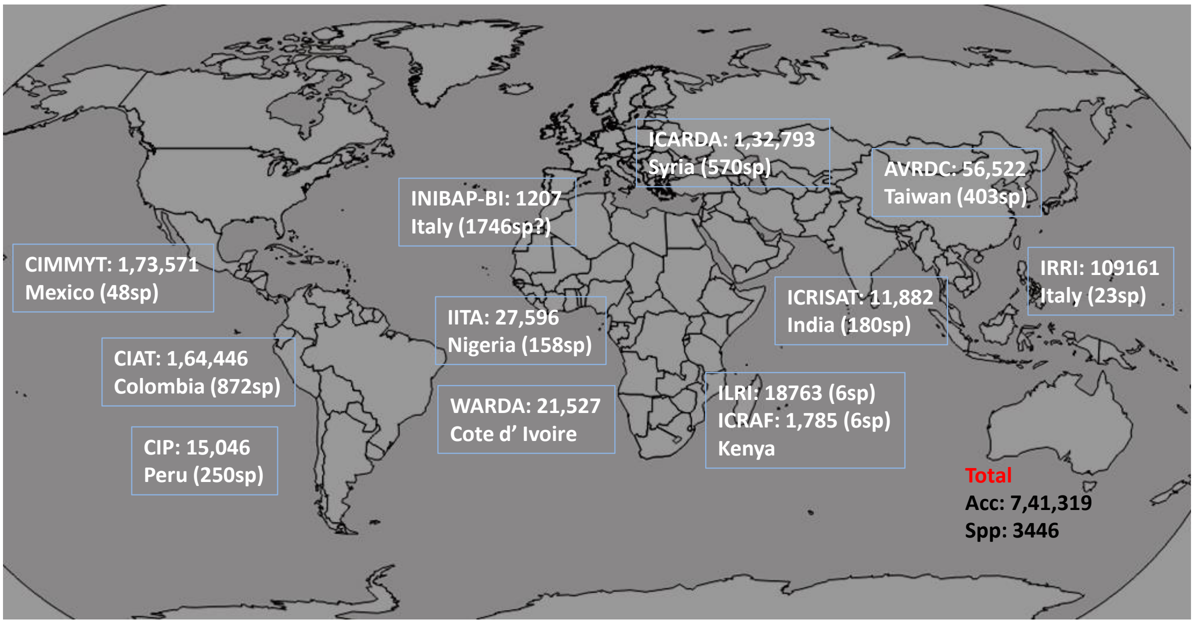

Figure 18. Eleven CGIAR Banks where Nepalese crops accessions are conserved as safety backup.

Ritual Practices of Hindu

Some species and landraces of certain crops are necessary in some religious purposes that help to protect by continuously growing eg sacred crop species such as barley, sesame, Rudrakshya, Tulsi, Jau, Kush, Bimiro etc.

Culturally Protected Areas

There are many Religious sites/ Sacred Groves (Temples and Monastery, Shrines, Monuments Stupa, etc) in Nepal. These sites are very useful to conserve CWRs and WEPs.

Leasehold, Community and Private Forests

Community forests are well protected areas where in-situ conservation strategy can be effectively applied. Many agricultural crop species can be effectively conserved and utilized in such forests.

Farmers Seed Network System

Exchange of seeds through farmers seed networks play key role for supplying the planting materials across the country. This system, therefore, need to strengthen and support for enhancing the conservation of landraces.

Protection of Some Plant Species

Government of Nepal has banned some agricultural tree species eg walnut, Khayer to cut and sale. However, this policy has not been effectively implemented in the field level. Effective implementation of this; and similar other policies should be imposed to some rare APGRs as well.

Botanical Gardens/ Parks

There are many gardens and parks in Nepal in public and private lands and they should consider AGPRs as one of the components.

Landrace Enhancement

Landrace should be made competitive which can be enhanced simply through selection in participatory way. This helps farmers to grow landrace continuously.

Listing, Registration and Release of landraces

Indigenous crop species and cultivars need to be listed, registered and released to promote their cultivation, conservation and use. For instance, until now, amaranth, foxtail millet, prosomillet are not yet in the national list. There is an urgent need to list them and register and release farmer preferred and adapted landraces and varieties to promote their conservation and use.

CONSERVATION AND UTILIZATION ACTION PLANS

Followings are the action plans (Joshi et al 2016b) that need to initiate at local, regional and national levels for conservation of APGRs by NARC, MoAD, DoA and NGOs.

1. Listing of local crops and cultivars and development of landraces catalogue
2. Identification of rare and unique landraces and potential landraces for large scale production (Joshi et al 2004)
3. Diversity mapping in terms of name given by farmers, intra and inter species of crops as well as diversity of functional traits of the given crops
4. Organization of diversity fairs of local crops
5. Establishment and maintenance of diversity blocks
6. Distribution of diversity kits of rare crops and landraces to farmers and local community
7. Establishment of on-farm conservation village
8. Organization of diversity field school for the management and promotion of diversity rich solutions
9. Organization of exploration and collection missions and conservation program
10. Organization of rescue mission for rare and endangered landraces during and after disasters
11. Establishment and maintenance of different types of field genebank (community field genebank, community mango orchard, school field genebank, DADO field genebank, village level field genebank)
12. Establishing crop specific parks of local crops and cultivars
13. Establishment and strengthening community seed banks and local seed networks
14. Establishing and strengthening household genebank (household seed bank and household field genebank)
15. Characterization and naming local landraces based on their specific traits and values
16. Initiation of landraces enhancement and conservation (LEC)
17. Collaboration with relevant stakeholders for crop wild relatives and wild edible plants conservation
18. Establishment of herbarium, museum and photo album

19. Study on landraces that have specific geographic origins and use values which can be geographical indicators
20. Development of ownership documents for important landraces

WAY FORWARD

Limited access to agricultural plant genetic resources leads food and nutrition insecurity. In the past, large number of APGRs have been lost from the fields and resulted in the establishment of Genebank. Conservation initiatives though started from 1984 in Nepal, functional Genebank, called National Agriculture Genetic Resources Center (NAGRC) with good storage and management facilities was established in 2010 in Khumaltar. Only NAGRC is not enough to conserve diverse agrobiodiversity. All relevant stakeholders should join and work together adopting four strategies ie ex-situ, in-situ, on-farm and conservation plant breeding (eg evolutionary plant breeding, landrace enhancement, cultivar mixture, site specific varietal development, etc). The strategy of using minimum inputs should be conservation so that conservation cost will be minimized and enabling environment will be created in such way that crop diversity can interact with biotic and abiotic stresses. Utilization of conserved APGRs are negligible, therefore need to speed up the use through establishing accessioning system, facilitating exchanges among stakeholders and pre-breeding. Important collections should have safety duplication and safety back up in different foreign genebanks. National Agricultural Biodiversity Strategy and Action Plan (NAB-SAP) and IMISAP (International treaty-multilateral system implementation strategy and action plan) should be developed with long term, medium term and short term action plans, objectives and strategies. District profile of APGRs should be developed for each district and mapping and monitoring APGRs should be initiated regularly. On-farm conservation of neglected and underutilized species of APGRs that are under threat should be initiated and strengthened. At least one year should be celebrated as the National Agrobiodiversity Year and one day each year should be celebrated as the National Agrobiodiversity day to promote conservation of APGRs in the country. The inauguration day of NAGRC can be considered as the national agrobiodiversity day.

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Utilization of Agricultural Plant Genetic Resources in Research, Breeding, Production, Nutrition and Distribution

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ABSTRACT
Agrobiodiversity is directly associated with food and nutrition security. Diverse needs of growers and consumers are being met through agrobiodiversity. Major uses of agricultural plant genetic resources (APGRs) are direct use for production, consumption as nutritious foods, breeding materials for the sustainable development, safe conservation for future use, conservation of diversity in ecosystems, scientific use for experimental materials and exchange and sale. The use of local landraces in research and breeding is very negligible. More than 5000 landraces have been characterized and evaluated. Many landraces were used to fulfill the academic requirements eg MSc and PhD degrees. Local landraces of 17 crops have been used to develop 39 released varieties of different crops in Nepal. 56% are dependent on agri-business for their livelihood. Cultivated land is 30,91,000 ha, where APGRs are directly used to grow. The availability of diverse genetic resources is a fundamental requirement for achieving food and nutrition security. Presently landraces of major food crops (rice, wheat, maize) provide limited food sources at the national level even though landraces of underutilized crops provide major sources of food and nutrition security particularly in marginal regions of hills and mountains. Some of nutritionally valued underutilized crops are millets, amaranths, asparagus, beans, buckwheat, soybean, sweet potato, taro, lemon, pumpkin etc. Use of diverse local germplasm are also used through own saving and local exchanges as gift and are major part in barter and informal seed system. Every farming household is like a shop and they sale agriculture produces either from their house or at local market, city market or hat bazar. Many Nepalese APGRs were used in research and production in foreign countries and Nepal introduces annually more than 2000 genotypes for research. Generally germplasm from the genebank are used for research and breeding, training and study, production and marketing but their use in Nepal is limited for hybridization and biotechnological research. Increase use of diverse genetic resources is suggested in national agricultural research system particularly in plant breeding, food production and consumption of nutritious foods including their facilitated exchange for promoting wider use and sharing for national and global food security. The role of crop diversity and plant breeding will become even more important in the near future to adapt to changing climate and market needs for achieving food and nutrition security in a sustainable way.

Keywords: Breeding, contribution, diversity, food and nutrition security, production

INTRODUCTION

Agriculture is the basis of life and agrobiodiversity is necessary for sustain production from different localities. 65% populations in Nepal are dependent on agriculture which contributes 31% GDP. Diversity is recognized in terms of agricultural plant genetic resources (APGRs), climate, land types, and farming communities. Eight agro-ecosystems available in the country are rainfed High Hill, rainfed Mid Hill, rainfed Tarai, irrigated High Hill, irrigated Mid Hill, irrigated Tarai, wetland agriculture and rangeland agriculture. Among 577 cultivated species; 484 species are indigenous and 93 are introduced species including forage species. About 224 wild species are closely related to crops (called crop wild relatives). Three broad groups of APGRs are agronomic crops, horticultural crops and forages and numbers of known species under these groups are 64, 145 and 275 respectively. The highest numbers of species are of tree forages followed by grass forages and spices.

Major three agro-ecozones are High Hill, Mid Hill and Tarai. Tarai (plain area) occupies 23% of total area (**Figure** 1) and main area for food production. Mid Hill and High Hill are terrain and sloppy. Cultivated agricultural land is 21% and cultivable but currently not in use is 7%. Due to the migration from village to city, about 10,30,000% of cultivated land remains fallow.

In these areas, site specific as well as household specific landraces are maintained by continue growing. There are many landraces that produce even in marginalized and harsh condition. Due to the availability of diverse APGRs, they have been using in diverse areas. Major uses of APGRs are in food production, marketing and to increase income; in consumption of diverse crop species and cultivars for ensuring household food and nutrition security; in crop improvement through conventional plant breeding and biotechnology, and in exchange and trade of valuable genetic resources. In addition to local crop landraces, there are many introduced crop species and varieties. We have here focused more on use of local crop landraces in different areas.

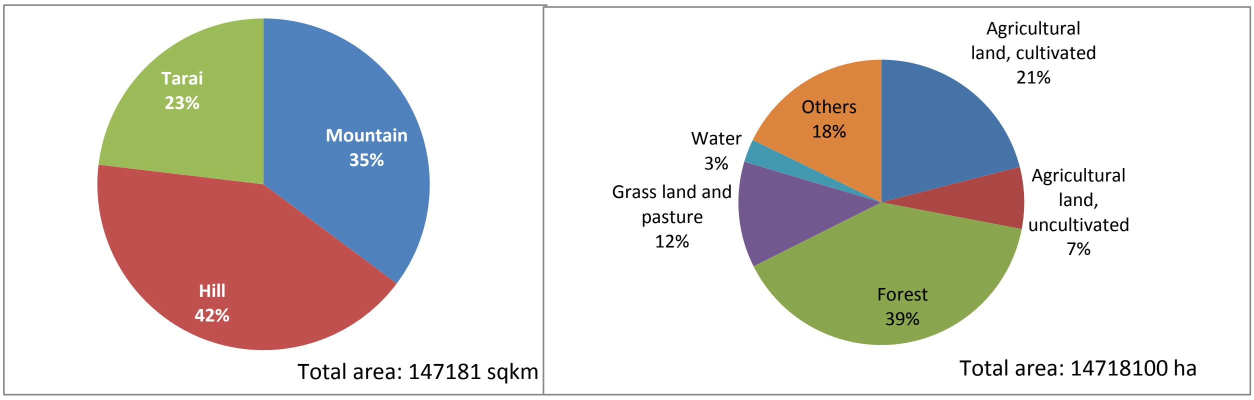

Figure 1. Total area distribution in Nepal (Left) and land use pattern (Right).
Source: MoAD 2015.

APGR FOR FOOD AND NUTRITION SECURITY

APGRs are mainly for food and nutrition security. About 71,387 ton of food in 2015 is deficit in Nepal and 35 districts are food deficit. The best strategy for increased food production is vertical expansion for which genetic enhancement is most (**Figure** 2). All methods (ie capacity enhancement, access and increased food production) should be considered for securing food in the country.

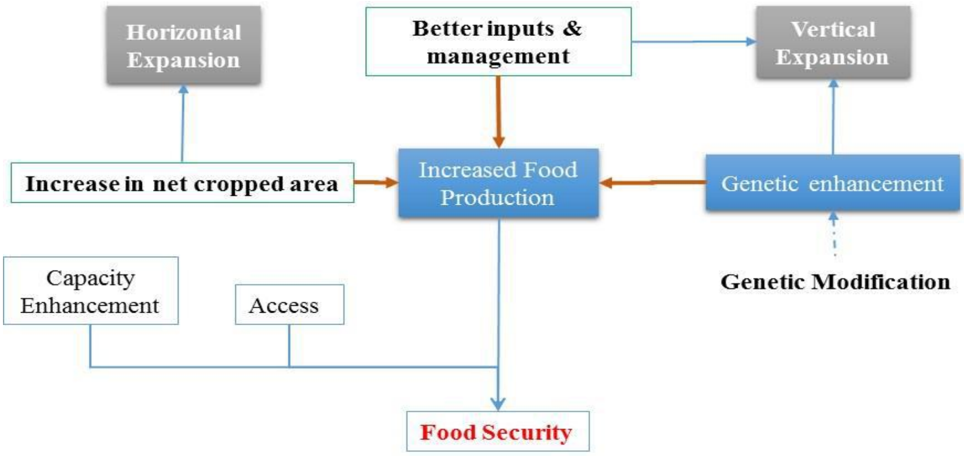

Figure 2. Approaches for food security in the country. Crop diversity is necessary for vertical expansion.
Adopted from Joshi 2017b.

UTILIZATION OF APGR

Human rely on APGRs for their survival. Main use of APGRs is for production, either for home consumption or for sale. More than 100 organizations are working on APGRs related activities in Nepal and their ultimate goal is to increase production in sustainable way. In addition to aesthetic value, APGRs are being used in research and breeding, production, business, education and training, as food and nutritional supplement, etc.

Research and Breeding

APGRs are the main component in agricultural research and breeding. Agricultural research was started from 1950, however, from the very beginning, foreign genetic resources have been considered in research and breeding, ignoring the local crop diversity. After the Convention on Biological Diversity, the local landraces have been increasingly used in research and breeding. There are many national and international projects related to local crop landraces.

Characterization and Evaluation

Characterization and evaluation of national and international germplasm have been done since 1950s in different crop species. Generally agromorphological traits based on IPGRI descriptors and traits selected by concern organizations are used to characterize and evaluate genetic resources (Genebank 2016). Characterization of germplasm is mainly concentrated on morphogenetic or agronomic characters, such as: plant height; yield components, growth duration and others. Based on these characters, many crops have been classified as early, medium, late maturing, tall, intermediate or short and so forth. Biochemical markers (isozyme) and molecular markers (RAPID, micro satellite) have also been applied. Tissue culture protocols for different crops have been refined. Trends of using novel approaches and local landraces in research, master and PhD thesis are increasing. Even through large number of germplasm have still been untouched, the trend of including national germplasm in research would check the genetic erosion. Earlier, introduction dominated in the crop improvement process resulted in the negligence in the study of local landraces.

More than 50,000 genotypes were characterized and evaluated so far in different research station of NARC (**Figure** 3). In current year, more than 1000 genotypes of different crops (agronomic crops, horticultural crops, and forages) are characterized and evaluated annually in research stations. Majority of these entries are foreign materials. NAGRC has facilitated and created enabling environment for use of local landraces in research.

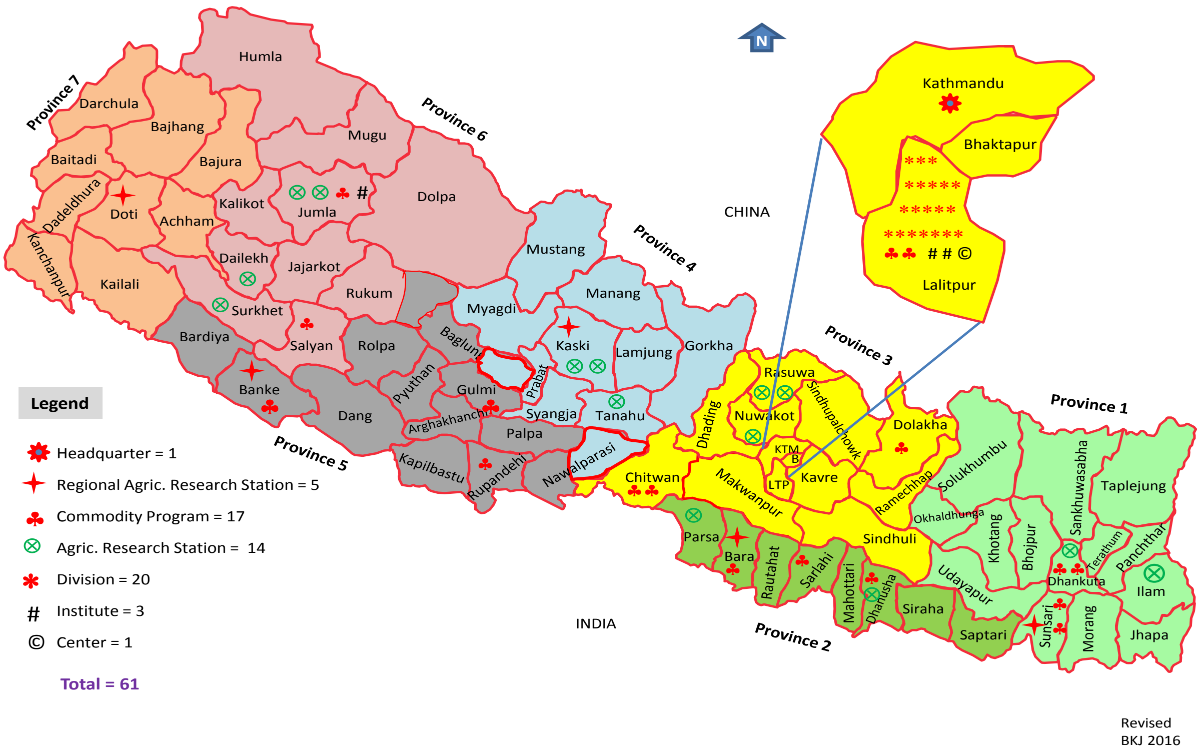

Figure 3. Research stations under Nepal Agricultural Research Council where APGRs are characterized and evaluated.

The possibility of starting a three lines heterosis breeding using local landraces was reported. Among the 14 rice genotypes tested for their ability to restore fertility and maintain sterility, two landraces (Kature and Ratodhan) are restorers and other two (Deharadune and Chiunde) are maintainers (Joshi 2000). A set of 183 landraces were characterized and evaluated over space and time (1998-2000) (Sharma et al 2001). There was wide variation in maturity. Landraces were comparable with the improved cultivars. There is a possibility of breeding for new levels of grain yield and other economical characters using these landraces. Blast resistance was widely available in these landraces RFLP, SSR and RGA were used to understand genetic variation in these landraces. The SSR markers produced 5 to 12 alleles reflecting the wide range of variability. These techniques indicate the two different gene pools. Laxmi well-adapted cultivar in Nepal is resistant to 25 single spore isolates of blast from different parts of Nepal. Blast resistance in Laxmi is linked to microsatellite markers RM25 and RM310 on chromosome of rice (Sharma et al 2001). Mansuli most widely grown cultivar in Nepal was improved for its blast resistance-using marker assisted backcrossing. RAPD markers were used to study variation in 11 populations of *Fagopyrum cymosum* (Trevir.) Meisn. and 8 population of tite buckwheat (Bimb et al 2001). Ohnishi (1985), Bajracharya et al (2001) and Bimb (2003 personal communication) surveyed different buckwheat landraces with isozymes. In-vitro response of buckwheat landraces was studied (Rajbhandari et al 1995, Joshi and Bimb 2002).

Crop Landraces in Modern Varieties

National Seed Board has released 241 varieties of 51 crops, registered 364 varieties of 37 crops and de-notified 35 varieties of 6 crops. Local landraces of 17 crops have been used to develop 39 varieties (**Table** 1). Among them 14 varieties were developed by crossing local landraces with exotic varieties. The highest number of varieties was released for Tarai region (**Figure** 4). A total of 92 varieties were released during 1990-1999, which was the highest in number comparing with other decades. Many local landraces were found superior than released and registered varieties for a number of crops.

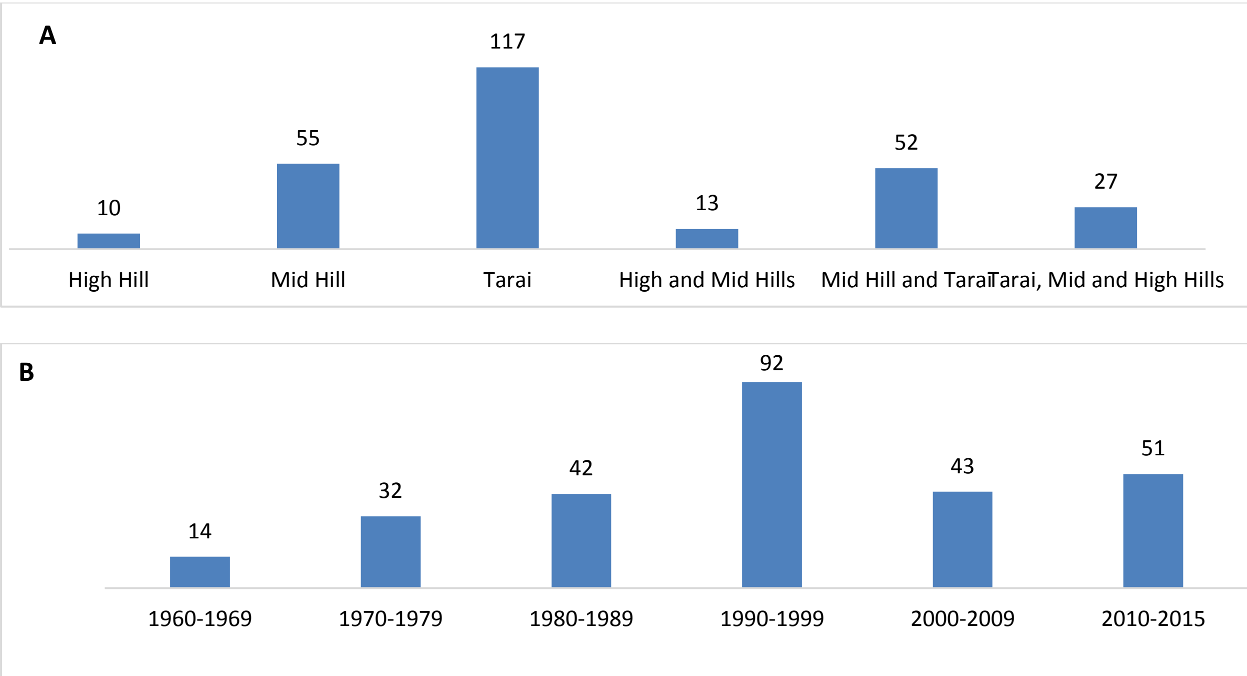

Figure 4. Total number of released varieties based on the recommended zones (A) and over the 10 years interval (B).
Source: Joshi 2017b, SQCC 2015, Joshi et al 2017b.

Table 1. Local landraces of crops used in released varieties

SN	Crop	Variety	Landrace used
1.	Asparagus Bean	KhumalTane	Local landrace
		SarlahiTane	Local landrace
2.	Barley	Solu Uwa	Landrace from Solukhumbu
3.	Broad Leaf Mustard	Khumal Broad Leaf	Local landrace
		Khumal Rato Pat	Local landrace
		Marpha Broad Leaf	Local landrace
4.	Cauliflower	Kathmandu Local	Local landrace
5.	Chickpea	Dhanush	Local landrace
		Trishul	Local landrace
6.	Cucumber	Kusle	Local landrace
7.	Egg Plant	Sarlahi Green	Local landrace
8.	Finger Millet	Okhale-1	Landrace from Okhaldhunga
		Kabre Kodo-1	Landrace from Surkhet
9.	Lentil	Sindur	Local landrace
10.	Maize	Ganesh-2	Local landrace
		Hetauda Composite	Local landrace
		Manakamna-1	Local landrace
		Manakamna-5	Local landrace
		Manakamna-6	Local landrace
		Rampur-2	Local landrace
		Resunga Composite	Local landrace

SN	Crop	Variety	Landrace used
11.	Niger	Nawalpure Jhuse Til-1	Local landrace
12.	Pigeon Pea	Bageswori	Local landrace
		Rampur Arahar-1	Local landrace
13.	Radish	Pyuthane Rato	Local landrace
14.	Rice	Khumal-2	Jarneli
		Khumal-4	PokhreliMasino
		Palung-2	PokhreliMasino
		Khumal –5	PokhreliMasino
		Chhomrong	Ghandruk local
		Machhapuchhre-3	Chhomrong
		Pokhreli Jetho budho	Jethodbudho landraces
		Khumal-8	JumliMarshi
		Lalka Basmati	Local Lalka Basmati
		Lekali Dhan-3	Chhomrong
		Lekali Dhan-1	Chhomrong
15.	Sesame	Nawalpure Khairo Til-1	Local landrace
16.	Soybean	Lumle Bhatmas-1	Local landrace
17.	Sponge Gourd	Kantipure	Local landrace

Source: Joshi 2017b, Upadhyay and Joshi 2003, Joshi et al 2017b, Joshi 2015.

APGR in Production

Production of landraces is generally low, however, their adaptation to local conditions is high. Using both national and international germplasm in research, productivity of many crops has been drastically increased (**Figure** 5). In last 25 years, percent increment in productivity of potato, wheat and rice were 319.4, 120.3 and 43.4 respectively. This increased productivity of many crop varieties has contributed for food and nutrition security in the country. Last year total productions of 118 commodities are given in **Table** 2. Among them rice, maize and wheat are the main crops in term to total production. These crops grow almost in all 75 districts (**Figure** 6). Different kinds of agricultural products are also exported to different countries (**Table** 3).

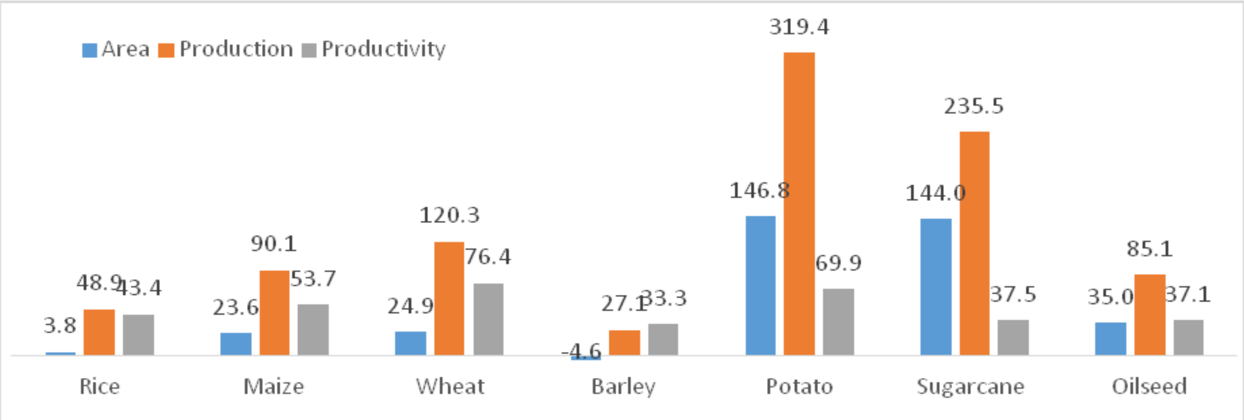

Figure 5. Percent increment in area, production and productivity of important crops over 25 years (1990-2014) in Nepal
Source: Joshi 2017b, MoAD 2015.

Table 2. Total production of agricultural crops in FY 2014/15

SN	Crop	Production, t	SN	Crop	Production, t
Cereals and pseudo-cereals			**Vegetables**		
1.	Paddy	4,788,612.00	59.	Cauliflower	494765
2.	Maize	2,145,291.00	60.	Cabbage	453600
3.	Wheat	1,975,625.00	61.	Broccoli	21323
4.	Millets	308,488.00	62.	Tomato	331736
5.	Buckwheat	10,870.00	63.	Radish	263215
6.	Barley	37,354.00	64.	BL Mustard	159205
	Total	**9,266,240.00**	65.	Carrot	31405
Grain Legumes			66.	Turnip	4796
7.	Lentil	227,492.00	67.	Capsicum	11516
8.	Chickpea	9,407.70	68.	Peas	63489

SN	Crop	Production, t	SN	Crop	Production, t
9.	Pigeon Pea	16,462.00	69.	French Beans	18688
10.	Black Gram	19,439.00	70.	French Beans-Pole types	55400
11.	Grass Pea	14,144.00	71.	French Beans-Bush types	18950
12.	Horse Gram	5,678.00	72.	French Beans-Sword types	9267
13.	Soybean	28,319.00	73.	Broad Beans	8274
14.	Others (Field Pea, Cow Pea, Broad Bean, Phaseolus, Masyang, Mungi, etc)	32,913.00	74.	Asparagus Beans	33026
	Total	**353,854.70**	75.	Cowpea	45287
15.	Potato	2586287	76.	Other (Legumes)	14776
Oil Seed			77.	Asparagus	1431
16.	Mustard	154105	78.	Tree Tomato	1019
17.	Sarsoon	11014	79.	Chili Akabare	30124
18.	Rayo	5598	80.	Chili	74902
19.	Sunflower	12924	81.	Okra	118585
20.	Groundnut	5260	82.	Brinjal	131405
21.	Sesame	3596	83.	Onion	248584
22.	Linseed	10402	84.	Cucumber	150051
23.	Niger	6714	85.	Pumpkin	106547
	Total	**209613**	86.	Squash	24016
Sugar, Beverages and Fibers			87.	Bitter Gourd	112309
24.	Sugarcane	3063000	88.	Pointed Gourd	24267
25.	Tobacco	2227	89.	Sponge Gourd	92815
26.	Jute	16530	90.	Ridge Gourd	11905
27.	Cotton	137	91.	Snake Gourd	11770
28.	Coffee	463.576	92.	Bottle Gourd	108208
29.	Tea	21394	93.	Ash Gourd	2362
Spices			94.	Balsam Gourd	2049
30.	Cardamom	5166	95.	Kakari	934
31.	Ginger	242547	96.	Kundruk	1045
32.	Garlic	44723	97.	Chayote	27815
33.	Turmeric	71812	98.	Watermelon	28513
34.	Chili	40172	99.	Other (Cucurbits)	11441
	Total	**404420**	100.	Drumsticks	2110
Tropical and subtropical fruits			101.	Lettuce	760
	Citrus	**222789**	102.	Fennel Leaf	427
35.	Mandarin		103.	Coriander Leaf	17114
36.	Sweet Orange		104.	Spinach	20977
37.	Lime		105.	Cress	14849
38.	Lemon		106.	Amaranths	12789
39.	Others		107.	Fenugreek Leaf	9080
	Tropical fruits	**641034**	108.	Swiss Chard	8169
40.	Mango		109.	Others (Leafy veg)	15874
41.	Banana		110.	Colocasia	40635
42.	Guava		111.	Yam	12565
43.	Papaya		112.	Elephant Food Yam	11690
44.	Jackfruit		113.	Other (Tubers)	5677
45.	Pineapple		114.	Other (Veg)	46554
46.	Litchi			**Total**	**3580085**
47.	Areca Nut				
48.	Coconut		**Forages**		**Area, ha**
	Winter (Temperate) fruits	**128155.3**	115.	Winter Grass (Jai, Berseem, Bhech)	5410
49.	Apple	43502.1	116.	Summer/Rainy Grass (Teosente, Bajra, Sudan)	3155
50.	Pear	34151.9	117.	Perennial Grass(Napier, Mulato, Paspalam, Setaria)	1740
51.	Walnut	7839.1	118.	Dale Grass (Ipillpil, Badahar, Raikhaniyo)	1110
52.	Peach	13318.6		**Total**	**11415**

SN	Crop	Production, t	SN	Crop	Production, t
53.	Plum	10508.3			
54.	Apricot	2735.1			
55.	Persimmon	2401.3			
56.	Pomegranate	2842.6			
57.	Hog Plum	10488.2			
58.	Kiwi Fruit	368.1			

Source: MoAD 2015, MoLD 2016.

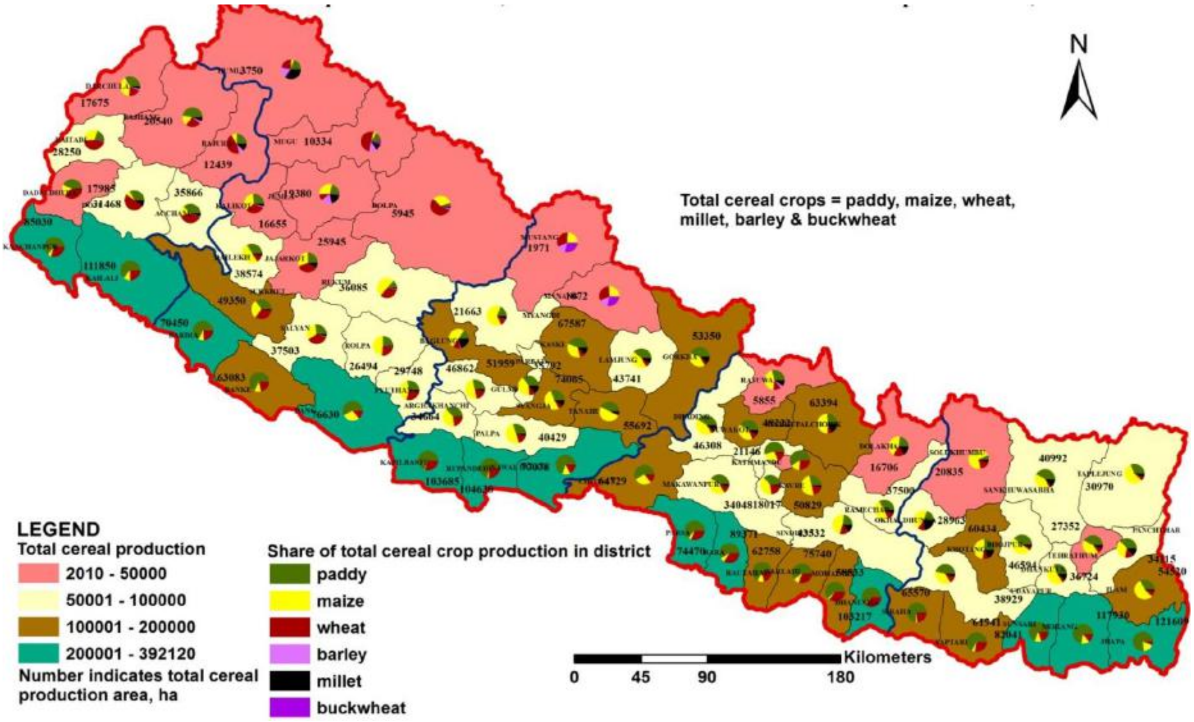

Figure 6. Distribution, production and share of total cereal crops production in 2011.
Adopted from MoAD 2011.

Table 3. Total export of major agricultural products from Nepal to different countries in FY 2014/15

SN	Agricultural commodities	Export		
		HS Code	Countries	Value NPRs'000
1.	Bulbs, tubers, tuberous roots, corms, crowns and rhizomes	6011000	Germany, United States	1721
2.	Seed potatoes fresh or chilled Total	7011000	India	152
3.	other potatoes, fresh or chilled Total	7019000	India	37839
4.	Tomatoes fresh or chilled	7020000	India	17090
5.	Garlic, fresh or chilled Total	7032000	India, Hong Kong	20155
6.	Cauliflowers and headed broccoli, fresh or chilled	7041000	India	31768
7.	Brussels sprouts, fresh or chilled	7042000	India	13844
8.	White & red cabbages, kohlrabi, kalee et, fresh or chilled	7049000	India	30740
9.	Cabbage lettuce, fresh or chilled Total	7051100	India, Australia, Singapore	37773
10.	Carrots and turnips, fresh or chilled	7061000	India	21
11.	Peas, fresh or chilled	7081000	India	469
12.	Beans, fresh or chilled	7082000	India	996
13.	Leguminous vegetable, fresh or chilled Total	7089000	India, China	8070
14.	Fruits of genus capiscum or pimenta, fresh or chilled	7096000	India	3
15.	Pumpkins, squash and gourds (Cucurbitaspp)	7099300	India	10
16.	other fresh or chilled vegetables Total	7099900	India, China	25729

SN	Agricultural commodities	Export		
		HS Code	Countries	Value NPRs'000
17.	Potatoes, frozen	7101000	India	263
18.	Dried onions	7122000	India	16762
19.	Dried Lentils,Whole	7134000	Bangladesh	1053656
20.	Dried Lentils,Whole	7134000	India	127007
21.	Dried Lentils,Whole	7134000	Singapore	73863
22.	Dried Lentils,Whole	7134000	UAE	3390
23.	Dried Lentils,Split	7134000	Hong Kong	663
24.	Buckwheat Total	10081000	India, Japan, UK, US	13275
25.	Millet seed Total	10082100	Belgium, Hong Kong, UK, US	2063
26.	Wheat or meslin flour except maida Total	11010000	China, Germany, UK	45019
27.	Groundnut Seed	12023000	India	7680
28.	Linseed	12040000	India	47251
29.	Shop nut Total	14049017	Canada, China, Czech R., France, Hungary, India, Japan, Netherland, New Zealand, Norway, Poland, Romania, Sweden, UK, US	39291
30.	Broom grass (Amriso)	14049018	India	122914

Source: MoF 2016.

Nutritional Value

Many landraces possess high nutritional value, however, nutritional study is necessary in detail for many landraces. Experience farmers know landraces that possess nutritional value. Some of landraces with high nutritional value are Jumli and Mustang beans, Akabare Khursani, Kalo Bhatmas, Black lentil, Tite buckwheat, Taro, Amala, Yellow tomato, Colored rice, local sweet potato, etc. City dwellers now look for local landraces that have special medicinal and nutritional value. Farmers grow continuously such landraces for their nutritional requirements.

APGR in Education and Training

Few crop landraces have been used in education specially for degree requirements (Bachelor, Master and PhD). Modern varieties are included in education and training materials. Generally, text book and training materials do not include crop landraces. Many PhD and Master students have considered rice, maize, wheat, barley, millets, bean, broad leaf mustard, etc to fulfill the degree requirements. Academic study on landraces is very limited. Most of the publications are of modern varieties and there are very few publications that deal local landraces.

Distribution: Germplasm Flow

Germplasm flow is basically for research, production and training. Genebanks both national and international distributes germplasm freely to researchers and producers worldwide. Many private companies export and import germplasm to sale growers for production. More than 2500 genotypes are introduced annually by Nepal Agricultural Research Council mainly from CGIAR centers for research and breeding (**Figure** 7). Through bilateral agreement, some collections of different crop species including crop wild relatives are exported to Japan, IRRI, CIMMYT, and UK. Within Nepal, NAGRC distributes about 500 accessions annually.

IMPORTANT AND UNIQUE CROP LANDRACES

Very special landraces exist in Nepal for a number of crops. Some of them are listed in **Table** 4. Bhate Phaper also called rice tartary buckwheat is very unique landrace (Joshi 2008) that has loose husk. Grains of this landrace is very easy to dehusk and available only in Dolpa. Rutin is major medicinal property of buckwheat and it is reported that Nepalese landraces have the highest rutin content. Jumli Marshi is cold tolerant rice landrace and widely used worldwide in breeding programs (Joshi et al 2017). Jumli Marshi has been used as a parent in many crosses in Nepal (Joshi 2015). Because of its very good taste and well adopted to cool environment, farmers prefer to grow in high altitude. Other rice landraces that have unique traits are Pokhareli Masino, Lalka Basmati, Anadi, Bhati, Ghamadi Dhan, Amagauj, etc. Pokhareli Masino is aromatic and good taste, and straw is also very good for livestock. It is one the parent of Khumal-4. Similarly Lalka Basmati is fine aromatic rice and many farmers in Tarai prefer to grow, consume and sale.

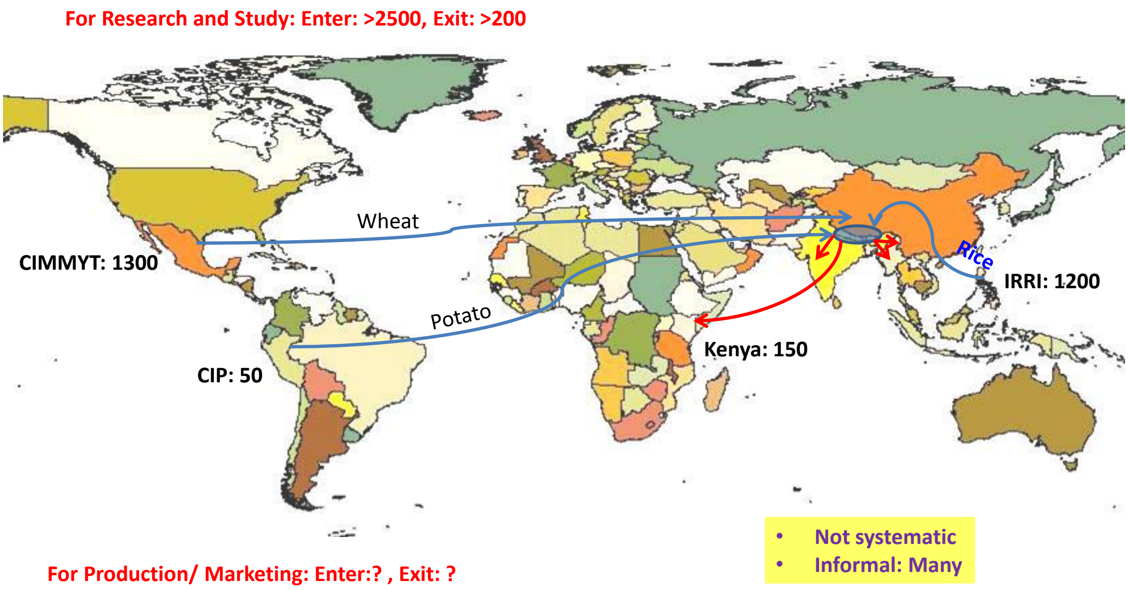

Figure 7. Recent germplasm flow of rice, wheat and potato for research.
Adopted from Joshi et al 2016.

Table 4. Some of the important and unique crop landraces in Nepal

Crop	Genotype	Uniqueness
Buckwheat	Bhate Phaper	Loose husk
	Kagpani Phaper	Highest rutin content
Cauliflower	Garve Cauli	Very large head, perenniality gene, vegetatively propagated
Chilly	Akbare Khursani	Medicinal value, very hot and does not have burning sensation on stomach
	Jire Khursani	All year round fruiting
Finger millet	Dailekh Local	High yielder and adapted to low fertility land
Maize	Pani Makkia	Tolerant to water logged condition
Rice	Amaghauj	Multiple spikelets per node
	Bhati	Deep water rice
	Gamadi Dhan	Matured panicle remained within flag leaf
	Jumli Marshi	Cold tolerance rice
	Mansara	Adopted to very marginalized land
	Samundaphinj	Swampy land rice
Sarson	Gorlikhorka	Highest oil content
Wheat	Dabde Local	For low fertility and moisture deficient land
	Mudule Gahun	Very sweet taste, awnless
	Pauder Local	Cold induced sterility tolerance

Source: Joshi 2017b, Upadhyay and Joshi 2003, Joshi 2015, Joshi 2008.

APGR WITH CULTURAL AND RELIGIOUS VALUE

There are many religions and caste in the country. Their most of the cultural values and religious functions are associated with APGRs. Sathiya rice landrace in Tarai is culturally used in Chhath festival (Joshi et al 2013). Traditional barley grains are necessary in various religious functions of both Hindu and Budhisteg barley, til (jautil) and oat for worship. Rice is the most important culturally and religiously. There is common practice of hanging chili pepper, lemon and garlic in front of the door for keeping house safe.

HOUSEHOLD AS A SHOP

If we compare the shop with farmer's household, the number of fresh items is higher in farmer's household and farmer produce everything themselves. But business person feel very happy and proud and get more profit from day to day sales. Farmers generally share many agricultural products with others as barter system, gift, or offer foods and other farm products to the visitors. They never think to sale products as did by business person. Each household therefore needs to consider as shop and farmers should consider their house as business hub.

AGRI-BUSINESS

Agri-business is everywhere in the country and involve all people from children to old people. There are very small to large scale business of agriculture. About 80% of APGRs are directly marketed whereas, 20% are processed and come under industrial products. Market has been established from household to local to regional to national to international levels. However, agri-business is not as profitable, respectful and smart as compared to other business.

Commercialized Varieties at National Level

Agricultural plant genetic resources are major source of Agri-business in Nepal generating a large value of income to producers, entrepreneurs and to the national economy. Some of the APGRs products that have significance value in the national market are tomato, radish, rayo, beans from the mountain region, mango from the Tarai, citrus from the Mid Hill, etc. Khumal-4 rice developed from one of the local landrace parent (Pokhareli Masino) has very high demand and sale in urban areas in Nepal (as Jeeramasino /local masuli) (Gauchan et al 2016). Lalka basmati, Pokhareli Jetho budho and other local aromatic rices from local landraces in different parts of Nepal are popular in the market. Seed market of local vegetables is very high specially seeds of Rayo (Marpha broad Leaf, Khumal broad Leaf), cucumber (Bhaktapur local), cauliflower (Kathmandu local), etc.

Commercialized Crops at International Level

About 50 agricultural products are commercially marketed in 25 foreign countries (**Table** 3). The important commercialized Nepalese crops that are exported to foreign countries and generate good revenue includes cardamom, lentil, tea, turmeric powder and ginger (http://www.customs.gov.np/en/statisticsmonthly.html).

GAPS AND ISSUES IN USE OF LOCAL APGRS

Large number of crop landraces have created and maintained over the decades by farmers and farming communities in Nepal. However, there are very limited use of local landraces in crop improvement, education, production and training. The potentialities of these landraces have not been explored. Poor investment and interest on R&D of landraces lead them to remain underutilized and non-commercialized. There are almost no incentives and support for local APGRs in crop breeding, production and marketing. Only focusing modern varieties helped to replace very valuable and important landraces. There are many cases of lost landraces eg Madhukari, Madhusar, Koili, Parewapankhe rice landraces. Policy even favors only released and registered varieties, ignoring the age old varieties grown by the farmers.

WAY FORWARD

Potentialities of local landraces should be explored and exploited at large scale. There are numbers of crop landraces that can get international market. Some landraces should be identified for commercialization focusing to international market. Collection, characterization and evaluation works should be systematized following accessioning system. Each district should develop district profile of APGRs. Registration system needs to establish at national as well as local level. Genetics as well other areas of these landraces should be studied and incorporated in education and training materials. Horizon of diverse local agricultural plant genetic resources in meeting household food and nutrition needs should be increased through value addition, marketing, genetic enhancement, demonstration, nutrition analysis, etc. Geographically linked value of any landraces must be protected and commercialized for the benefit of poor and local community. Agriculture business should be made respectful and the habit of easting rice two times in a day should be changed, ie one meal in a day from other food items (millets, wheat, maize, etc). Policy needs to modify for considering all existing local landraces as legal materials.

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Geographical Indication: A Tool for Supporting On-farm Conservation of Crop Landraces and for Rural Development

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ABSTRACT

Micro climatic variations within Nepal enable to produce diverse agricultural products. Agricultural products are generally associated with their place of production and are influenced by specific local, geographical factors such as climate and soil. Such features are treated as geographical indication (GI) and considered intellectual property that need to protect and ultimately help to promote conservation of agrobiodiversity on-farm and boost economy of local community. GI is any indication (name or sign) that identifies a product as originating from a particular place, where a given quality, reputation or other characteristics of the product are essentially attributable to its geographical origin. GI gives exclusive right to a region (eg village, town, region or country) to use a name for a product with certain characteristics that corresponds to their specific location. This paper has reviewed and identified potential GI products of Nepal in agricultural plant genetic resources (APGRs) linked to specific geographical locations to promote them for conservation and improve local economy. It also outlines geo-linked popular crop landraces and their traits for their potential trade promotion and value addition. The well-known examples of GIs in South Asia include Darjeeling tea, Basmati rice, Himalayan waters, Alphonso and Sindhri mangoes, Bhutanese red rice, Pakistani shu (wind proof woolen fabric) and ajrak (designs from Sindh), jasmine (Hom Mali) rice. More than hundred popular agricultural products which have already established their reputation representing their GI are identified in Nepal. Some of them are cultivated, and some are collected from wild source and marketed as such and some are processed for use or sold in the local markets or exported abroad. Most of the products possess greater cultural and age-old traditional values. Even though Nepal became member of World Intellectual Property Organization (WIPO) in 1997, Paris Convention for the Protection of Industrial Property 1983 in 2001 and World Trade Organization (WTO) in 2004, the country has yet to formulate legislation on GI protection, Just recently in 2017, the country has approved National Intellectual Property Policy in which GI is included. As a member of WTO, the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement of the WTO obligates Nepal to improve and manage IPR through formulating policy, law, regulation, etc. We suggest that important indigenous crop landraces products identified here are to be protected with GI by developing suitable legislation for their market promotion, on-farm conservation and livelihood enhancement of local communities. They can be potentially protected through *sui generis* systems (ie special regimes of protection) or using collective or certification in Nepal to protect IPR of the traditionally valued and popular crop landraces and their products.

Keywords: Agriculture products, geographical indication, geo-linked traits, intellectual property right

INTRODUCTION

Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs and symbols, names and images. IP is protected in law by, for example, patents, copyright and trademarks, which enable people to earn recognition or financial benefit from what they invent or create. The IP system aims to foster an environment in which creativity and innovation can flourish. IP through Patent, design and trademark act was enforced since 1936 in Nepal (MoC 2017). Later it was replaced by Patent, Design and Trademark Act 1965 (amendment 1987). IPR currently is regulated by Patent, Design and Trademark Act 1965; Copyright Act 2002 and Copyright Regulation 2004 (MoCS 2010). Department of Industry under the Ministry of Industry is responsible for registration and regulation of IPR. Recently GoN has approved the National Intellectual Property Right Policy 2017 which includes Copyright policy, Patent policy, Industrial design, Trademark policy, GI policy, Varietal protection policy, Trade secrete policy, Traditional knowledge policy, etc. Among these rights, GI gives exclusive right to a region (eg village, town, region or country) to use a name for a product with certain characteristics that corresponds to their specific location.

Nepal becomes member of World Intellectual Property Organization (WIPO) in 1997, Paris Convention for the Protection of Industrial Property 1983 in 2001 and World Trade Organization (WTO) in 2004 and later of agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) in 2004. This obligates Nepal to improve and manage IPR through formulating policy, law, regulation, etc.

Micro climatic variations within Nepal enable to produce diverse agricultural products. Agricultural products are generally associated with their place of production and are influenced by specific local, geographical factors such as climate and soil (Subedi 2006). Such features are treated as geographical indication (GI) and considered intellectual property that need to protect and ultimately help to promote conservation of agrobiodiversity on-farm and boost economy of local community (http://www.wipo.int/geo_indications/en/).

This paper has reviewed and identified potential GI products of Nepal in agricultural plant genetic resources (APGRs) linked to specific geographical locations to promote them for conservation and improve local economy. It also outlines geo-linked popular crop landraces and their traits for their potential trade promotion and value addition. Among the listed agricultural products which have already established their reputation representing their GI, some of them are cultivated, and some are collected from wild source and marketed as such and some are processed for use or sold in the local markets or exported abroad. Most of the products possess greater cultural and age-old traditional values.

UNDERSTANDING GEOGRAPHICAL INDICATION AND ITS ADVANTAGES

A geographical indication (GI) is a sign used on products that have a specific geographical origin and possess qualities or a reputation (WIPO DNA, http://www.wipo.int/geo_indications/en/) that are due to that origin. In order to function as a GI, a sign must identify a product as originating in a given place. In addition, the qualities, characteristics or reputation of the product should be essentially due to the place of origin. Since the qualities depend on the geographical place of production, there is a clear link between the product and its original place of production. Simply a GI is a name or sign used on certain products which corresponds to a specific geographical location or origin (eg a town, region, or country). GIs are about culture, geography, traditions, heritage and traditional practices of people and countries.

Why GI Protected

GI denotes quality and origin of products and maintains good reputation for the product. It is necessary for preventing the product from generic products and protecting the domestic market from competitors.

Advantages

- Legal protection and preventing from unauthorized use
- Benefits for farmers and local producers, boost the rural development
- Reduces unfair practices of trade preserving local culture and resources
- Provides complete information to consumers
- Improves incomes of farmers and retains rural population
- Consumers attach greater importance to the quality of foodstuffs in their diet
- Helps consumers differentiate between products coming from a particular region and similar products coming from a different region
- Good impact of GI on price, consumers willing to pay higher price
- Marketing tools in the local products that have a specific quality and that is exclusive to or essentially due to the geographical environment in which the products are produced

GIs and Developing Countries

GI is an instrument of rural development (Marie-Vivien and Chabrol 2014). Promotion of products having certain characteristics could be of considerable benefit to the rural economy, in particular to less-favored or remote areas, by improving the incomes of farmers and by retaining the rural population in these areas (EC Regulation No 2081/92) eg Italian Tuscan Olive Oil sold at premium ever since its registration in 1998. Differentiation of products can lead to increase in prices of the protected products; allows genuine producers to capture the rents, entry barriers for “fakes”. Issue is whether the framework is appropriate for developing countries.

TYPES OF GI

There are three type of GI in practice to promote and protect names of quality agricultural products and foodstuffs.

- **Protected Designation of Origin (PDO)**: Characteristics resulting solely from the terrain and abilities of producers in the region of production with which they are associated (require all stages of the food production process to be carried out in the area concerned. Quality wines produced in a specified region become Protected Denomination of Origin (PDO).

- **Protected Geographical Indication (PGI):** Characteristic or reputation associating them with a given area, and at least one stage in the production process must be carried out in that area, while the raw materials used in production may come from another region. Table wines with geographical indication become Protected Geographical Indication (PGI).
- **Traditional Speciality Guaranteed (TSG)**: Traditional Speciality Guaranteed is food designation, the most lenient of EU food designations because it doesn't restrict a food item to a geographical area, as the other designations do. Rather, the emphasis is on the product being made with "traditional" ingredients, or techniques, rather than being on the place where it is made.

PRODUCTS AND RIGHTS ASSOCIATED WITH GI

A geographical indication right enables those who have the right to use the indication to prevent its use by a third party whose product does not conform to the applicable standards (http://www.wipo.int/geo_indications/en/). For example, in the jurisdictions in which the Darjeeling geographical indication is protected, producers of Darjeeling tea can exclude use of the term “Darjeeling” for tea not grown in their tea gardens or not produced according to the standards set out in the code of practice for the geographical indication. However, a protected geographical indication does not enable the holder to prevent someone from making a product using the same techniques as those set out in the standards for that indication. Protection for a geographical indication is usually obtained by acquiring a right over the sign that constitutes the indication.

Type of Products

Geographical indications are typically used for agricultural products, foodstuffs, wine and spirit drinks, handicrafts, and industrial products. For example, gundruk and sinki could be Nepali GI but not momo as it is originated and used in Tibet.

GI around the World

One of the first GI systems is the appellations of origin include Gruyère cheese (from Switzerland) and French wine which was endorsed with government-issued stamp that acts as official certification of the origins and standards of the products in France during the early part of 20th century (Jain 2009). Well-known examples of GIs in South Asia include Basmati rice, Himalayan waters, Alphonso and Sindhri mangoes, Bhutanese red rice, Pakistani shu (wind proof woolen fabric) and ajrak (designs from Sindh), jasmine (Hom Mali) rice. In India the Geographical Indications of Goods (Registration and Protection) Act, 1999 came in force with effect from September 2003. Section 2(e) of the Act defines a GI as “geographical indication”, in relation to goods, means an indication which identifies such goods as agricultural goods, natural goods or manufactured goods as originating, or manufactured in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristic of such goods is essentially attributable to its geographical origin and in case where such goods are manufactured goods one of the activities of either the production or of processing or preparation of the goods concerned takes place in such territory, region or locality, as the case may be.”

Figure 1. Geographical indication protected logo for Darjeeling Tea.

Darjeeling tea (**Figure** 1) was the first GI granted in India in October 2004 (Ravindran and Mathew 2009). It is the most coveted tea in the world and achieved international status similar to champagne or scotch whisky. Darjeeling planters association was formed in 1892. Darjeeling logo as well as the word is now registered as the certification trademarks of the board under Trademarks act of 1999. The quality, reputation and characteristics of Darjeeling tea are essentially attributable to its geographical origin.

PROTECTION METHOD OF GI

GI can be protected in accordance with international treaties and national laws under a wide range of concepts eg special laws for the protection of geographical indications or appellations of origin; trademark laws in the form of collective marks or certification marks; laws against unfair competition; consumer protection laws, or specific laws or decrees that recognize individual geographical indications. There are three main ways to protect a geographical indication:

- *S*ui generis system (special regimes of protection)

- Using collective or certification marks
- Methods focusing on business practices, including administrative product approval schemes.

These approaches involve differences with respect to the conditions for protection or the scope of protection. Two of the modes of protection (sui generis systems and collective or certification mark systems) share some common features, such as the fact that they set up rights for collective use by those who comply with defined standards. GI are protected in different countries and regional systems through a wide variety of approaches and often using a combination of two or more of the approaches outlined above. These approaches have been developed in accordance with different legal traditions and within a framework of individual historical and economic conditions.

GI AND TRADEMARK

A trademark is a sign used by an enterprise to distinguish its goods and services from those of other enterprises. It gives its owner the right to exclude others from using the trademark. A geographical indication tells consumers that a product is produced in a certain place and has certain characteristics that are due to that place of production. It may be used by all producers who make their products in the place designated by a geographical indication and whose products share typical qualities. Some trademarks are given in **Figure** 2 and some of them might be GI.

Figure 2.Trademark of some agricultural products (need to study for considering them as geo-related products).

APPROACHES FOR GEO-LINKED TRAITS STUDY

We conducted focus group discussion to collect information on GI in Nepal. We requested all 75 district agricultural development offices (DADOs) to send the GI related APGRs and agricultural products. Simple questionnaire was circulated to all participants during this 2nd National Workshop on CUAPGR. Twelve experts shared knowledge on GI related APGRs. Friends were also asked to share information through facebook. Here, we have listed possible APGRs and agricultural products based on the information gathered.

For the GI right to the particular products, research is necessary to identify particular crop landraces and agricultural products that possess particular geo-linked traits. Such traits should be verified and identified growing crop landraces in geographical areas where GI is applicable and in other areas so that expression of geo-linked traits can be assessed in a particular landrace. Research should be designed after the extensive survey on potential GI related APGRs.

GEO-DIFFERENCES AND AGRICULTURE

Geography in Nepal varied from plain to very steeply slope. We can see the big differences in soil and climate across the country. Due to this variation, farmers are able to create, develop and maintain diverse landraces of crops and agricultural practices. Some of unique traits in some landraces are mainly created due to the particular environment ie geographical indication.

Geo Indicators and Geo Linked Crop Traits

It is very important to assess the geographical features of different localities so that one can relate with traits expression in crop landraces. Generally agricultural products originated from cold areas are popular and tasty, eg cold water fish, cold tolerant rice, beans from cold areas, etc. Study on impact of environmental factors on quality of agricultural products may help to implement the GI.

Location Specific Unique Crop Landraces

Farmers and agricultural extension workers have reported many crop landraces that possess unique traits. Some are shown in **Figure** 3 and listed in Table 1 (Joshi 2017). Bhate Phaper (rice tartary buckwheat) is very unique landrace of buckwheat that has loose husk and high rutin content, available only in Dolpa district. Black lentil from Rauwa is very famous for its good taste. Local sugarcane from Mahabharat village, East Nepal is very soft, juicy and very famous for raw eating. The number of unique landraces of rice and potato are relatively high (**Table** 1).

Figure 3. Mapping of some unique landraces of different crops in old Nepal map (top) and federal map (bottom).

Table 1. Location specific unique crop landraces

SN	Crop	Landrace	Location	Unique traits
1.	Banana	Mungre Kera	Lamjung and Tanahun	Yellow, long finger
2.	Buckwheat	Bhate Phaper	Dolpa	Loose husk
3.	Cauliflower	Sthaniya	Aaruchaur, Rupakot, Syangja	Perennial, sweet, large head, branch for propagation
4.	Cucumber	Madale Kaakro	Pelakot, Aaruchaur, Rupakot, Syangja	Good for pickle, disease and insect tolerant
5.	Finger millet	Dalle Kodo, Barshe Kodo	Ghanapokhara-5, Lamjung	Dhindo sweet and tasty
6.	Ginger	Syangja	Chilaune bas	High dry ginger recovery

SN	Crop	Landrace	Location	Unique traits
7.	Lapsi	Bhagara Sthaniya	Bhagara, Parbat	More pulp, tasty, long storability
8.	Lentil	Sindur	Siraha	Small seeds, good taste, high quality
9.	Maize	Murali	Chapakot, Syangja	Pop corn
10.	Mandarin	Rumjataar Ko Suntala	Rumjataar, Okhaldunga	sweet
11.	Mayal	Local Mayal	Marpha	Red bunchy small fruit, roostock for apple and pear
12.	Naked barley	Kalo Uwa	Jhong, Mustang	Black in color, tasty and colored flour
13.	Pigeon pea	Dhanusha Local	Dhanusa	SMD resistant, small seeds, tasty
14.	Potato	Tarkhole Seto, Dhorpatan Local	Tara VDC, Bobaang VDC, Baglung	Scented, fissa futne
15.	Potato	Sthaniya	Jantarkhani, Okhaldunga	Boiled having very special taste
16.	Potato	Sthaniya	Gatlang, Rasuwa	Easy and fast cooking, special taste
17.	Radish	Choto	Jumla, Humla	High off season vegetable, good storability, tasty, large and turnip-shaped
18.	Rice	Pokhareli	Pokhara	Scented, fine grain, good taste, fine grain good quality
19.	Rice	Junde Masino	Lamjung	Highly scented
20.	Rice	Anadi	Gandaki zone	Glutinous and used as delicacy
21.	Rice	Ekle, Jhinuwa, Lekali, Basmati	Ghanapokhara-5, Lamjung	Scented, bhatbadne
22.	Rice	Mallaji (Red and Black)	Lekhphant, Parbat	Aadilo
23.	Rice	Anadi	Bhagwana, Parsa	More starch, good for popped rice
24.	Rice	Jarneli	Chapakot, Syangja	Sweet, soft
25.	Rice	Jhinuwa	Syangja	Scented
26.	Rice	Gudura	Aruchaur, Syangja	Disease tolerant, high milling recovery
27.	Rice	Mansara	Aadhikhola, Syangja	Disease and lodging tolerant, high milling recovery
28.	Rice	Ate, Belguti, Chirakhe	Ikhu, Terathum	More straw, lodging tolerant, tasty
29.	Rice	Ghaiya, Chattar, Chobo, Pakhe Jhinuwa, Debkotini, Kalo jhinuwa	Bhanu, Tanahun	Drought tolerant, tasty, good for beaten rice, disease tolerant
30.	Rice	Atte marsi, Dudhe marsi	Lokhim, Salyan, Tingala, Solukhumbu	Tasty, soft
31.	Rice	Anadi	Pokharathok, Palpa	Medicinal property for joint problem
32.	Sea buck thorn	Tora/Daale chuk	Muktinath	Juicy yellow pulp, antioxidant property
33.	Sesame	Nawalpur Khario Til-1	Chitwan	Less fibre, good for pickle
34.	Sponge gourd	Basaune Ghiraula	Syangja	Scented, late maturity, fruiting only after bhadra
35.	Taro	Hattipau, Kharibot,	Purkot, Aabu, Tanahun	Tasty vegetable, sweet for boiled
36.	Til	Kalo and Seto	Kotdarbar, Ramjakot, Sundhara; Tanahun	Tasty pickle
37.	Wheat	Kadu	Kimtang, Nuwakot	Tasty, nutrition
38.	Wheat	Naaphal	Humla	Winter wheat, high protein content

POPULAR LOCATION-SPECIFIC CROPS

There are many age-old reputed crops produced from certain geo-locations. Twenty such products are listed in **Table** 2. Apple from Dolpa and Mustang is very famous among the consumers and they are willing to pay more. All the visitors to Dolpa looks for apple to buy and bring to home. Nepalese people generally discuss and share among relatives and friends about the importance and value of geographically valued agricultural products. Many visitors give such products to neighbor and relative as gift. In the market, such products are sold by the name of crop and name of location eg Jumla ko simi (bean from Jumla), Dhunibesi ko ambaa (guava from Dhunibesi), etc. In this category, people generally do not talk about varieties or landraces, only associated at crop levels.

Table 2. Geo-linked popular crops and their important traits

SN	Crop	Location	Important traits	Geo linked crop name
1.	Apple	Marpha, Dolpa and Jumla	Very delicious, juicy, high demand and market value	Marpha ko shayu
2.	Apricot (local)	Humla	Oil from seed has medicinal value	Humlako Chuli (local apricot)
3.	Bamboo shoot	Pokhara	Tasty and nutritious	Tusa
4.	Bean	Jumla, Mustang, Humla, Rasuwa and Lukla	Very delicious, nutritious, high demand	Jumla ko simi, Mustang simi, Lukla ko simi
5.	Big cardamom	Ilam	Good smell	Ilam ko alainchi
6.	Black gram	Ramechhap	Easy to cook, tasty, *layalu pan*	Kalo maas
7.	Garlic	Lasune, Tehrathum	Very pungent	Lasune
8.	Guava	Dhunibensi	Delicious, soft	Dhunibensi ko ambaa
9.	Lapsi	Lele, Lalitpur, Bhatapur	Sweet and tasty	Lapsi ko maada
10.	Mandarin	Khoku, Dhankuta	Delicious	Khoku ko suntala
11.	Mandarin	Manakamana, Gorkha and Dhankuta	Juicy, tasty	Manakamana ko suntala
12.	Pear	Pharping, Kathmandu	Delicious and juicy	Pharping ko naspaati
13.	Potato	Mude, Dolakha; Langtang; Hemja, Kasaki	Soft, tasty, farrapareko after boiling	Mude ko aalu, aalu
14.	Radish	Pyuthan	Tasty, high demand	Pyuthan ko mula
15.	Rice	Jumla	Adapated to cold areas, tasty, nutritious, andilo hune	Jumli Marshi (red rice)
16.	Spinach	Patan, Lalitpur	Tasty	Patan ko palungo
17.	Sugarcane	Dhunibensi	Soft, juicy	Dhunibensi ko ukhu
18.	Sweet orange	Sindhuli, Ramechhap	Juicy	Sindhuli ko junar
19.	Tea	Ilam	Good taste	Ilam ko chiya, Mai Valley Pure Ilam Tea,
20.	Timur	Salyan, Pyuthan	Pungency, good taste, medicinal value, high oil content	Pepper from Salyan and Pyuthan

GEO-LINKED CROP LANDRACES

Within crop species, there are many landraces developed in certain geography and has geo-linked property. They are listed in **Table** 3. Jhapali Malbhog is the landrace of banana. It is tasty, has thin skin, scent and high market value. Such geo-linked traits are very common in landraces but it is hard to report such property in modern varieties. This indicates that location specific genes had evolved after interaction of genotypes with environment over the years. Most of such landrace have very good taste and sold in the market with high price and consumers pay more price for taste, nutrition, purity and delicious.

Table 3. Geo-linked popular crop landraces and their important traits

SN	Crop	Landrace	Location/ address	Geo-linked trait	Value of this trait	Geo-information
1.	Banana	Jhapali Malbhog	Kawasoti, Nawalparasi	Scented, tasty, large size, thin skin	Quality and market value	Sub tropical
2.	Banana	Ghiu Kera	Lamjung; Tanahun	Scented green, long storage life	Quality and market value	Sub tropical
3.	Bean	Jumli bean	Jumla	Good taste, high cooking quality	High market value	Cool temperate
4.	Bean	Gatlange Simi	Gatlang, Rasuwa	Fast cooking, special taste	High demand	Warm temperate
5.	Bean	Asare Simi	Maarming, Sindhupalchowk	Fast cooking, very special taste for daal	High market value	Cool temperate
6.	Black cumin	Himali Jira	Jumla	Good spice	Medicinal value	Cool temperate
7.	Black gram	Chillo Maas	Gorkha	Good cooking quality good for Dhal	High market value	Sub tropical
8.	Black gram	Malneta	Salyan,	Very tasty and	High market	Sub tropical

SN	Crop	Landrace	Location/ address	Geo-linked trait	Value of this trait	Geo-information
			Sindhupalchowk	scented	value	
9.	Black gram	Kalo Maas	Lamjung, Tanahun	Very tasty and good cooking quality	High demand	Sub tropical
10.	Black gram	Fusro	Keshabtaar, Tanahun	Easy cook, sweet, tasty, good for masyaura	High demand	Sub tropical
11.	Black gram	Malta ko Maas	Malta, Lalitpur	Easy cooking, lesilo, chiplo, lassa aune	High market value	Warm temperate
12.	Black lentil	Kalo Musuro	Goljung, Rasuwa	Fast cooking, special taste	High demand	Warm temperate
13.	Broad leaf mustard	Ghujmujje Rayo	Dalchoki, Lalitpur	Tasty, easy to cook, soft	High demand	Warm temperate
14.	Broad leaf mustard	Marpha Chauda paat	Marpha	Softness, taste, ratooning	Popular and high market value	Cool temperate
15.	Cardamom	Jirmale, Salakpure	Salakpur, Ilam	Drought tolerant, good smell	Wide adaptation, high demand	Warm temperate
16.	Cauliflower	Kathmandu Local	Kathmandu	Good aroma, good cooking quality, tasty, large head	High market value	Warm temperate
17.	Chili pepper	Akabare Khursani	Eastern Nepal	Unique pungent, tasty, high capasaicin	High market price and demand	Warm temperate
18.	Colocasia	Hattipaaile	Lamjung and Tanahu	Large size, many eyes, easy and good cooking quality	High value	Sub tropical
19.	Cucumber	Bhaktapur Local	Bhaktapur	Soft and tasty	High market value	Warm temperate
20.	Cumin	Kalo Jira	Kobang, Mustang	Black and bunchy seed, highly aromatic	High demand	Cool temperate
21.	French bean	Trishuli Simi (Pole Type)	Trishuli	Longer shelf life, tasty	High market price	Sub tropical
22.	Ginger	Sthaniya Bose	Jaljale, Terathum	Different trait, and tasty	Good demand	Warm temperate
23.	Kagati	Sthaniya Soon Kagati	Fabchmara, Terathum	More juicy, thin skin	High market value	Sub tropical
24.	Karu	Sthaniya karu	Helambu, Sindhupalchok	Taste similar to horlick, easy cooking, mixed in tibetian tea	Good demand	Warm temperate
25.	Lentil	Kalo Musuro	Rasuwa	Fast cooking, good taste, scented	High market value	Warm temperate
26.	Maize	Yellow Kande Makai	Kunjo, Mustang	Spiny, good popping quality, aroma and tasty while popped	Good demand	Cool temperate
27.	Maize	White Kande Makai	Kunjo, Mustang	Spiny, good popping quality, aroma and tasty while popped	Good demand	Cool temperate
28.	Mandarin	Manakamana ko suntala	Manakamana, Gorkha	Tasty, sweet, juicy, large	High market value	Warm temperate
29.	Mandarin	Khokana ko suntala	Khokana, Dhnkuta	Sweet, juicy	Tasty, fetch high price	Warm temperate
30.	Mandarin	Khoku Local	Palpa and Kirtipur	Loose skin, juicy	High market value	Warm temperate
31.	Mountain dill	Mountain Sauf	Jumla	Good spice, good smell	High market value	Cool temperate
32.	Nepal Aromatic Garlic	Mustang Jimbu	Jomsom, Mustang	High aroma	High market value	Cool temperate
33.	Pear	Pharping	Pharping	Juicy, soft	High market	Warm

SN	Crop	Landrace	Location/ address	Geo-linked trait	Value of this trait	Geo-information
		Naspaati			value	temperate
34.	Potato	Mude	Mude, Dolakha	Easy cooking, tasty	High market value and demand	Warm temperate
35.	Potato	TharuAalu	Patabhar, Bardiya	Tasty, high storability, blight tolerant	High demand	Tropical
36.	Potato	Helambu Local	Helambu, Sindhupalchowk	Soft and tasty	Good market value	Cool temperate
37.	Rayo	Gujmujje and Dunde	Dalchoki, Lalitpur	Soft, tasty	Good market value	Warm temperate
38.	Rice	Jethobudo Dhan	Pokhara, Kaski	Soft, scented	High market value	Warm temperate
39.	Rice	Tilki Dhan	Dang	Fine grain, scented	High market value	Sub tropical
40.	Rice	Kala Namak	Kapilbastu	Scented, tasty	High market value	Sub tropical
41.	Rice	Jumli Marshi	Jumla	Cold tolerance, taste, redish	High market value	Cool temperate
42.	Rice	Halpuda	Sankhuwsaba	Soft, tasty, most popular	High demand	Warm temperate
43.	Rice	Battisara	Chapakot, Syangja	Sweet, soft, high tillering	Good market value	Warm temperate
44.	Rice	Tilki	Gadriya, Kailali	Scented, tasty	High demand	Tropical
45.	Rice	Ghyu Puri	Urma, Kailali	Scented, tasty	High market value	Tropical
46.	Rice	Suwa Pankhi	Msuriya, Kailali	Scented and tasty	Good demand	Tropical
47.	Rice	Samundhra fini, Asange, Kalikathe	Shikharbesi, Nuwakot	Scented, fine grain, tasty, soft	High demand	Sub tropical
48.	Soybean	Kalo Bhatmas	Kathmandu valley	Black seed coat, high starch, tasty,	High price, cultural value	Warm temperate
49.	Soybean	Pahenlo Thulo	Purkot, Tanahun	Soft, nutritious, tasty	High demand in hotel	Warm temperate
50.	Sweet orange	Junar	Sindhuli	Sweet, juicy	Tasty, fetch high price	Sub tropical
51.	Sweet orange	Mausam	Dandeldhura	Sweet, juicy	Tasty, fetch high price	Sub tropical
52.	Tori	Surkhet Local Tori-3	Surkhet	High oil content, drought tolerant	High demand	Sub tropical
53.	Wheat	Mudule	Chipchipe, Bhirkot, Baidi, Deurali, Purkot, Tanahun; Oyakjung, Terathum	Tasty and sweet, drought tolerant, good for bread and dindo, sweet, disease tolerant	High demand	Warm temperate

POPULAR GEO LINKED AGRI-PRODUCTS

Some of famous agricultural products are listed in **Table** 4 and **Figure** 3. These are very popular at national and international levels. Many of them are processed in the same localities where their raw materials are grown eg Bhote tea, cheese, etc and some of them are processed other than growing areas eg handmade paper, whiskey, millet wine, dried zinger, etc. These products have very good reputation for taste, sweetness and delicious. Coverage of geography area depends on the types of products eg nuggets (mix of taro and black gram) cover larger areas where as dried zinger is popular only from Pyuthan and Butwal.

Table 4. Geo-linked crops and animal products (processed or modified)

SN	Product	Location	Importance	Geo-linked product name
1.	Bhote tea	Mustang, Manang, Solukhumbhu	Unique taste	Bhotechiya
2.	Black pig meat	Dharan	Cultural value, tasty	Dharan ko kaalo sungur

SN	Product	Location	Importance	Geo-linked product name
3.	Cap	Palpa	Good and attractive	Palpali Dhaka
4.	Cheese	Illam	Good taste and color	Ilam ko cheese
5.	Cheese	Langtang, Jiri	Tasty	Yak ko cheese
6.	Dried slice of radish	Mid Hill	Tasty, long storability	Mula ko chaana
7.	Dried zinger	Pyuthan and Butwal	Strong smell, tasty	Nepali sutho
8.	Fish	Trishuli	Delicious	Trishuli ko machha
9.	Fish	Kulekhaani	Delicious, high market value	Kulekhaani ko asala maachha
10.	Fish	Koshi river	Tasty, delicious, camphoric fragrance	KoshikoJalkappor
11.	Hand made paper	High Hill	Unique	Nepali kaagaj
12.	High land coffee	Mid Hill range	Good taste and color	High land coffee
13.	Millet wine	East Mid Hilll	Tasty, high demand	Thumba, Chyaang
14.	Nuggets (amala)	Mid Hill	Tasty, long storability	Titaura
15.	Nuggets (mix of black gram and taro)	Mid HIll	Delicious and long storability	Masyoraa
16.	Oil	Khokana	Tasty, good smell	Khokana ko tel
17.	Pashmina	High mountain	Fine wool	Mountain goat pashmina
18.	Sugarcane jaggery	Tokha	Sweet, good smell	Tokha ko chaaku
19.	Whiskey	Kathmandu	Very strong, high market value	Ailaa
20.	Wool for carpet	High Hill	Soft and attractive	Bhyaglung sheep ko oon
21.	Yogurt	Bhaktapur	Very good taste, high market demand and value	Bhaktapur ko dhahi, Juju Dhau

Figure 3. Different geo-linked agricultural products.

MARKET AND INCENTIVES FOR GI PRODUCTS

Almost all cities sell some location specific agricultural products. Seasonal agriculture products can be seen along the road side selling by the name of location with the slogan of very good taste. Some market places are listed below where location specific products are sold. Main incentive with these products is higher price for producers or business person and good taste for consumer. Other incentives are high demand, attraction of tourists, conservation of landraces through continue growing, good reputation, knowledge sharing, etc.

Local and National Market Places

We can see many local and national markets where particular products are sold. Some markets are listed in **Table** 5. Relatively these products are sold at higher price and visitors prefer to buy some mainly because of good taste and popular products. For example, Juju Dhau is very famous yogurt from Bhaktapur. Many consumers prefer Juju Dhau and are willing to pay more. Most of the local markets related to location specific are seasonal and can be found along the road and hat bazar. Most of such products are not well labeled, packed and cleaned.

Table 5. Market places of geo-linked products for sales in Nepal

SN	Market	Address	GI products	Geo-location of GI products
1.	Chipledungha	Pokhara, Kaski	Bamboo shoot, Jethodbudo rice, black gram, Manakamana ko Suntala, Banana	Kaski; Gorkha; Lamjung and Tanahun
2.	Damauli bazar	Damauli, Tanahun	Banana, black gram, Makai Bodi	Lamjung and Tanahun
3.	Dhunche bazar	Dhunche, Rasuwa	Black lentil	Rasuwa
4.	Dumre bazar	Dumre, Tanahun	Banana, Manakamana ko Suntala,	Gorkha, Tanahun
5.	Fikkal bazar	Fikkal, Ilam	Ilamko tea, akabare khursani, cheese	Ilam
6.	Food Cooperation	Thapathali, Kathmandu	Jumli beans	Jumla and Humla
7.	Hetauda bazar	Hetauda, Makawanpur	Fermented bamboo shoot	
8.	Kalimati bazaar	Kalimati, Kathmandu	Beans, banana, apple	High and Mid Hills
9.	Malekhu bazar	Malekhu, Dhading	Grain legumes	Dhading
10.	Nepalgunj bazar	Nepalgunj, Banke	Apple, beans, Jumli Marshi, buckwheat	Jumla, Humla, Dolpa
11.	Sindupalchok	Sindhupalchok	Black scented black gram	Sindhupalchok
12.	Thimi	Thimi, Bhaktapur	Juju Dhau	Bhaktapur

Nepalese GI at international Level

Nine agricultural products are identified (**Table** 6) that are popularly marketed internationally in the name of Nepal products. Most of them were originated in Mid Hill of Nepal and good taste is the popular trait. Many other products originated from Nepal are found in the foreign cities where Nepali people live, however; all these might not be considered as GI. Lentil and turmeric powder are most popular among them. The benefits of these GI products were not reached to the growers. There are many GI products originated from Nepal and can be marketed internationally. These should be identified along with GI linked traits for long term sale.

Table 6. GI products from Nepal at international market

SN	GI product	Geo-location of GI product	Value
1.	Bhirmauri ko maha (wild bee honey)	High Hill, Nepal	Natural, nutritious, taste
2.	Gundruk (fermented leaf or silage of broad leaf mustard)	Mid Hill, Nepal	Sour, organic, long storability, tasty
3.	High land coffee	Mid Hill	Good taste, high market value
4.	Himalayan honey	High and Mid Hill, Nepal	Nutritious, taste
5.	Organic highland coffee	Mid Hill, Nepal	Taste
6.	Orthodox tea	East Nepal	Taste
7.	Turmeric power	West Mid Hill, Nepal	Medicinal value, high color, good sent
8.	Lentil	Tarai	Small, tasty and pink

POLICY ON GEO-INDICATORS

A number of treaties administered by the World Intellectual Property Organization (WIPO) provide for the protection of GIs, most notably the Paris Convention for the Protection of Industrial Property of 1883, and the Lisbon Agreement for the Protection of Appellations of Origin and their International Registration (http://www.wipo.int/geo_indications/en/). Nepal became a member of WIPO in 1997 and has been a member of the Paris Convention since 2001. In addition, Articles 22 to 24 of the TRIPS deal with the international protection of GIs within the framework of the WTO. All products are covered by Article 22 of TRIPS, which defines a standard level of protection. It states geographical indications have to be protected in order to avoid misleading the public and to prevent unfair competition. WTO and TRIPS Agreement provide a framework for the legal protection of prominent names of products identified to an area in a geographical sense (Malla and Shakya DNA). Trademark operating guidelines 2015, developed by Department of Industry has provision of geographical indication. Recently in 2017, the country has approved National Intellectual Property Policy 2073 in which GI is included. This national policy on IPR has the following provisions.

- Section 8. Policy
  Clause 2: Mentioned as identification and promotion of GI
  Clause 4: Application of IP as a national development tools under maximum utilization of GI
- Sub section 8.2:E. GI policy
  Clause 15: With focusing on specific geographical areas, GI rules will be formulated
  Clause 16: Arrangement of provision of GI as IP of nontransferable right
- Section 9. Working policy9.1:6
  For the support to market access and value addition, producers of agriculture and forest products are identified through the use of GI
- Section 9. Working policy9.2:1
  H. Registered under the trademark will not be protected under the GI and registered under the GI will not be protected under the trademark
  I. Registered under the certification mark will not be protected under the GI
- Section 9. Working policy9.2
  2: Under the IP protection, staff involved in any institutions on the innovation will be encouraged to access his participation on benefits.
- Section 9.4:6
  There is provisioned of the registration fees borne by GoN for GI to local resource based products

WAY FORWARD

APGRs and agriculture products listed here should be verified and need to identify particular traits associated with geo-location. A recognizable image and reputation has to be created for the local product of a country. An appropriate exploitation and promotion of a developing country's natural and agricultural resources can serve as a determining factor of economic development and foreign direct investment. Geographical indications need adequate protection from unauthorized use by third parties, so that consumers are not deceived and the reputation for quality of a product is protected. Based on the provision in WIPO and TRIPS, own system should be established and necessary rules and regulation should be developed. It is urgent to exercise the implementation of GI and already well known products should be granted GI rights through joint work of concerned bodies. Province and central level government should have right to grant GI to the community so that enabling environment will be created for the customers and producers to get more benefited. Standard practices are necessary to develop for marketing GI products at local, national and international markets.

We suggest that important indigenous crop landraces products identified here are to be protected with GI by developing suitable legislation for their market promotion, on-farm conservation and livelihood enhancement of local communities. They can be potentially protected through *sui generis* systems as mentioned in the NIP policy (ie special regimes of protection) or using collective or certification in Nepal to protect IPR of the traditionally valued and popular crop landraces products.

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Nepalese Agricultural Plant Genetic Resources outside the Country

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ABSTRACT

Despite a long history of agricultural research in Nepal, rich agricultural plant genetic resources are not fully utilized on its breeding programmes for the benefit to farming community and the nation. There are few successful cases in cold tolerant rice, traditional vegetables such as cucumber and broad leaf mustard, mandarin fruit and local goats. Majority of notified fruits and vegetables are exotic. Nepal Agricultural Research Council, a public sector research apex body, collaborates with CGIAR system for research and exchanges of agricultural plant genetic resources. Nepalese genetic resources of rice, wheat, amaranth, barley, buckwheat, lentil, finger millet and leafy green vegetables are globally valued and some major cereals were already collected, conserved and exchanged with international genebanks prior to 1992. A total of 23600 accessions of various crops are officially deposited as safety duplicate or back up in various genebanks of twelve countries. The collections of Nepalese crop genetic resources are 12,498 in GeneSys, 11,702 in CGIAR genebanks, 850 in the World Vegetable Center, 4,136 in the National Institute of Agro-biological Sciences of South Korea, 3510 in the European Plant Genetic Resources Search Catalogue and 5000 in IJAR Japan. These genetic resources are publicly available. It is also assumed that a large number of plant genetic resources such as medicinal and aromatic plants, high altitude ornamental plants, traditional vegetables and fruits are gone abroad and their records in the national system have been unaccounted for due to failure to identify legal focal authority to regulate exchange of genetic resources, weak phyto-sanitary and regulatory enforcement and illegal mal-practices.

Keywords: Accession, crop improvement, genebank, germplasm, plant genetic resources

INTRODUCTION

Nepal is a hot spot for biodiversity including agricultural biodiversity (Shrestha and Shretha 1999) as she harbors 6973 flowering species, 790 species with food values, and 577 cultivated species along with forage crops (Joshi 2017a). Among 577 species, indigenous and introduced species are 484 and 93, respectively. Further, there are 64 species of agronomic crop; 145 species of horticultural crop and 275 species of forages. Additionally, 224 wild species of cultivated crops species are reported in Nepal. Many conservation initiatives have been started in Nepal to manage these vague agricultural biodiversity (Joshi et al 2013, Joshi et al 2016a). Different collections and utilization strategies are now in place (Joshi 2017b). These Agricultural Plant Genetic Resources (APGRSs) are assets for future generation at national as well as at global level and need to be properly utilized and conserved. In the past, thousands of landraces of many crops including wild were collected and taken away from Nepal. There is very limited information on actual data of exported germplasm and their impact on food security and understanding science. Some information is available at Upadhyay and Joshi (2003), Gupta et al (2000), Joshi (2017a), Shrestha (1998), Joshi et al (2016b, 2016c), GENESYS (https://www.genesys-pgr.org/welcome); NIAS, Japan (http://www.naro.affrc.go.jp/archive/nias/eng/about/index.html); AVRDC, Taiwan (https://avrdc.org/); USDA (http://www.ars-grin.gov/npgs/) and EURISCO (http://www.ecpgr.cgiar.org/resources/germplasm-databases/eurisco-catalogue/). This paper highlights the status of Nepalese APGRs outside the country, however, there are many missing information.

EXPLORATION AND COLLECTION MISSION

Exploration and collection mission from various countries were organized in various parts of Nepal officially and unofficially and took away many landraces and wild relatives of many species (Shrestha 1998, Upadhyay and Joshi 2003). The first exploration mission was reported in 1938 but official document on crops and accessions collected is lacking. The exploration and collections details are described by Upadhyay and Joshi (2003) and Joshi (2017a). One record showed that five accessions of *Amaranthus hypocondriacus* L. from Langtang area of Nepal reached to Japan in 1975 (Tomita et al 1981). An expedition team from Genebank, Japan back in 1985 collected genetic resources of Rhododendron and Lilium from Nepal (Okuno et al 2007).

Later in 2010 with the purpose of conserving APGRs, National Agriculture Genetic Resource Center (NAGRC also known as National Genebank) was established under Nepal Agricultural Research Council by government of Nepal. After its establishment, NAGRC has collaboration with national research organization (NARO) of many countries (Japan, Korea, UK etc). With financial and technical support from these countries, NAGRC is conducting exploratory and collection mission in the country. Recently two exploration missions were completed (NAGRC 2016), one in coordination with NIAS, Japan and another with Royal Kew Garden. The first mission collected 88 accessions of chilli (42), amaranth (15), broad leaf mustard (3), sorghum (1), pumpkin (6), garden pea (1), lentil (1), perila (1), rapeseed (1), barley (3), buckwheat (3), chenopodium (1), maize (1), finger millet (2), sponge gourd and beans (4). The half seeds of all 88 accessions are safety back up in NIAS, Japan. In second exploration, crop wild relatives of 29 species were collected. The collected crops with number of accessions are rice (7), amaranth (4), lady's finger (3), wild walnut (2), barberry (2), wild pear (3), alpine strawberry (1), swiss chard (2), banana (2), wild peach (1), wild pomegranate (1), bay berry (1), buckwheat (2), wild cucumber (2), field pea (1), rapeseed (1), finger millet (2), alfalfa (1), carrot (1), pearl millet (1), wild apple (1), egg-plant (1), sweet potato(2), cowpea (1) and pigeon pea (1).

CONSERVATION OUTSIDE THE COUNTRY

More than 23600 accessions of Nepalese APGRs are stored in more than 12 different foreign countries (Joshi 2017a). Safety mechanism has been adopted through storing safety backup of 1976 accessions in 6 different CGIAR's banks and safety duplicate of 69 accessions of barley in world seed vault, Koreas in black box system (Joshi 2017a). Details of Nepalese APGRs conserved outside the county are explained in first paper of this proceedings by Joshi et al. The exact numbers of accession based on species in these genebanks are difficult to elucidate. However, most of these accessions are of rice, wheat, barley, finger millet, buckwheat and some are vegetables (capsicum, eggplant, tomato, pea and cowpeas). These germplasm can be accessed by Nepalese scientists upon request.

EXPORT TREND AND USES

During 1980s, collections and export of germplasm for research and conservation was high. After ratifying the Convention on Biological Diversity (CBD) by government of Nepal (GoN) in 1993, there was restriction on germplasm collection and export. Recently the trend of exporting germplasm is increasing mainly because of implementation of ITPGRFA for which Nepal became a member in 2009. Due to the poor documentation system, involvement of many organizations and illegal collections and export in the past, actual numbers of germplasm conserved outside the countries are not known. In case of rice, nine different genebanks (NAGRC, Nepal; IRRI, the Philippines; NIAS, Japan; NBPGR, India; NAC, Korea; NBC, Bhutan; USDA, USA; Vavilov Institute, Russia and ARC, Benin) across the globe have conserved 8389 rice accession till date (Joshi et al 2016c). Among these accessions, sixty countries have received Nepalese rice accessions through IRRI for research and production. IRRI distributed 7353 times these accessions of rice to the recipient countries starting from 1975 (Joshi et al 2017). Most commonly studied landraces were Jumli Marshi for cold tolerance, Chhomrong Dhan for cold tolerance and blast resistance, *Oryza nivara* S.D.Sharma & Shastry for brown plant hopper. Some released varieties (eg Sabitri, Radha-4, Khumal-4, Sukhadhan 1, 2 and 3) were reported to be directly used for commercial grain production in Bhutan, India and Madagascar (Joshi et al 2017). Beside these, wheat landrace named Mudule is used in research purpose and another landrace Pasang Lahmu is universally used as donor for yellow rust resistant gene to recent wheat cultivars. Nepalese released wheat varieties NL-297, Gautam, Bhrikuti are at massive scale production in adjoining Tarai districts of India particularly Uttar Pradesh and Bihar (Madan R. Bhatta, Personal Comm. 2016). Maize variety, Manakamana-3 is grown in Bhutan. In addition, Bhate Phapar, a landrace of buckwheat is in research and production in Russia, Japan and Canada (Joshi 2008). Nepalese lentil is taken by ICARDA from early 1970s and used extensively in breeding program. Major export agricultural products are course grain rice, lentil, cardamom, ginger, local mandarin, radish seeds, tea, Akabare chili, leafy vegetables, etc for consumption.

COLLABORATIVE EFFORTS

Different organizations collaborate with international organizations for collections and sharing APGRs. Nepal Agricultural Research Council has good collaboration with Consultative Groups on International Agricultural Research (CG) Centers. They are exchanging large number of genotypes each year and some of safety back up accessions are given in **Figure** 1.

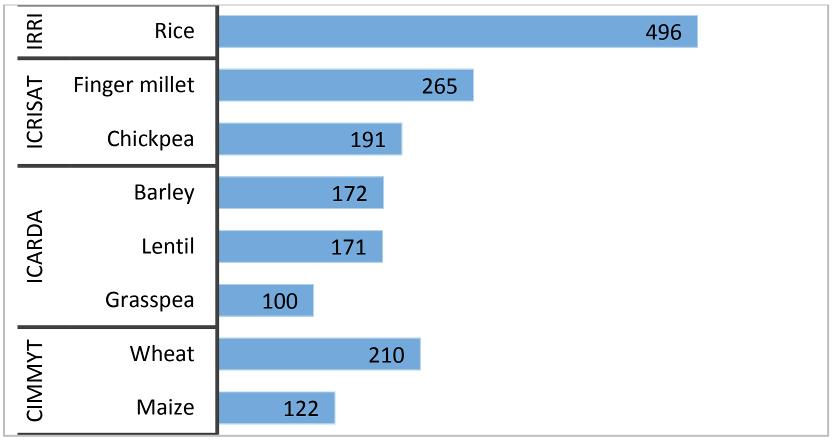

Figure 1. Number of accessions of different crops from Nepal safely duplicated in different CG Centers.

EXPORT POLICY

The present mechanism of export of APGRs is shown in **Figure** 2 (Joshi 2017a). Any germplasm can be imported and exported after getting approval from National Plant Quarantine Program. Materials are exported for research and breeding; conservation; production, and raw and finished products for consumption. This policy is for research, breeding and production materials for which, SMTA is generally developed for the germplasm export and import. Major issue is poor documentation of these materials and their impact or uses after export and import. Instead of multi-window system of exporting APGRs, single window system (Bhattarai et al 2016) is proposed following scientific documentation and studied (**Figure** 3). To implement the newly proposed mechanism there is need of regulatory body for which government need to formulate agrobiodiversity conservation and exchange law.

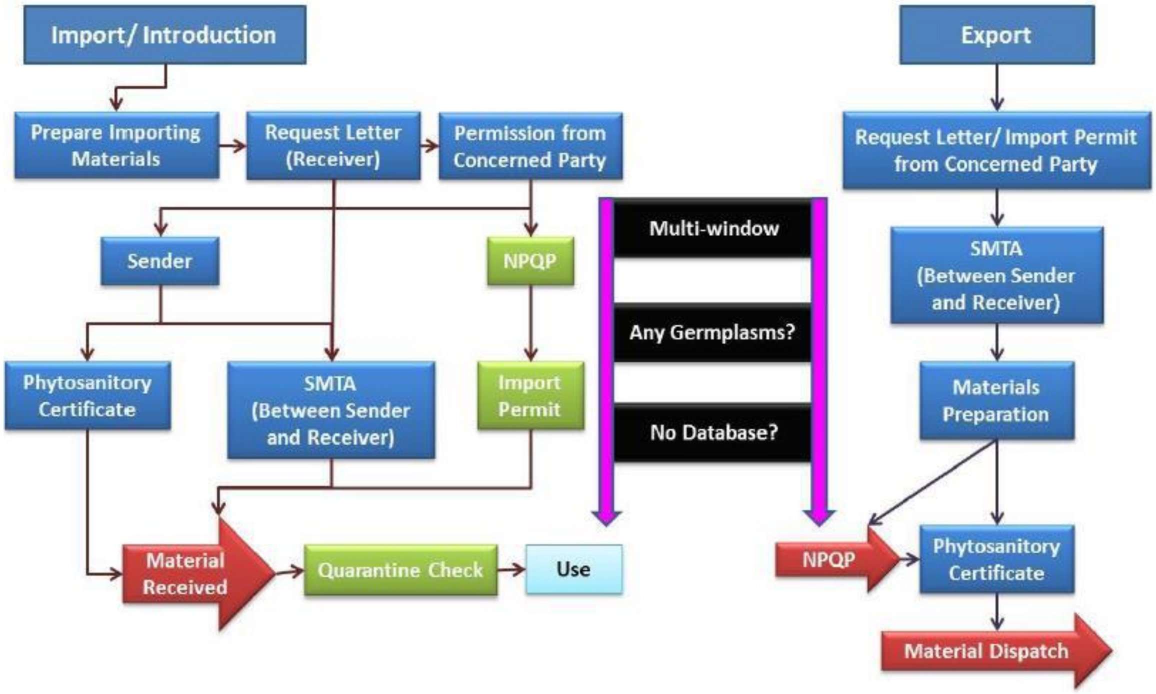

Figure 2. Present mechanism of germplasm export and import in Nepal.
Adapted from Joshi 2017a.

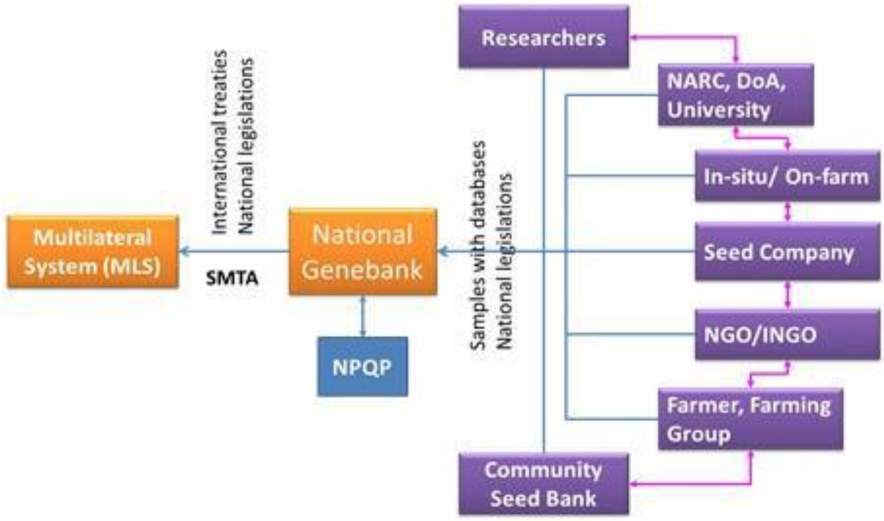

Figure 3. Proposed plan for export (A) and import (B) of Nepalese Plant Genetic Resources.
Adapted from Bhattarai et al 2016.

WAY FORWARD

Detail information on collections along with useful traits of APGRs that are outside the country are not well documented and available. Impact and use value of Nepalese APGRs should be studied at global level and important landraces that have global market need to identify. Repatriation of some locally not available but conserved APGRs needs to implement. Important landraces from these foreign genebanks should be restored in National Genebank. Comparative study might be useful for knowledge update in genetic variation among on-farm and ex-situ materials. In addition to APGRs, a large number of medicinal and aromatic plants, high altitude ornamental plants are gone abroad and their records in the national system have been unaccounted for due to failure to identify legal focal authority to regulate exchange of genetic resources, weak phyto-sanitary and regulatory enforcement and illegal mal-practices. To solve the issue of mal-practice the one door mechanism should be implemented for which we need regulatory law which is lacking at present. Commercially potential Nepalese APGRs should be registered and need to consider under the intellectual property right.

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Introduced Agricultural Plant Genetic Resources in Nepal

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ABSTRACT

Introduction of many economically important Agriculture Plant Genetic Resources (APGRs) in Nepal dates back to 1850s during Rana regimes. Potatoes were reported to be introduced into Nepal in 1793. Many cultivated plant species were introduced by elite families of Kathmandu valley while they made foreign tour for official and private businesses. International Agriculture Research Centers have also played a great role in the introduction of elite cultivars of agricultural plants. Overseas Development Administration (ODA) of United Kingdom (UK) through Lumle Agriculture Research Centre and Pakhribas Agriculture Centre in 1968 and 1972 helped to introduce exotic species. Among 577 cultivated species listed in APGR database, 93 are introduced species. About 73% of the released varieties in the country (above 80% of wheat, potatoes and lentils alone) have ancestors originated in foreign countries. Among the released crop varieties, 183 varieties of 43 crops including 4 forage species and 56 registered varieties of 20 crop species are developed by using foreign breeding materials. Though, introduction of horticultural species started from 1850 during Rana Dynasty, extensive introduction was done during Hill Agriculture Development Project (HADP) (1973), Horticulture Development Project Phase-I and Phase-II (1985-1997), and FAO funded Vegetable Development Project (1985). About 49 species of fruits and nuts introduced from foreign sources, are planted in DoA and NARC stations. National Citrus Research Programme, Paripatle, Dhankuta has introduced and maintained the most exotic germplasms of citrus species. Horticulture Research Station, Rajikot, Jumla, NARC has introduced ten spur type apple cultivars from India and fifteen exotic apple cultivars from Canada in 2011 and these are under evaluation. In 2016, six spur type apples were also introduced by FDD, Kirtipur. Similarly, 28 olive cultivars in 2006 and six additional olive cultivars were introduced in 2016 by FDD, Kirtipur. Some of the private nurseries like 'Everything Organic Nursery', Kavre and 'Technology Demonstration Centre of ICIMOD' at Godawari, Lalitpur were also found to be the collection centers of many exotic cultivars of horticultural plants. Some of the exotic materials have already been evaluated, selected, multiplied, maintained and notified in national system while many are still needed to be evaluated and utilized.

Keywords: Elite cultivars, evaluation, exotic germplasm, horticultural crops, selection

INTRODUCTION

Agricultural Plant Genetic Resources (APGRs) are one of the important resources for developing new varieties of interest. APGRs are the basic materials for genetic improvement of agricultural plant species used by breeders. Introduction of APGRs have been started since time immemorial but literatures reported that introduction of economically important agriculture plants dates back to 1793 when potato was introduced from India in Kathmandu valley (Joshi et al 2016a, Khairagoli 1979). Most of the horticultural exotic cultivars were introduced around 1850s in Ranas regimes (Acharya and Atreya 2013). Many elite Rana families introduced plants while they made foreign tour for official and private businesses. International Agriculture Research Centers have also introduced many plant cultivars for research and demonstration purposes. For example, elite lines/cultivars generated by IRRI, CIMMYT, ICRISAT, ICARDA, CIP, AVRDC, JICA, FAO, ICIMOD, INTRA-CIRAD, ICAR etc have been generously supported testing materials in different agro-ecological zones of Nepal. The collaborative activities between national programs and IARCs have been effective in exchange of germplasms, testing of advanced breeding lines, conservation and utilization of germplasm. Regional intergovernmental initiatives of SAARC collaborative activities on crop improvement programs have also encouraged the exchange of elite lines/germplasm. This hastened the process of exotic germplasm introductions.

It has been reported that there are 6973 flowering plant species, 790 food value plant species and 577 cultivated plant species including forage species in Nepal (Joshi 2017). Three broad groups of APGRs are agronomic crops, horticultural crops and forages and the number of known species under these groups are 64, 145 and 275 respectively. Among 577 cultivated species listed in APGR database, 93 species are introduced species (**Figure** 1) (Joshi 2003).

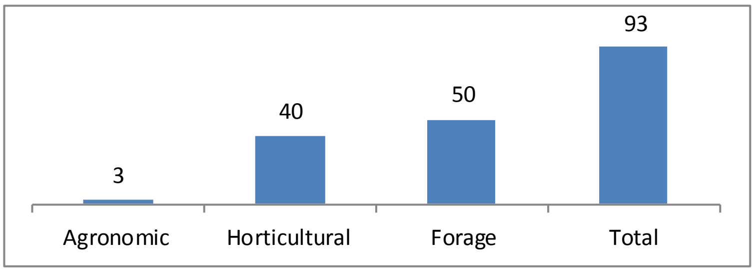

Figure 1. Number of agricultural plant species introduced in Nepal until 2013.

About 73% of the released varieties in the country (about 80% of wheat, potatoes and lentils alone) have ancestors that introduced from outside Nepal. Among the released and registered agriculture crop varieties, 173 varieties of 43 crops including four forage species are developed by using the foreign breeding materials. Similarly, 56 registered varieties of 20 crop species are developed by using exotic breeding materials (**Figure** 2). In some of the crop species, about 95-100% of the released varieties are developed by using germplasms originated outside the country. It is reported that a total of 605 varieties of 65 crops are released and registered. The total 241 varieties of 51 crops are released and a total of 364 varieties of 37 crops are registered (Joshi et al 2016a, NARC 2014, SQCC 2013). This dependency is expected to increase with climate change as pest and disease outbreak in major crops resulting from increased temperature, drought and erratic rainfall.

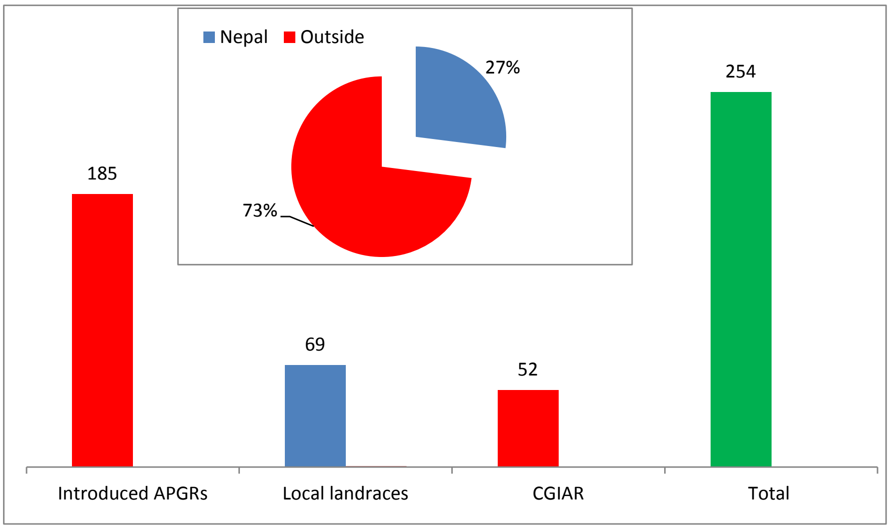

Figure 2. Status of origin of crop varieties released in Nepal until 2016.
Source: Joshi 2017.

Although, growing fruits in Nepal is not of recent origin, there are some fruit species such as mango, litchi, papaya, guava which were introduced and planted in orchards prior to Rana Regime. King Rana Bahadur Shah established a laid out fruit garden at Sera Phant of Nuwakot district for the first time in Nepal. In this garden fruit species introduced were mango, litchi, papaya, pineapple, banana, guava, mandarin, carambola. Prime Minister Mr Jung Bahadur Rana received the European vegetable seeds during his visit to the United Kingdom and Europe. In cereal (barley, maize, wheat, rice), grain legumes (chickpea, french bean, fababean, lentil), oilseeds (soybean, groundnut), vegetables (potato, onion, cauliflower, cabbage, tomato, carrot), fiber crops (cotton), fruits (apple, pear, avocado, macadamia nut, olive), commercial crop (coffee), fodder and grasses (mulberry, berseem, lucern, molasses) and many species and cultivars of ornamentals have been introduced in early nineties. Until now, it is reported that a total of 192 cultivars of 42 important fruits are introduced.

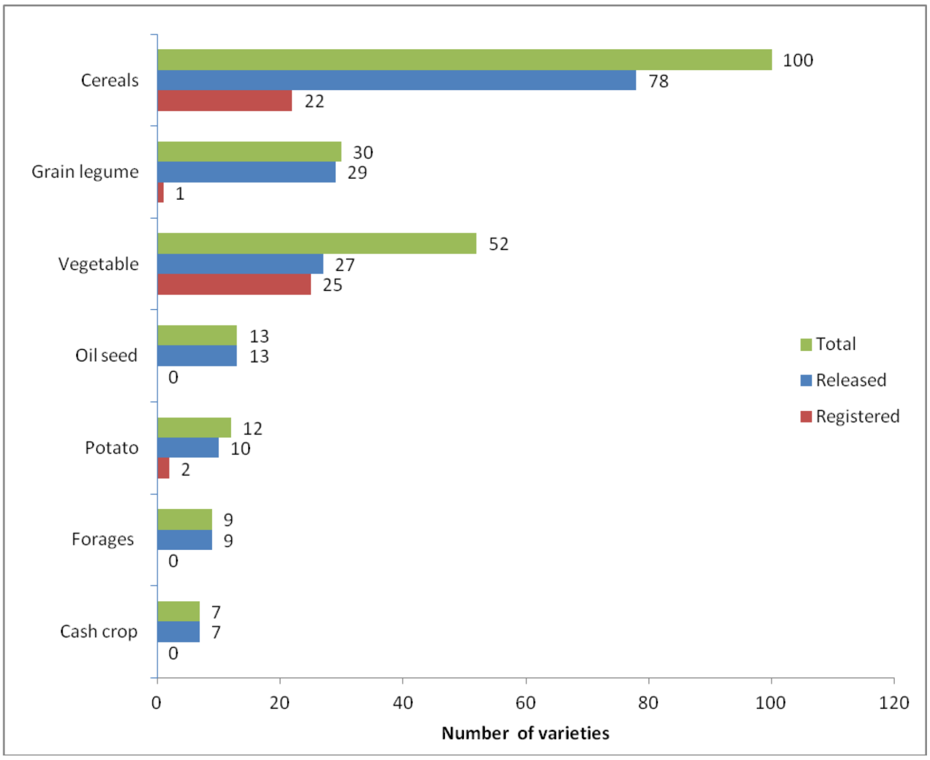

Figure 3. Number of crop varieties released and registered in national system by using foreign genetic materials until 2016.

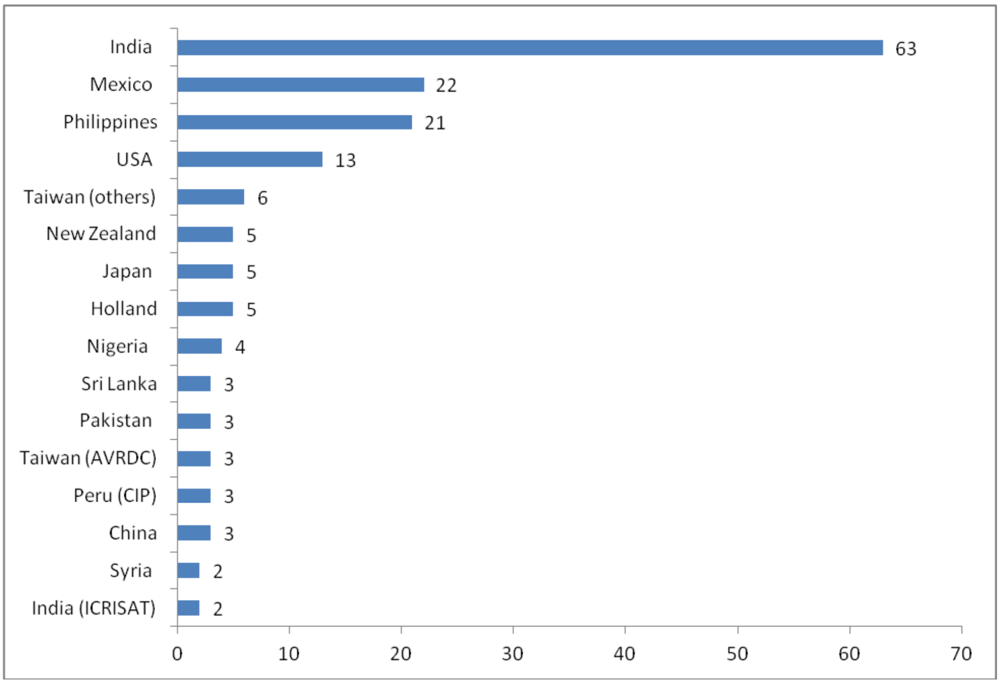

Figure 4. List of countries from where released varieties were originated.

Systematic introduction of horticultural crops was done effectively after Chandra Samsher (JBR) established Agricultural Council as the first government entity for agricultural development in 1937 and opened agricultural farms in Tahachal and Balaju in Kathmandu valley. Moreover, horticultural plant genetic resources were introduced extensively since 1960s when 13 horticulture farms were established with the support of Indian Cooperation Mission (ICM). Tropical fruits especially mango, litchi and guava have been maintained at Sarlahi Horticultural Farm. Temperate fruits apple, peach, pear and plum have been conserved at Horticulture Station, Kirtipur and Mustang. Citrus species have been conserved at Horticultural Research Station, Dhankuta. There are also some exotic collections in the Institute of Agriculture and Animal Sciences (IAAS). Horticulture Research Stations under Nepal Agricultural Research Council (Local stations: 14, Regional Station: 5, Division:

20 and Commodity program: 17) and government farms under DoA (Horticulture farm centre under the Vegetable Development Directorate 10 and under the Fruit Development Directorate: 12) received exotic germplasms of fruits and vegetables and maintained them. Introduced fruit germplasms have been maintained at 21 agricultural research centers of farms under NARC and DoA since the 1960s.

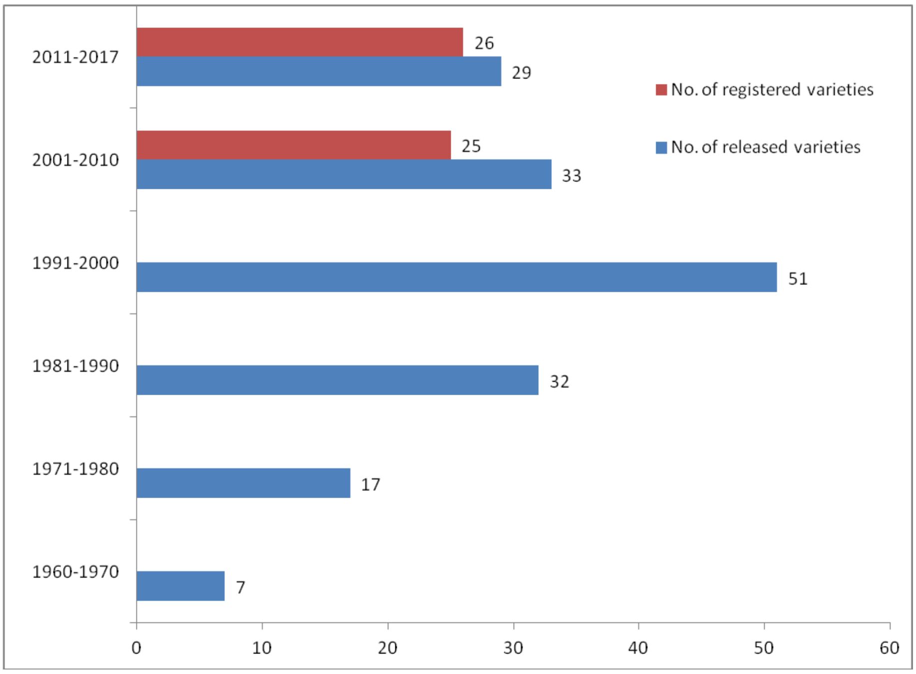

Figure 5. Time horizon of released/registered varieties by using foreign genetic materials.

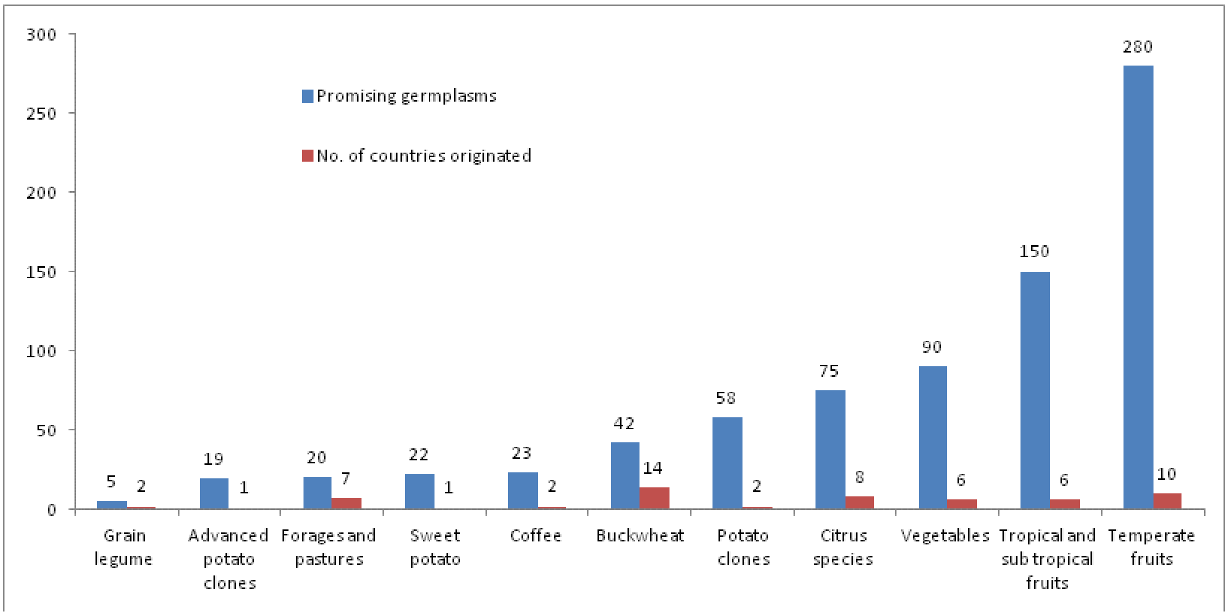

Figure 6. Number of introduced and promising germplasms available at NARC, DoA and private farms.

INTRODUCED AGRONOMIC PLANT GENETIC RESOURCES

Rice is the most important food crops in Nepal. The introduction of rice varieties started from 1951. Several Japanese varieties were introduced in 1951 and late in 1950s. Similarly, number of rice varieties were introduced from Philippines (IRRI), India and USA and tested in Kathmandu (Mallick 1981). China-13, CH45 and N136 were introduced from India in 1958 (Joshi et al 2016). CH45 was tested in Kathamndu and Parawanipur and then released as variety in 1959. CH45 is the first recommended introduced (from India) variety in Nepal (Mallick 1981). BR34 and BR8 were introduced from India in 1961 and released for cultivation in Tarai region. In 1965, Taichung Native-1, the first dwarf *indica* variety, was introduced from India. Several exotic varieties were obtained through IRRI and from Taiwan during 1965 to 1997. For example, some rice varieties were introduced from Taiwan, 16 varieties from IRRI and 14 from India in 1966. Until now 47 landraces originating in 12 countries were used to develop 20 mid and High Hills rice cultivars and 35 landraces originating in 11 countries were used to develop 28 Tarai rice cultivars. About 13 landraces originating in 8 countries were used to develop Khumal-4 rice variety (Joshi et al 2016a, b; Joshi 2015; Joshi 2004). The National Rice Research Program, Hardinath receives more than 100 genotypes annually for evaluation.

Although Nepal is a centre of diversity of rice, many parent lines were introduced from IRRI, The Philippines. A total of 42 improved varieties are developed and released while 22 varieties are registered by utilizing foreign genetic materials so far (**Annex** 1 and **Annex** 2). Among the Indian varieties, Sona Masuli from Andhra Pradesh and Ranjit from Assam and West Bengal were introduced by farmers themselves. Similarly, Samba Mahsuri (Sawa Masuli) from Andhra Pradesh and Sarju-52 from Uttar Pradesh of India were also introduced informally and cultivated by farmers (MoAD 2015). Moreover, Kanchhi Masuli (Indian variety) has been grown in eastern Nepal since the early 1990s and is popular among farmers due to its wide adaptation, good yield, and medium grain quality. Likewise, Rambilas, believed to be the sister line of Radha-11, was introduced and cultivated by farmers themselves (MoAD 2015, Pandey et al 2012).

Wheat is believed to have been introduced in the 16th or 17th century in far-western Nepal from India (Joshi et al 2016a, b). Before 1900, the cultivation of bread wheat in Nepal was confined to the far and Mid Western Hills, although the exact date of the entry of these tall wheat varieties in the area is not known. In 1965, the Department of Agriculture launched a ‘grow more wheat’ campaign, with the introduction of Mexican semi-dwarf varieties such as Kalyan Sona S227, Lerma Rojo 64, Sonora 64, and Pitic 62. In 1967, Lerma Rojo 64, Sonora 64 and Pitic 62 were recommended for cultivation. In 1968, Kalyan Sona S227 was recommended for plain areas (Joshi et al 2016a, b, Joshi 2015, Joshi 2004). The National Wheat Research Program receives more than 1000 genotypes annually. Only exotic parents were used to develop all 35 modern wheat varieties; 89 ancestors originated in 22 countries, most from the United States (13%), India (13%), France (12%), Argentina (6%) and Italy (6%) (Joshi et al 2016a, b).

Different buckwheat genotypes have also been introduced from Japan, Canada, USSR, Poland, China, South Africa, Brazil, Mongolia, Yugoslavia, India, USA, Sweden and Czechoslovakia (Joshi 2008). About 250 exotic landraces of common buckwheat were introduced from 14 countries and evaluated in Nepal (**Table** 1). Most of the exotic lines were dwarf and earlier in maturity than Nepalese landraces while some of the introduced buckwheat genotypes are of self-compatible, determinant and tetraploid types.

Table 1. Introduced buckwheat (*Fagopyrum esculentum* Moench) germplasms in Nepal until 2008

SN	Germplasm	Country of origin
1.	GF-5011	Brazil
2.	GF-5004,GF-5007, GF-5010, GF-5013, GF-5016,Mancan, CBBP-1, CBBP-2, CBBP-3, CBBP-4, CBBP-5, CBBP-6	Canada
3.	GF-5005, GF-5018, GF-5020	China
4.	*	Czechoslovakia
5.	*	India
6.	GF-5009,IR-13, Tokyo, To-Matusoba, Shinshu-O-Soba (4x), Shinano-Ichigo, Shinano Soba, Shinano-Natsu Soba, Miyazakizairai	Japan
7.	GF-50019	Mongolia
8.	GF-5002, GF-5239, Emka (4x)	Poland
9.	Shiva	Slovenia
10.	GF-5006	South Africa
11.	*	Sweden
12.	GF-5015	USA
13.	GF-5001, GF-5003, GF-5008, GF-5012, Scorospelaya, Soumchanka (determinant)	USSR
14.	Darja	Yugoslavia

Source: Joshi 2008.

Lentils are the major grain legume in Nepal. About 95% of the breeding materials in the National Grain Legume Research Program (NGLRP) are received from external sources especially ICARDA (**Table** 2) (Joshi et al 2016a).

Oil seed crops were introduced from India, Bangladesh, Denmark and Australia (Koirala 1995). Similarly 162 exotic genotypes of sesame were introduced from Ethiopia (by IDRC) during 1995.

Table 2. Promising introduced grain legume germplasms available at NGLRP, Nepalgunj, Nepal

SN	English name	Nepali name	Scientific name	Promising lines	Source	Year of introduction
1.	Lentil	Musuro	Lens culinaris Medik.	ILL 7723	ICARDA, Syria	1995
2.	Chickpea	Chana	Cicer arietinum L.	KPG-59	CSA, University, Kanpur	2001
				ICCV 97207	ICARISAT, India	2001
				ICCV98933	ICARISAT, India	2001
3.	Pigeon pea	Rahar	Cajanus cajan (L.) Millsp.	ICP 7035	ICARISAT, India	1995
				ACC#8661	ICARISAT, India	1995
4.	Soybean	Bhattamas	Glycine max (L.) Merr.	PK 327	GB, University, Pantnagar	1998
				PK 7394	GB, University, Pantnagar	1998
				IARS 87-1	IARI, Delhi	2005
5.	Mungbean	Mung Mass	Vigna radiata (L.) R.Wilczek	HUM 16	BHU, Varanasi	2011
				Pant 5	GB, University, Pantnagar	2011

In case of groundnut, a total of 145 lines have been collected from other countries, including 76 from the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), 51 from the USA, 12 from the Upper Volta, and one each from Bhutan, Brunei, Ghana, Israel, Pakistan and Senegal (Upadhyay and Joshi 2003). Groundnut materials were introduced from AGLN of ICRISAT. Until the period of 1995, 236 exotic germplasms of groundnut including 20 genotypes from SAARC countries were introduced and evaluated at National Oilseeds Research Program, Sarlahi (Koirala 1995).

INTRODUCED TUBER CROP GENETIC RESOURCES

Potatoes are the fifth most important major crop in Nepal in terms of area coverage and second in terms of production. British Colonel James Kirkpatrick reported the evidence of potato cultivation in the 1790s in India and reported that potatoes were introduced into Nepal, initially in the Kathmandu Valley from Patna, India in 1793 (Joshi et al 2016a, Khairagoli 1979). In 1957, trials of 20 exotic including local potatoes were carried out on experimental farms in Singhadurbar, Parwanipur and Rapti (Joshi et al 2016a). About 95% of the genetic materials of potatoes are received from Cetro Internacional de la Papa CIP, Peru. More than 50 genotypes of potatoes are received annually from CIP, thus the main source of the new germplasm for potato in Nepal, the second being Central Potato Research Institute (CPRI), India.

Table 3. Introduced and released potato (*Solanum tuberosum* Linn.) varieties maintained at field gene bank /potato park at Hattiban research farm and at in-vitro tissue culture in NPRP, 2015/16

SN	CIP #	Origin	Varieties	Received date	Source
1.	800258	India	Kufri Jyoti	1980/81	CIP, Peru
2.	-	The Netherlands	Cardinal	Nov. 26, 2004	SASA, UK
3.	800048	The Netherlands	Desiree	Oct. 27, 2004	CIP, Peru
4.	720123	CIP, Lima, Peru	Janak Dev	Feb. 12,1998	CIP, Peru
5.	800265	India	Kufri Sindhuri	1980/81	CIP, Peru
6.	388572.4	CIP, Lima, Peru	IPY-8	1989/1990	CIP, Peru
7.	388572.1	CIP, Lima, Peru	Khumal Laxmi	1989/1990	CIP, Peru
8.	676008	CIP, Lima, Peru	Khumal Rato-2	Feb.12,1998	CIP, Peru
9.	720088	CIP, Lima, Peru	Khumal Seto-1	Feb.12,1998	CIP, Peru
10.	-	USA	Khumal Ujjwol	2004/2005	Idaho, USA

Source: NPRP 2016.

Table 4. Introduced potato (*Solanum tuberosum* Linn.) clones maintained at *in-vitro* tissue culture in NPRP, 2015

SN	CIP #	Pedigree		Received date	Planting materials	Source
		Female	Male			
1.	306514.64	303887.17(1)	303887.17(1)	13-Aug-14	In-vitro	CIP, Peru
2.	306087.132	303887.6(1)	303828.20(1)	13-Aug-14	In-vitro	CIP, Peru
3.	306087.56	303887.6(1)	303828.20(1)	13-Aug-14	In-vitro	CIP, Peru
4.	306087.72	303887.6(1)	303828.20(1)	13-Aug-14	In-vitro	CIP, Peru
5.	306418.1	303887.6(1)	303888.4(1)	13-Aug-14	In-vitro	CIP, Peru
6.	306018.4	303887.6(1)	303803.16(1)	13-Aug-14	In-vitro	CIP, Peru
7.	306018.66	303887.6(1)	303803.16(1)	13-Aug-14	In-vitro	CIP, Peru
8.	306154.126	303826.2(1)	303835.19(1)	13-Aug-14	In-vitro	CIP, Peru
9.	306143.65	303887.6(1)	303835.11(1)	13-Aug-14	In-vitro	CIP, Peru
10.	306418.53	303887.6(1)	303835.19(1)	13-Aug-14	In-vitro	CIP, Peru
11.	306416.68	303887.10(1)	303888.4(1)	13-Aug-14	In-vitro	CIP, Peru
12.	306513.57	303887.17(1)	303835.11(1)	13-Aug-14	In-vitro	CIP, Peru
13.	306143.62			14-Aug-14	In-vitro	CIP, Peru
14.	304394.56	Shepody	391207=(LR93.050)	15-Aug-14	In-vitro	CIP, Peru
15.	381381.9	378493.915	PRECOZ BULK			CIP, Peru
16.	395017.242	393085.13	392639.8			CIP, Peru
17.	703312					CIP, Peru
18.	703825					CIP, Peru
19.	396012.266	391004.1	393280.58			CIP, Peru
20.	392025.7	Linea 21	386614.16=(XY.16)			CIP, Peru
21.	395445.16					CIP, Peru
22.	392797.22					CIP, Peru
23.	393382.44					CIP, Peru
24.	395112.32					CIP, Peru
25.	397079.26					CIP, Peru
26.	395017.229					CIP, Peru
27.	392637.229					CIP, Peru
28.	392637.10	387143.22	387170.9			CIP, Peru
29.	399078.11	391686.5	393079.4			CIP, Peru
30.	391058.175					CIP, Peru
31.	393613.2					CIP, Peru
32.	392759.1					CIP, Peru
34.	399067.22					CIP, Peru
35.	393536.13					CIP, Peru
36.	394611.112					CIP, Peru
37.	701165					CIP, Peru
38.	39400.52					CIP, Peru
39.	393381.106	388611.22	676008=(I-1039)			CIP, Peru
40.	703287					CIP, Peru
41.	393371.159	387170.16	389746.2			CIP, Peru
42.	395443.103	BWH-87.289	385280.1=(XY.13)			CIP, Peru
43.	397067.2					CIP, Peru
44.	396033.102	392639.53	393382.64			CIP, Peru
45.	399706.27					CIP, Peru
46.	392633.54	387132.2	387334.5			CIP, Peru
47.	391002.6	386209.1	386206.4			CIP, Peru
48.	392973.48	KRASA	385280.1=(XY.13)			CIP, Peru
49.	393083.2	387315.27	390357.4			CIP, Peru
50.	399079.22	395274.1	395257.6			CIP, Peru
51.	393371.164	387170.16	389746.2			CIP, Peru
52.	395111.13					CIP, Peru
53.	391930.13					CIP, Peru
54.	391930.1	BWH-87.338	SELF			CIP, Peru
55.	396287.5					CIP, Peru
56.	391046.14	386209.1	387338.3			CIP, Peru

SN	CIP #	Pedigree		Received date	Planting materials	Source
		Female	Male			
57.	393073.179					CIP, Peru
58.	306022.69	303816.2(1)	303803.18(1)			CIP, Peru
59.	304369.22	Mariela	676008=(I-1039)			CIP, Peru

Source: NPRP 2016.

Table 5. Advanced potato (*Solanum tuberosum* Linn.) clones introduced from India and maintained at field genebank of Khumaltar, 2015/16

SN	Accession	SN	Accession
1.	Tech 7016-397029.21	11.	Tech 7001-301024.14
2.	Tech 7020-304371.2	12.	Tech 7006-304350.1
3.	Tech 7019-388972.22	13.	Tech 7003-302498.7
4.	Tech 7014-393371.58	14.	Tech 7011-304387.17
5.	Tech 7015-396311.1	15.	Tech 7021-304405.47
6.	Tech 7012-391058.175	16.	Tech 7018-304394.56
7.	Tech 7008-304351.109	17.	Tech 7010-304368.46
8.	Tech 7005-304347.6	18.	Tech 7007-304350.118
9.	Tech 7004-303381.3	19.	Tech 7017-397079.6
10.	Tech 7009-304366.46		

Source: *NPRP* 2016.

Table 6. Introduced sweet potato (*Ipomoea batatas* (L.) Lam.) germplasms maintained at field genebank at NPRP, 2015/16

SN	CIP #	Code	Germplasms	Origin	Source	Year of introduction
1.	400039	CIP-10-01	10-C-1	DOM	CIP, Peru	Feb 6, 2010
2.	400917	CIP-10-02	Comal	ECU	CIP, Peru	Feb 6, 2010
3.	440001	CIP-10-03	Resisto	USA	CIP, Peru	Feb 6, 2010
4.	440007	CIP-10-04	W-208	USA	CIP, Peru	Feb 6, 2010
5.	440008	CIP-10-05	W-213	USA	CIP, Peru	Feb 6, 2010
6.	440012	CIP-10-06	W-217	USA	CIP, Peru	Feb 6, 2010
7.	440014	CIP-10-07	W-219	USA	CIP, Peru	Feb 6, 2010
8.	440015	CIP-10-08	W-220	USA	CIP, Peru	Feb 6, 2010
9.	440020	CIP-10-09	W-225	USA	CIP, Peru	Feb 6, 2010
10.	440021	CIP-10-10	W-226	USA	CIP, Peru	Feb 6, 2010
11.	440047	CIP-10-11	Bugsbunny	PRI	CIP, Peru	Feb 6, 2010
12.	440099	CIP-10-12	TIS 9101	NGA	CIP, Peru	Feb 6, 2010
13.	440112	CIP-10-13	Centennial	USA	CIP, Peru	Feb 6, 2010
14.	440135	CIP-10-14	Travis	USA	CIP, Peru	Feb 6, 2010
15.	440185	CIP-10-15	L 0-323	USA	CIP, Peru	Feb 6, 2010
16.	440267	CIP-10-16	Hung Loc 4	VNM	CIP, Peru	Feb 6, 2010
17.	440287	CIP-10-17	VSP 3	PHL	CIP, Peru	Feb 6, 2010
18.	440328	CIP-10-18	AVRDC-CN 1840-284	TWN	CIP, Peru	Feb 6, 2010
19.	440513	CIP-10-19	Koganesengan	JPN	CIP, Peru	Feb 6, 2010
20.	441538	CIP-10-20	Tenian	USA	CIP, Peru	Feb 6, 2010
21.	441624	CIP-10-21	L 4-13	USA	CIP, Peru	Feb 6, 2010
22.	Japanese Red	HRD-10-01	-	JPN	Japan	-

Source: NPRP 2016.

Table 7. Introduced true potato seed (TPS) germplasms conserved in *in-vitro* form at tissue culture lab, NPRP, Khumaltar

SN	CIP number	Germplasm	Source	Year of introduction
1.	370116	MF –I	CIP, Peru	Oct 30, 2007
2.	370102	MF-II	CIP, Peru	Oct 30, 2007
3.	84007.67	TPS-67	CIP, Peru	May 2000
4.	370123	TPS-13	CIP, Peru	May 2000
5.		TPS 1 = HPS 2/67 (MF II x TPS-67)	CIP, Peru	1987-88
6.		TPS 2 = HPS 7/67 (TPS 7 x TPS 67)	CIP, Peru	1987-88

HPS- Hybrid Potato Seed.

INTRODUCED HORTICULTURAL CROPS

Though the horticultural crop cultivation started since time immemorial, systematic introduction of horticultural crops was done effectively during the period of 1948-1967 with the establishment of number of horticulture farms and stations in the country. The first introduction of fruit genetic resources in Nepal dates back to 1850 when Prime Minister Janga Bahadur Rana brought saplings of fruits from UK (Acharya and Atreya 2013). USAID Project was the first foreign funded project supported and funded for Kakani Station in 1952. A total of 13 horticulture farms/stations were established by the support of Indian Cooperation Mission in 1960.

Fruits

Swiss Government Integrated Hill Development Project (IHDP) (1975 to 1985) and Hill Agriculture Development Project (HADP) (1976 to 1979) introduced fruit germplasms in Nepal. New cultivars of fruits were imported from India, Japan, China, Pakistan, Thailand and USA during the Horticulture Development Project (JICA Phase I and II) (1985 to 1995). Some of the important germplasms were Japanese pear, grape, persimmon and chestnut (Gotame et al 2014, Kaini 1995). Godawari Horticulture Farm was established as a plant introduction station. Kakani and Parawanipur Horticulture Stations were also established as the progeny cum demonstration orchards. Many saplings of citrus were introduced to Pokhara region during 1961 to 1962, but unfortunately this also introduced citrus decline. Similarly apples, pear, peach, and plum were introduced in Horticulture Farms-Daman, Kakani, Godawari and Kirtipur. Mango and litchi were introduced to Parawanipur. Similarly, Janakpur Agriculture Development Programme (JADP) aided by Japan, introduced different cultivars of mandarin, sweet orange and grapes in Sindhuli, Ramechhap and Janakpur but details are not available (Verma 1995). During the course of horticulture development, government had introduced 40 cultivars of apple from India. Some of these varieties viz Red Delicious, Royal Delicious, Golden Delicious, McIntosh, Red June, Jonathan, Grannysmith etc have now become popular. Similarly, many cultivars of peach, plum, pear, apricot, walnut, almond chestnut and pecannut have been introduced and evaluated. Peregrin, Elbera, Springtime of peach; Bartlet, Chojuro, Kosui, Hosui, Okusankichi of pear; Green Gaze, Meriposa, Santa Rosa of plum; Shakarpara, Kaisa of apricot; Kyoho, Olympia, Tano Red of grape; Fuyu, Zero, Hiratanenashi of persimmon; Ne-Plus-Ultra, Non-Pereil of almond and Heartley, Payne, Ashley of walnut were performed well enough to be the commercial cultivars (Kaini 1995).

Most of the cultivars of tropical fruits grown in Nepal are introduced from other countries particularly from India. Bombay Green, Bombay Yellow, Maldaha, Dasheri, Calcuttia, Mallika, Amprapali of mango; William Hybrid, Harichhal, Chinia Champa, Robusta, Cavendish Dwarf of banana; Giant Kew and Queen of pineapple; Lucknow-49 and Alahabadi Safeda of guava; Early Seedless, Early Large Red, Late Large Red, Rose Scented of litchi; and Washington and Honey Dew of papaya are the popular cultivars of introduced tropical fruits (Kaini 1995). Amrapali, the regular bearing mango was introduced into Sarlahi Horticulture Farm. Pakistan Government has presented kinnow, mango and pomegranate plants which were planted at Sarlahi, Kirtipur, Nepalgunj, Panchkhal, Dhankuta farms (Verma 1995).

Diverse genetic resources base of fruits and nuts in Nepal is contributed mostly by exotic fruit germplasms. Altogether there were 47 species of fruits and nuts from tropical zone of Tarai (Tarahara, Janakpur, Sarlahi, Parwanipur and Nepalgunj) to cold temperate zone of High Hill (Marpha, Rajikot and Satbanj) across the country. The most exotic apple varieties were maintained in the farms at Satbanj and Marpha farms that belong to DoA. Horticulture Research Station, Rajikot, Jumla has recently introduced ten spur type apple cultivars from Solan, India and 15 additional exotic cultivars from Canada in 2011 and are under evaluation (ARS-Hort 2014). Reports shows that about 40 exotic peach varieties were also maintained in DoA and NARC stations in 1960s. National Citrus Research Programme, Paripatle, Dhankuta has maintained most exotic germpalsm of citrus species. Mango is maintained in farms at Sarlahi and Janakpur. Some of the private nurseries like Everything Organic Nursery, Kavre and Technology Demonstration Centre of ICIMOD at Godawari, Lalitpur were also found to be the collection centres of many exotic varieties of fruit and nut species.

Table 8. Horticultural plant genetic resources introduced during 1978/79

SN	Common name	Scientific name	Cultivars	Country of origin	Year of introduction
1.	Grape	Vitis vinifera L.	Cuttings of Thompson Seedless, Perlette	Australia/USA	1978/79
2.	Pecan nut	Carya illinoinensis	Mahon, Wichita Roomork,	USA	1978/79

SN	Common name	Scientific name	Cultivars	Country of origin	Year of introduction
		(Wangenh.) K.Koch	Mohawk, Choctaw, Appache, Cheyenne, Western Schlay		
3.	Walnut and Black walnut	Juglans regia L.	Ashley, Franquettc, Hartley, Payne, Northern California	USA	1978/79
4.	Fig	Ficus carica L.	White Genoa		1978/79
5.	Avocado	Persea americana Mill.	Fuerte, Hass, Ethinger, Reod, Wes Indian, WI, Fuerto, Mexican, Guatemalon, TopaTopa and Rahan-I	Israel	1978/79
6.	Banana	Musa paradisiaca L.	Dwarf Cavandish, William Hybrid	Israel	1978/79
7.	Apricot	Prunus armeniaca L.	Bhenheim, Tilton		1978/79
8.	Apple	Malus domestica Borkh.	Anna, Vered, Pollinisor-28	Israel	1978/79
9.	Mango seed	Mangifera indica L.	Sabre (Polyembryonic)	Israel	1978/79
10.	Olive	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R. Ferguson	Picae, Manzamilla, Toffahi, Hamed, Lakka	Israel	1978/79
11.	Peach	Prunus persica L. Batsch	Orion, Jun& Gold, Spring Crest, Spring time, Red Heaven, Sun Crest	USA	1978/79
12.	Cherry	Prunus avium (L.) L.	Early Budder, Early River, Black Tartarian, European Francis		1978/79
13.	Grape	Vitis vinifera L.	Thompson seedless, Perlette		1978/79
14.	Plum	Prunus domestica L.	Stanley Apricot, Bhenhium, Tilton		1978/79
15.	Almond	Prunus amygdalus Batsch	Ne-Plus-Ultra, Nonpareil, Mission, Ashley, Franquettc, Hartly & Payne		1978/79
16.	Peach	Prunus persica (L.) Batsch	Nemagourd rootstock		1978/79
17.	Olive	Olea cuspidata Wall. & G.Don	Mansanilo, Nuovo		1978/79
18.	Coffee	Coffea arabica L.	*Coffee arabica*		1978/79
19.	Mecademia nut	Macadamia integrifolia Maiden & Betche	Ikaika, Kakea, Keaau, Keauhou, (Mecademia – Ietraphylla rootstock	Australia	1978/79
20.	Guava	Psidium guajava L.	Van Retiof	South Africa	1978/79
21.	Sweet orange	Citrus sinensis (L.) Osbeck	Malta, Blood Red, Washington Navel, Hamton, Jafa, Samanti, Masoumbi Pineapple, Satgudhi, Valencia Late		1978/79
		(Citrus nobilis) × (Citrus × deliciosa)	Kinnow	Pakistan	1978/79
22.	Unshiu	Citrus unshiu (Yu. Tanaka ex Swingle) Marcow.	Kelomonden	Japan	1978/79
23.	Grapefruit	Citrus paradisisi Macfad.	Kip, Megalopsicarpa, Alnado Tangello		1978/79
Vegetables					
1.	Onion	Allium cepa L.	Red Creole, Texas Gramo 502, Gladalon Brown & Lockyer Brown Early	USA	1978/79
2.	Black Pepper Seed	Piper nigrum L.	Turrialba 3187	Costa Rica	1978/79

Source: Verma 1995.

Thirty-two different genotypes of citrus (16 mandarin, 6 sweet orange, 4 grapefruit, 3 tangor and 3 tangelo) were introduced from the French National Institute for Agriculture Research (INRA)-CIRAD, France in 2005. Many other genotypes were introduced from JICA, ICAR, ICIMOD, Vietnam and others (**Table** 9) **(**NCRP 2013). These genotypes have been conserved and are being evaluated in field gene bank of NCRP, Dhankuta. NCRP has continued the study on the germplasm introduction and selection of mandarin.

Table 9. Introduced citrus germplasms preserved in field gene bank of NCRP, Dhankuta

SN	Accession no	Cultivar/genotype	Source	Year of introduction
Mandarin orange (Citrus reticulate Blanco)				
1.	NCRP-02	Kinnow	Pakistan	
2.	NCRP-03	Frutrel Early	Unknown	
Unshiu Mandarin (Citrus unshiu Yu.Tanaka ex Swingle)				
3.	NCRP-04	Unshiu	JICA, Japan	2001
4.	NCRP-05	Miyagawawase- Unshiu	JICA, Japan	2001
5.	NCRP-06	Okitsuwase- Unshiu	JICA, Japan	2001
6.	NCRP-08	Pongan, Tangerine	ICIMOD	2002
7.	NCRP-80	Satsumawase	INRA-CIRAD, France	2005
8.	NCRP-81	Satsuma Mino	INRA-CIRAD, France	2005
9.	NCRP-82	Satsuma URSS	INRA-CIRAD, France	2005
10.	NCRP-88	Fortune	INRA-CIRAD, France	2005
11.	NCRP-89	Kara	INRA-CIRAD, France	2005
12.	NCRP-90	Nova	INRA-CIRAD, France	2005
13.	NCRP-91	Pixie	INRA-CIRAD, France	2005
14.	NCRP-92	Dancy	INRA-CIRAD, France	2005
15.	NCRP-93	Avana	INRA-CIRAD, France	2005
16.	NCRP-94	Page	INRA-CIRAD, France	2005
17.	NCRP 95	Satsuma Okitsu	INRA-CIRAD, France	2005
18.	NCRP-97	Clamentine Mandarine Hernandina	INRA-CIRAD, France	2005
19.	NCRP-98	Clamentine Mandarine Oroval	INRA-CIRAD, France	2005
20.	NCRP-99	Clamentine Mandarine Commune	INRA-CIRAD, France	2005
21.	NCRP-100	Clamentine Mandarine Marisol	INRA-CIRAD, France	2005
22.	NCRP-101	Clamentine Mandarine Nules	INRA-CIRAD, France	2005
Tangor (Citrus reticulata × Citrus sinensis)				
23.	NCRP 102	Ellendale	INRA_CIRAD, France	2005
24.	NCRP 103	Murkott	INRA_CIRAD, France	2005
25.	NCRP 72	Ortanique	INRA_CIRAD, France	2005
26.	NCRP-07	Tangor, Murkotte	JICA, Japan	
Tangelo (Citrus reticulata × Citrus maxima or x Citrus paradise J.W. Ingram & H.E. Moore)				
27.	NCRP 73	Minneola	INRA_CIRAD, France	2005
28.	NCRP 74	Oriando	INRA_CIRAD, France	2005
29.	NCRP 75	Seminole	INRA_CIRAD, France	2005
Sweet orange (Citrus sinensis (Linn.) Osbeck.				
30.	NCRP-13	Valencia late	ICAR, India	
31.	NCRP-14	Sevelle common	ICAR, India	
32.	NCRP-15	Navelencia	ICAR, India	
33.	NCRP 16	Malta Blood Red	ICAR, India	
34.	NCRP 17	Samauti	ICAR, India	
35.	NCRP 18	Masambi	ICAR, India	
36.	NCRP-19	Vanelle	ICAR, India	
37.	NCRP-20	Ruby	ICAR, India	
38.	NCRP 21	White Tanker	ICAR, India	
39.	NCRP-22	Washington novel	ICAR, India	
40.	NCRP 23	Hamlin	ICAR, India	
41.	NCRP 24	Pine Apple	ICAR, India	
42.	NCRP-25	Yashida Navel	FDC, Kirtipur	2001
43.	NCRP-26	Madam Vanous	GREAT Nepal Pvt. Ltd, Kathmandu	2002
44.	NCRP-27	Delicious Seedless	ICIMOD	2002
45.	NCRP-28	Skages Bonanja	ICIMOD	2002
46.	NCRP-29	Blood red	ICIMOD	2002

SN	Accession no	Cultivar/genotype	Source	Year of introduction
47.	NCRP-30	New Hall Navel	ICIMOD	2002
48.	NCRP-31	Succari	ICIMOD	2002
49.	NCRP-32	Meisheu-9	ICIMOD	2002
50.	NCRP 34	Lue Gim Gong	ICAR, India	2002
51.	NCRP 83	Cara Cara Novel	INRA_CIRAD, France	2005
52.	NCRP 84	Lane Late	INRA_CIRAD, France	2005
53.	NCRP 85	Pine Apple	INRA_CIRAD, France	2005
54.	NCRP 86	Valencia Late	INRA_CIRAD, France	2005
55.	NCRP 87	Salustiana	INRA_CIRAD, France	2005
56.	NCRP 96	Tamango	INRA_CIRAD, France	2005
Grapefruit (Citrus paradisica Macf.)				
57.	NCRP 45	Shamber	ICIMOD	2002
58.	NCRP 76	Henderson	INRA_CIRAD, France	2005
59.	NCRP 77	Star Ruby	INRA_CIRAD, France	2005
60.	NCRP 78	Reed	INRA_CIRAD, France	2005
61.	NCRP 79	Pink Rubi	INRA_CIRAD, France	2005
Pumelo (Citrus grandis/Citrus maxima)				
62.	NCRP-44	Phultrac (Pumelo)	Vietnam	
63.	NCRP-43	Nam Roi (Pumelo)	Vietnam	
64.	NCRP-42	Phodiem (Pumelo)	Vietnam	
Rootstocks				
65.	NCRP 65	Citrange C-35	INRA_CIRAD	2005
66.	NCRP 66	Citrange – Carrizo	INRA_CIRAD	2005
67.	NCRP 67	Poncirus – Pomeroy	INRA_CIRAD	2005
68.	NCRP 68	Flying Dragon	INRA_CIRAD	2005
69.	NCRP 69	Citrumelo 4475	INRA_CIRAD	2005
70.	NCRP 70	Volkameriana	INRA_CIRAD	2005
71.	NCRP 71	Rangapur lime Red	INRA_CIRAD	2005
72.	Trifoliate, Poncirus trifoliate Raf.	USDA , Normal trifoliate, Rubid		
Citrus species introduced by private farms/organizations				
73.	Tangarin	Tangerin –Ponkan	ICIMOD	
74.	Lime, Citrus aurantifolia (Christm.) Swing	Bears Lime and Maxicon Lime	USA by EVON Kavre	
75.	Lemon, Citrus limon (Linn.) Osbeck.	Mayers	USA by EVON Kavre	

Source: NCRP 2013.

Table 10. Origin and sources of introduced citrus germplams in Nepal during Horticulture Development Project II and II (1985-1996)

SN	Common name	Scientific name	Introduced germplasm	Origin	Source	Year of introduction
1.	Mandarin orange	Citrus reticulata Blanco	Yoshida Ponkan, Deko Ponkan, Hayaka, Oto Ponkan, Murkott	Japan	Japan	1999
			Frutrel Early	Israel	Israel	
			Thai Tangarin	Thailand	Thailand	
			Clementine, Arlendo Tenjelo, Madam Venous	Europe	Europe	
			Kinnow	California	Pakistan	
2.	Unshu	Citrus unshiu (Yu. Tanaka ex Swingle) Marcow.	Imamura Unshu, Miyaga Wase, Miyauchi Iyo, Aoshima Unshu, Otsu-4	Japan	Japan	1987
			Okitsu Wase,	Japan	Japan	1996
3.	Pummelo (Bhogate)	Citrus maxima (Burm.) Merr.	Jaffa, Malta Blood Red, New Valencia,	Europe	India	

SN	Common name	Scientific name	Introduced germplasm	Origin	Source	Year of introduction
			Washington Navel, Samauti, First Valencia, Old Valencia, Oka Orange, Seminal, Valencia Late			
			Fukuhara-1, Fukuhara-4, Kiyomi, New Tarocco, Yoshida Navel	Japan	Japan	1987
4.	Pummelo	Citrus maxima (Burm.) Merr.	Thai Pummelo	Thailand	Thailand	1996
			Amanatu,	Japan	Japan	1987
			Ohtachibana,	Japan	Japan	1995
			Banpeiyu,	Japan	Japan	1996
			Kawachibankan	Japan	Japan	1985
5.	Lemon *Citrus limon (Linn.)* Burm. f.	Citrus limon (L.) Osbeck	Lisbon	Europe		1996
			Eureka	Europe		
6.	Acid lime	Citrus aurantifolia (Christm.) Swingle	Rangapur Lime	Israel	India	
7.	Kumquat (Muntala)	Fortunella japonica (Thunb.) Swingle	Golo, Lamcho			
8.	Citrange	Citrus × insitorum Mabb.	Carizzo Citrange, Troyer Citrange	USA	USA	
9.	Grapes	Vitis vinifera L.	Kyoho, Steuben, Olympia, Muscat Belly A			1985-95
10.	Chestnut	Castanea crenata Siebold & Zucc.	Krulunba			1985
11.	Pear, Nasi pear, Asian pear	Pyrus pyrifolia (Burm.f.) Nakai	Kosui, Hosui, Shinko			1985
12.	Apple	Malus domestica Borkh.	Fuji			1985
13.	Persimmon	Diospyros kaki L.f.	Fuyu, Jiro			1985
14.	Kiwi	Olea europaea L.				1985
15.	Grape	Vitis vinifera L.				1985
16.	Peach	Prunus persica (L.) Batsch				1985

Source: FDD 2014.

Table 11. List of introduced fruit and nut germplasm in Nepal

SN	Common name	Introduced germplasm
1.	Apple	Alkin Apple Liberty, Ambri, Ambrosia, Anna, Baldwin, Bell Flower Milberg, Benoni, Beauty of Bath, Blushing Susan, Brameley, Bright N Early, Chaubattia Princess, Chaubattia, Anupam, Chaubattia Swarnima, Chaubattia Alankar, Chaubattia Anuraj, Commercial, Cox's Orange Pippin, CO Op 12, CO Op 13, Co-Op-12-20, Co-Op-13-20, Crimson Gold, Cripsin (Mutsu), Dorsett Golden, Ein Shemer, Fall Russet, Fuji, Gala, Gold Spur, Golden Delicious, Grany Smith, Cox Orange Pippin, Green Graveinston, Honey Crispin, Jim, Jonagold, Jonathan, Jonared, Jubile Fuji, Kasmiri, Katja, King of Pippin, Kullu, McIntosh, Masadi, Neomi, Oregon Spur II, Pine Apple, Pristine, Red Chief, Red Delicious, Red Gold, Red Gravenstein, Red Fuji, Red Spur, Redfree, Rich-a-Red, Robinete, Royal Delicious, Rome Beauty, Rymer, Sansa, Scarlet Gala, Sinta, Stark Spur Golden, Stark All Bledge, Starkrimson Delicious, Spintzen Berg, Summer Pippin, Tore, Tsuqura, Ushyu (seed purpose), Sunrise, Summer Pippin, Sweet Ambri, Top Red, Tori Kullu, Tsagaru, Vance Delicious, Vered, Well Spur, Winter Banana, Zestar, M series, MM series clones
2.	Almond	All In One, Big Early King, Chaubattia Madhu (Indian), Erzhuanzhi (Chinese), Garden, IXL, Kasmir, Lanzhoudajiexin (Chinese), Meixin (Chinese), Prince, Ne-Plus Ultra, Non-Pareil, Sunflower, Safaida Special (Indian), Taxes Spring, Mission

SN	Common name	Introduced germplasm
3.	Apricot	Blenheim (Indian), Shakarpara, Tilton (Indian), Kaisha, Royal, Shakarpara, Xinli (Chinese)
4.	Avocado	Ethinger, Feurte, Hass, Mexicola Stuart, Reed, Topa Topa
5.	Aonla	Chakaiya, Kanchan (NA-4), NA-6, NA-7, NA-10
6.	Banana	Chinia Champa, Dwarf Cavendish, Harichhal, Robusta, FIA, William Hybrid,
7.	Bael	Narendra Bael-5 (NB-5), Narendra Bael-7 (NB-7), Narendra Bael-9 (NB-9), Narendra Bael-17 (NB-17)
8.	Blackberry	Amarand, Loganberry, Mestry, Ollalie, Sunshine
9.	Blueberry	Petriot, Misty
10.	Chestnut	Liangxiangbanli (Chinese), Chukoba, Eshizuchi Ebuki, Tanjawa, Tsukuba, Kumini, Mori Wase, Yamane Wase (Japanese Chestnut)
11.	Dragon fruit	Unidentified
12.	Fig	Masui Dolphin, White Genoa, White Turkey
13.	Feijoa	Gem-K., Memuth, Pineapple Zem, Triumph, Memmoth
14.	Grape	Blueberry, Blackberry, Beauty Seedless, Concurd, French, Himrod, Kyoho, Red Olympia, Delaware, Muscat Bally, Olympia, Perlette, Seedless, Steuben, Tano Red, Thompson, Black Olympia, Buffalo, Campbell Early, Izuka Kyoho, Niyo Muscat, Muscat Belly A, Egyption, Black Muscat
15.	Grape rootstocks	T-8, T-5BB, SO 4, 101-14
16.	Guava	Allahabadi, Allahabad Safeda, Chittidar, Chinese Guava, Lucknow-49, Lalguda, Seedless, KG-1
17.	Gooseberry	Captivator
18.	Hazelnut	Green Leaf, Purple Leaf
19.	Jackfruit	Khajawa, Rasdar
20.	Jujube	Banarasi, Gola, Umran, Jingzhao, Chuizhao
21.	Kiwifruit	Abbott, Allison, Bruno, Hayward, Monty, Red Kiwi, Mattuwa, Tomuri, Montgomery
22.	Litchi	Patharia Red, Shahi, China, Bambai, Kalkattiya, Early Large Red, Muzaffarpur, Maclean, Seedless, Early Green, Koshelia, Rose Scented, Dehara Rose, Bambay Red, Bedana, Deharadun, Late Large, Phash, Ujali, Purbi, Deshi,
23.	Loquat	Mogi, Nagasaki Wase, Tanaka, Nagasakiwase
24.	Macadamia nut	Keuhou (Australia), Kakea, Ikaika
25.	Mangosteen	Unidentified
26.	Mango	Amrapali, Bombay Green, Chausa, Dashehari, Gola, Jarda, Mallika, Maldah, Shilhat, Alphonso, Anupati, Bhadaiya Maima, Bombay Yellow, Kalkattiya, Fazli, Gulab Khas, Jardalu, Sukul, Sukhtara, Anarbahartal, Aman Dashari, Bathuwa, Duckmai, Jarda, Heden, Kent, Kishna Bhog, Langra, Ladbi Midhuwa, Lal Maldaha, Maghukupia, Sipiya, Safeda Maldaha, Radi, Neelam, Gulab Bhog, Hattijhul, Maya, Safeda, Suvarna Rekha, Heden, Langra, Kapari, Gurkha,Kale, Late Green, Malewa Safeda, Malika Mumbasa, Sukhia, Sipiya, Toapuri
27.	Olive	Hojiblaco, Arbequina, Al-Sorani, Al-Zaity, Sevillenca, Souri, Al-Kaisy, Borriolenca, Azapa, Morona, Pico Limon, Dan, Manzanilla, Picudo, Picual, Lechinde Sevilla, Arbequaina, Frantoio, Oblanga, Gordal, Hanaid, Kratojo, Osulu, Picae, Toffahi, Hamed, Lakka, Mission, Leccino, Marino, Nocella, Femminella, Frattese, Cuspidata, Sipressino, Noceelara, Roscialo, Pendalino, Bourbon, Taggiasca, Carbonama, Coratina, Ascolana, Itrana, Bosana, Leonclino, Frattese, Cassanese, Gentile, Angnairi, Carorea, Canino, Moriala, Maurino, Rajo, Rasara, Pientone, Ezzacorona, Valescosona
28.	Passion fruit	Unidentified
29.	Pomegranate	Muskat Red, Bedana, Kandari Red, Ganesh, Mridula, Wonderful, Ruby Red, Ganesh, Kandhari, Sinduria (Bhagwa), Red Dyana, Ruby, Red Beauty
30.	Pear	Barlett, Chinese, Havana, Bask Pear, Bosc, Comice, Danjou, Seckel, Red Hosui, Hosui, Kosui, Chojuro, Nijusaki, Shinko, Atago, Golden Ichigonijiseki Nitaka, Okisangkichi, Yakumo, Waseka, Suli, Xuili, Changxili, Kikusui, Nitaka, Tsugaru, Anju, Kikusui, Patal, Golden Nijisekki, Okisankichi , Megatchu
31.	Peach	Orion, Texas, Peregrine, Arm Gold, French Early, Florida Bell, Florida Red, Hakuto, Matsumori Wase, Odamahakuho, Red Haven Tekeihakuto, Texas, Yamanehakuto Cardinal, Arm Gold, Early Red, Juna Gold, Stark Early Glow, Springtime, Sun Crest, June Pride, Sangita, Desert Gold, Elberta, Yuhuala, Youtao, Beijing-8, Sharbati, Alton, July Alberta, Spring Time, Golden Cline, Red June, Red Hawana, Orayin, Armgold, Panamint (Nectarin), Florida Bell
32.	Plum	Green Gage, Santa Rosa, Methley, Satsuma, Formosa, Mariposa, Prunas, Margong, Starking Deliciosa, China, Beauty, Rome Beauty, Black Chamba, Frontier, Gaili, Huahuan, Li-3, Umewasi (Japanese)
34.	Pecan Nut	Mahan, Mohak, Choctaw, Bichita , Steward
35.	Pineapple	Giant Kew, Queen

SN	Common name	Introduced germplasm
36.	Persimmon	Mayakawa Jiro (Non- astringent), Jiro (Non- astringent), Fuyu (Non- astringent), Matchumotowase fuyu (Non- astringent), Ubeni (Non- astringent), Jengimaro (Pollinizer), Hiratanenasi (Astringent), Mompe (Astringent), Hachiya (Astringent), Hanagoso (Astringent), Suruga (Astringent), Atago (Astringent), Songbenzhaosheng, Qianchuan Cilang Cilang, Hiratanehashi, Mayakabajiro, Matsomotowasefuyu, Hanna Golo Jengimaro (Polinizer), Hiratasenamy
37.	Phalsa	Faizabadi
38.	Raspberry	Autumn Bliss, Cascade Delight, Malling Jewel, Willamtte
39.	Sweet Cherry	Bigarreau, Noir Gross, Stella, Red Heart, Van Lambert, Sun Burst, Summit Bing, Rainier
40.	Sour Cherry	Montmorency
41.	Strawberry	Sally, Red Cavendish, Nyoho
42.	Sapota	Criket Ball, Amez
43.	Walnut	Xifu1, Partap, Kashmiree, Padro, Fringbet, Extra Hartley Xiluo-1, Xiluo-3, Xiling-2, Australian
44.	Yacon (Ground Apple)	Unidentified
45.	Pepino Melon	Unidentified
46.	Spur type apple cultivars	Red Spur, Red Chief, Oregon Spur II, Top Red, Star Krimson Delicious, Bright N Early, Red Gold, Vance Delicious, Well Spur, Stark Spur Gold
47.	Apple	Ambrosia, Blushing Susan, Honey Crisp, Gala, Red Gravenstein, Jonagold (P), Jubile Fuji, Pristine, Redfree, Robinete, Sinta, Sunrise, Tsagaru, Zestar and Jim

Source: Gotame et al 2014, ARS-Hort 2014.

A total of 28 olive (*Olea europaea* L.) cultivars are available in Kirtipur farm, Kolti farm, and Dolpa farm. They were established by the Italy funded FAO project in 2006. This fiscal year 2015/16, following germplasms/cultivars were brought by DoA, Fruit Development Directorate, Kirtipur from Rajasthan, India through bidding process.

Table 12. Olive (*Olea europaea* Linn.) cultivars introduced by FDD in 2016

SN	Cultivars	Total number	Year of Introduction	Sources
1.	Arbequina	2550	2016	India
2.	Picholine	2550	2016	India
3.	Frantoio	2550	2016	India
4.	Coratina	2800	2016	India
5.	Koroneiki	2125	2016	India
6.	Picual	2125	2016	India
	Total	17500		

Recently, Fruit Development Directorate (FDD), Kirtipur has brought five spur type apple scion varieties and dwarf apple rootstocks through bidding process from the Himanchal Pradesh, India and planted at DoA farms (**Table** 13).

Table 13. Spur type apple varieties introduced from the Himanchal Pradesh, India and planted at different DoA farms, 2017

SN	DoA Farms	Apple cultivars						Apple rootstocks		
		Fuji	Gala	Starkspur Gold	Honey Crips	Red Gravestein	Total	M-9	MM-106	MM-111
1.	Central Horticulture Centre, Kirtipur	41	36	36	39	44	196	50	32	35
2.	Temperate Horticulture Development Centre, Marpha	50	50	50	50	50	250	100	100	100
3.	Temperate Horticulture Nursery Development Centre, Daman	30	30	30	30	30	150	70	70	70
4.	Horticulture Centre, Solukhumbhu	35	30	35	35	35	170	45	30	28
5.	Dry Fruit Development Centre, Satbanj	20	20	20	20	20	100	70	70	70

6.	Temperate Fruit Rootstock Dev. Centre, Bonch	10	10	10	10	10	50	35	20	25
7.	Floriculture Development Centre, Godawari	20	20	20	20	20	100	0	0	0
8.	Horticulture Research Station, Rajikot	0	10	0	0	0	10	10	10	10

Vegetables

Hill Agriculture Development Project (HADP) sponsored by FAO had introduced considerable number of exotic fruit and vegetable germplasms during 1978/79, but due to the lack of proper recording system very few are known to date (Verma 1995).Japanese Oversees Volunteers (JOCV) also introduced different types of vegetable seeds. Similarly FAO supported Fresh Vegetable Seed Production Project during 1981 introduced many vegetables (**Table** 14). Seed samples of many vegetable varieties were received from India, Holland, USA and AVRDC, Taiwan.

Table 14. List of popular introduced vegetable cultivars/germplasms in Nepal

SN	English name	Scientific name	Cultivars/germplasm	Source	Year of introduction
1.	Tomato	Lycopersicon esculentum Mill.	Pusa Ruby, Pusa Early Dwarf, Roma, Monprecos, CL 1131		1981
2.	Eggplant, Brinjal	Solanum melongena L.	Nurki, Pusa Kranti, Pusa Purple Long		1981
3.	Hot/Sweet Pepper	Capsicum annuum L. / Capsicum frutescens L.	California Wonder, Chinese, Pusa Jwala, Yatsufusa		1981
4.	Knolkhol	Brassica caulorapa (DC.) Pasq.	White Vienna		1981
5.	Carrot	Daucus carota L.	Nantes, New Kuroda		1981
6.	Swisschard		Ford Hook Giant		1981
7.	Onion	Alium cepa L.	Red Creol, Nasik Red, N53,		1981
			Red Creole, Texas Gramo 502, Gladalon Brown & Lockyer Brown Early	USA	1978/79
8.	Pea	Pisum sativum L.	Arkel, New Line Perfection, Bonevile, Sikkim		1981
9.	French bean	Phaseolus vulgaris L.	Kentucky Wonder, Contender		1981
10.	Black Pepper Seed	Piper nigrum L.	Turrialba 3187	Costa Rica	1978/79
11.	Asparagus	Asparagus officinalis var altilis L.	Mery Washington	USA	2000
12.	Okra	Abelmoschus esculentus (L.) Moench	Arka Anamika	India	
13.	Summer squash	Cucurbita pepo L.	Bloom house		
14.	Brinjal	Solanum melongena L.	Pusa Purple Long		
15.	Broccoli	Brassica oleracea var. italica Plenck	Green sprouting		

Source: Verma 1995

Table 15. Introduced vegetable and spice germplasms available at HRD, Khumaltar, 2016/17

SN	Common Name	Scientific name	Exotic germplasm	Source	Year of introduction
1.	Tomato	Lycopersicon esculentum Mill.	HRD1, HRD6, HRD7, HRD9, HRD10, HRD11, HRD12, HRD13, HRD14,	Solan and IIVR, Varnasi	2004
			HRD2, HRD3, HRD4 (Bacterial wilt resistant)	Bangladesh	2004
				India	2004 to 2010
			HRA1, HRA2, HRA3, HRA4, HRA5, HRA6, HRA7, HRA8, HRA9, HRA10, HRA11, HRA12, HRA13, HRA14,	AVRDC	2007

SN	Common Name	Scientific name	Exotic germplasm	Source	Year of introduction
			HRA15, HRA16, HRA17, HRA18, HRA19, HRA20 (Late blight resistant)		
			CLN2545B , HRD17	AVRDC	2007
			HRD18	UK	2005
			HRA31, HRA33, HRA34, HRA36, HRA38, HRA39, HRA41 (Late blight resistant)	German	2008
			STM 01, STM02, STM03, STM05, STM06, STM08, STM010,	SAARC countries	2013
			V5	SAARC countries	2012
			BARI-5	Bangladesh	2000
2.	Chilli	Capsicum annuum L.	Suryamukhi	India	2012
			HRDCHI008, HRDCHI010, HRDCHI011, HRDCHI012, HRDCHI014	AVRDC	2012
3.	Capsicum	Capsicum frutescens L.	HRDCAP001, HRDCAP003, HRDCAP004, HRDCAP005	India	2014
			HRDCAP002	Philippine	2014
4.	Faba Bean	Vicia faba L.	HRDFB001, HRDFB002, HRDFB003, HRDFB004, HRDFB005, HRDFB006, HRDFB008, HRDFB009, HRDFB013,	ICARDA	2013
5.	Radish	Raphanus sativus L.	HRDRAD003, HRDRAD005	Japan	2011
6.	Cucumber	Cucumis sativus L.	HRDCUM003, HRDCUM006, HRDCUM007, HRDCUM009		2012
			HRDCUM010		2013
			HRDCUM012, HRDCUM013, HRDCUM014, HRDCUM015, HRDCUM016, HRDCUM017, HRDCUM018		2014
			HRDCUC004, HRDCUC 006, HRDCUC 009, (gynoecious lines)	India	2010
7.	Cauliflower	Brassica oleracea var. botrytis L.	HRDCAU003 (Golden Agani), HRDCAU005 (Early and summer lines)	India	2010

Cash Crop

Arabica coffee has its primary centre of origin in highlands of south west Ethiopia and the Boma Plateau of Sudan. Tea (*Camellia sinensis* (L.) Kuntze) has been believed to be originated in South East Asia and China. In 1938 AD, a hermit Mr Hira Giri had brought some seeds of coffee from Sindu Province of Myanmar (the then Burma) and had planted in Aapchaur of Gulmi District for the first time in Nepal (Thapa et al 2011). The crop remained unnoticed as a curiosity crop until 1970s. Then it spread from one farmer to another as a curiosity plant for about four decades. Expansion of coffee as commercial crop to some extent took place when Government of Nepal imported coffee seed from India for distribution in 1963. The major shift to commercial coffee production took place in mid-eighties. After the establishment of Nepal Coffee Company (NeCCo) in Manigram, Rupandehi district, in 1983/84, the coffee producers were able to sell coffee. Until early 2000, coffee producers were not very sure of coffee being a source of income or income generating crop due to the market problem. However, after the year 2002, substantial increase in the export and also increase in domestic market consumption to some extent motivated coffee producers to consider as a major income generating crop.

Table 16. Coffee (*Coffea arabica* L.) varieties introduced and maintained at ARS (Horticulture), Malepatan, Pokhara

SN	Cultivar	Source/origin	Year of introduction
1.	Tekisic	El Salvador (Latin America)	1997/98 (2054)
2.	Pacas	El Salvador (Latin America)	1997/98 (2054)
3.	Pacamara	El Salvador (Latin America)	1997/98 (2054)
4.	Selection-10		
5.	Yellow Cattura		
6.	Hawaii Kona		

SN	Cultivar	Source/origin	Year of introduction
7.	Indonesia		
9.	Catuai Amarillo		1994 (2051)
10.	Catuai Vermello		1994 (2051)
11.	Caturra Amarillo		1994 (2051)
12.	Caturra Vermelo-		1994 (2051)
13.	Bourbon Amarillo		1994 (2051)
14.	Bourbon Vermelo		1994 (2051)
15.	Mundo Novo (hybrid)	El Salvador (Latin America)	
17.	Indo Tim-Tim		
18.	San Roman		
19.	Catisic	El Salvador (Latin America)	1997/98 (2054)
20.	Catimore	El Salvador (Latin America)	
21.	Chhetradeep		

Source: ARS- Hort 2014.

Nepal has a long history of tea (*Camellia sinensis* (L.) Kuntze) cultivation, initiated with the establishment of Ilam Tea Estate in the Hills of Ilam District in 1863. However, it is believed by historians that the first tea bushes in Nepal were grown from seeds which were given as a gift by the Chinese Emperor to the then Prime Minister and de facto ruler of Nepal, Jung Bahadur Rana. It is believed that tea plantation in Nepal started within the same decade, when it was introduced in Darjeeling Hills of India. Mr Gajaraj Singh Thapa is the remarkable name in Nepalese Tea history who planted tea first time in Ilam District of Nepal. Visioning better future prospects of the tea industry in Nepal, in 1965 a second tea plantation, Soktim Tea Estate was set up in the plains of Jhapa district. After the democratic movement of 1950, floor was opened for investment in the industry. As a result, the stagnant tea industry witnessed an inflow of public and private investment. First tea plantation at private tea sector in Tarai was established in 1959 and was registered with the name of Bhudhakaran Tea Estate. From 1978 to the 1990s, various efforts were made by the Nepal Tea Development Corporation to encourage the participation of small and marginal farmers in the growth and production of Tea as a cash crop.

FODDER AND FORAGES

More than 50 species of improved annual and perennial forages (leguminous and non-leguminous) along with more than 30 species of fodder trees are introduced and cultivated in Nepal. However, only fifteen forage species are released by the Pasture and Forage Research Division of Nepal Agricultural Research Council (NARC) till now. Introduction of white clover in Kathmandu was done by Jung Bdr Rana in 1860s. In 1944, introduction of sub-tropical forage species e (Rye grass, cocks foot and paspalum) was done in sheep farm, Chitlang. In 1960/61, subtropical forage species: Pennisetum, Brachiaria, Chloris, Cencrus, etc were introduced. Over 17 different pasture species were introduced in Multi-purpose Agriculture Center, Jiri. About 20 promising germplams have been maintained in Fodder and Pasture Research Division, Khumaltar.

Table 17. Introduced fodder and forage germplasms and maintained at Fodder and Pasture Research Division, Khumaltar

SN	Common name	Scientific name	Exotic germplasms	Country of origin
1.	Teosinte	Euchlaena mexicana Schrad.	Makaichari 1	USA
2.	Common vetch	Vicia sativa L.	Kutil Kosha 1	Turkey
3.	Stylo	Stylosanthes guianensis (Aubl.) Sw. var. guianensis	Palpa Stylo	USA
4.	Cocksfoot	Dactylis glomerata L.	Rasuwa Cocksfoot	UK
5.	Napier	Pennisetum purpureum Schumach.	Hatti Ghash 1	Africa
6.	Setaria	Setaria anceps Stapf ex Massey	Khumal Bansho	Africa
7.	Naked oat	Avena sativa L.	NZA3/1, NZA 3/13, NZA3/14, NZA3/17, NZA 3/18, NZA3/22, NZA3/32, NZA3/33, NZA3/40	New Zealand
			Baiyan 4, Baiyan 8, Baiyan 10, Baiyan11	China
8.	Ubon paspalum	Paspalum dimidiatum L.		Bangkok
9.	Mombasa guinea grass	*Panicum maximum* Jacq. cv.Mombasa		Bangkok
10.	Tanzania guinea	Panicum maximum *Jacq. cv.Tanzania*		Bangkok

SN	Common name	Scientific name	Exotic germplasms	Country of origin
	grass			
11.	Ubon stylo	Stylosanthes acuminata M.B.Ferreira & Sousa Costa		Bangkok
12.	Desmodium green leaf	Desmodium intortum (Mill.) Urb.		Bangkok
13.	Mulato II	Brachiaria ruziziensis Germ. & C.M.Evrard		Bangkok
14.	Cobra CIAT			Bangkok
15.	Setaria splendida	Setaria sphacelata (Schumach.) Stapf & C.E.Hubb. ex Moss		
16.	Signal	Brachiaria decumbens Stapf		
17.	Joint vetch	Aeschynomene americana L.		
18.	Kudzu	Pueraria thumbergiana (Siebold & Zucc.) Benth.		
19.	Red clover	Trifolium pratense L.		
20.	Lucerne series	Medicago sativa L.		

WAY FORWARD

All quantitative information showed that Nepal is 90-100% dependent on foreign germplasms for varietal development and this dependency is expected to increase with climate change as pest and disease outbreak in major crops resulting from increased heat, drought and erratic rainfall. It is important that the introduced crop should not post any threat to indigenous and or available genetic resources. Moreover, fruit germplasms collected and maintained till to-date in Government farms are scattered all over the country. A National Genetic Resource Centre (NGRC) for fruit and nut germplasm repository should be established to utilize these introduced and existing fruit and nut species in fruit development activities. These germplasms available in public institutions and private farms should be characterized, evaluated, multiplied and selected for wider geographical recommendation based on yield performance, export quality and market niches from the single door. NARC, as a leading apex body for fruit research should define lead centre for each commodity and focus on variety improvement and production technologies on national level. In-situ evaluation of these genotypes using a common protocol could be a worth at initial step whether they are under public or private description. Elite genotypes should be multiplied and mother plants should be supplied to private nurseries for commercial sapling production. Some of the exotic materials except fruits and nut species have already been evaluated, selected, multiplied, maintained and notified in national system while many are still needs to be evaluated and utilized. The promising introduced APGRs should be evaluated, selected and utilized for food and nutritional security. Attention on variety development is virtually lacking in fruits, ornamentals, tea and coffee.

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Annex 1. Introduced and released crop varieties in Nepal

SN	Crop	Varieties	Released year	Country of origin	Status
1.	Early rice	Hardinath-1	2004	Srilanka	Released
		Chaite-6	1991	IRRI	Released
		Chaite-4	1987	IRRI	Released
		Chaite-2	1987	IRRI	Released
		Bindeshwori	1981	India	Released
		CH-45	1966	IRRI	Released
2.	Main season rice	Radha-14	2016	IRRI	Released
		Sugandhit Dhan-1	2016	India	Released
		Sukkha Dhan-4	2014	IRRI	Released
		Sukkha Dhan-5	2014	IRRI	Released
		Sukkha Dhan-6	2014	IRRI	Released
		Sambha Masuli Sub-1	2011	IRRI	Released
		Swarna Sub-1	2011	IRRI	Released
		Barkhe - 2014	2011	IRRI	Released
		Sukhha Dhan -3	2011	IRRI	Released
		Sukhha Dhan - 2	2011	IRRI	Released
		Sukhha Dhan - 1	2011	IRRI	Released
		Tarahara-1	2010	IRRI	Released
		Hardinath-2	2010	Indonesia	Released
		Ghaiya -1	2010	IRRI	Released
		Barkhe 3004	2006	IRRI	Released
		Ram Dhan	2006	India	Released
		Mithila	2006	Philippines	Released
		Chandannath - 3	2002	China	Released
		Chandannath - 1	2002	China	Released
		Radha-12	1995	India IRRI	Released
		Radha-11	1995	India IRRI	Released
		Radha-4	1995	India IRRI	Released
		Khumal-9	1990	Nepal IRRI	Released
		Khumal-7	1990	Nepal IRRI	Released
		Ghaiya-2	1987	India	Released
		Makwanpur-1	1987	Sri Lanka	Released
		Khumal-3	1984	India	Released
		Kanchan	1982	IRRI	Released
		Himali	1982	IRRI	Released
		Sabitri	1979	IRRI	Released
		Janaki	1979	Sri Lanka	Released
		Masuli	1973	Malaysia	Released
		Chainan-2	1967	Taiwan	Released
		Tainan-1	1967	Taiwan	Released
		Chainung-242	1967	Taiwan	Released
		Taichung-176	1967	Taiwan	Released
3.	Maize	Arun-6	2015	CIMMYT	Released
		KYM-33	2014	CIMMYT	Released
		KYM-35	2014	CIMMYT	Released
		Poshilo Makai-1	2008	CIMMYT	Released
		Manakamana-4	2008	CIMMYT	Released
		Shitala	2006	CIMMYT	Released
		Deuti	2006	CIMMYT	Released
		Manakamana-3	2002	CIMMYT	Released
		Ganesh-1	1997	CIMMYT	Released
		Arun-2	1981	CIMMYT	Released
		Rampur Composite	1975	Thailand	Released
		Khumal Pahenlo	1965	India	Released
4.	Wheat	Tilottama	2016	CIMMYT	Released
		Danphe	2016	CIMMYT	Released
		Nepal- 971	2010	CIMMYT	Released

SN	Crop	Varieties	Released year	Country of origin	Status
		WK- 1204	2007	CIMMYT	Released
		Kranti	1997	CIMMYT	Released
		Pasanglhamu	1997	CIMMYT	Released
		Achyut	1997	India	Released
		Annapurna-4	1994	CIMMYT	Released
		Bhrikuti	1994	CIMMYT	Released
		Annapurna-3	1991	CIMMYT	Released
		Annapurna-1	1988)	CIMMYT	Released
		Nepal-297	1985	India	Released
		UP-262	1978	India	Released
		RR-21	1970	CIMMYT	Released
		Lerma-52	1960	Columbia	Released
5.	Barley	Ketch	1974	Australia	Released
		CI-10448	1974	USA	Released
		Galt	1974	USA	Released
		HBL-56	1974	India	Released
		Bonas	1974		Released
6.	Finger millet	Sailung Kodo-1	2015	India	Released
		Kavre Kodo-2	2015	India	Released
		Dalle-1	1980	India	Released
7.	Buckwheat	Mithe Phaper-1	2015	Japan	Released
8.	Lentil	Maheshwor Bharati	2007	Syria	Released
		Sagun	2007	Syria	Released
		Shital	2004	Pakistan	Released
		Khajura Musuro-2	1999	India	Released
		Khajura-1	1999	India	Released
		Shikhar	1990	Pakistan (ILL4404)	Released
		Simal	1990	India (LG7)	Released
		Shishir	1979	India (P43)	Released
		Simrik	1979	India (T36)	Released
9.	Chickpea	Avrodhi	2008	India	Released
		Kalika	1990	India (ICCCL-82108)	Released
		Kosheli	1990	India (ICCCC-32)	Released
		Sita	1987	India(ICCCC-4)	Released
		Radha	1987	India (JG-74)	Released
10.	Soyabean	Puja	2006	India	Released
		Tarkari Bhatmas-1	2004	China	Released
		Cobb	1990	USA	Released
		Seti	1990	AVRDC, Taiwan	Released
		Ransom	1987	USA	Released
		Hardee	1977	USA	Released
11.	Pigeon pea	Rampur Arahar-1	1992	India	Released
12.	Black gram	Kalu	1989	India	Released
13.	Cowpea	Malepatan-1	2011	Nigeria	Released
		Surya	2004	Nigeria	Released
		Prakash	1990	Nigeria (IT82-D 789)	Released
		Akash	1990	Nigeria (IT82-D 752)	Released
14.	Mung bean	Pratikshya	2006	AVRDC	Released
		Kalyan	2006	AVRDC	Released
		Pusha Baishakhi	1975	India	Released
15.	Rapeseed (Tori)	Preeti	2005	India	Released
		Bikash	1989	India	Released
		T-9	1980	India	Released
16.	Mustard (Rayo)	Krishna	1998	India	Released
		Pusa Bold	1988	India	Released
17.	Niger	Nawalpur Khairo Til-1	2000	India	Released
		Nawalpur Jhuse Til-1	2000	India	Released
18.	Ground nut	Baidehi	2005	ICRISAT	Released

SN	Crop	Varieties	Released year	Country of origin	Status
		Rajharshi	2005	ICRISAT	Released
		Jayanti	1996	India	Released
		Jyoti	1996	India	Released
		Janak	1989	India	Released
		B-4	1980	India	Released
19.	Sugarcane	Jiptur-4	2004	India	Released
		Jiptur-3	2004	India	Released
		Jiptur-2	1996	India	Released
		Jitpur-1	1996	India	Released
20.	Jute	Itahari-1	1999	Brazil	Released
		Itahari-2	1999	Taiwan	Released
21.	Cotton	Tamcot S.P.-37	1988	USA	Released
22.	Potato	Khumal Ujjwal	2014	USA	Released
		Khumal Upahar	2014	CIP	Released
		Khumal Laxmi	2008	CIP	Released
		IYP-8	2008	CIP	Released
		Khumal Seto-1	1999	Argentina	Released
		Khumal Rato-2	1999	India	Released
		JanakDev	1999	Mexico	Released
		Desire	1992	Netherlands	Released
		Kufri Sinduri	1992	India	Released
		Kufri Jyoti	1992	India	Released
23.	Cauliflower	Sarlahi Dipali	1994	India	Released
		Dolpa Snowball	1994	Holland	Released
24.	Radish	Chalis Dine	1994	Japan	Released
		White Neck	1994	Japan	Released
		Mino Early	1990	Japan	Released
25.	BLM (Rayo)	Khumal Chaudapat	1994	India	Released
26.	Turnip	Purple Top	1994	Japan	Released
27.	Onion	Red Creole	1990	India	Released
28.	Tomato	Roma	1994	USA	Released
		Manprekas	1994	Holland	Released
		NBL-1	1994	Taiwan	Released
		Pusa Ruby	1990	India	Released
29.	Carrot	Nantis Forte	1990	India	Released
30.	Cabbage	Copenhagen Market	1994	Netherland	Released
31.	Pole Bean	Trishuli Simi-1	1994	USA	Released
		Jhange Simi-1	1994	USA	Released
32.	Pea	Sarlahi Arkel	1994	India	Released
		New Line	1994	USA	Released
		Sikkime	1994	India	Released
33.	Capsicum	California	1994	USA	Released
34.	Chilli	Jwala	1994	India	Released
35.	Brinjal	Nurki	1994	India	Released
36.	Squash (Jukini)	Ashare Squash	1994	USA	Released
37.	Swiss Chard	Susaag	1994	Holland	Released
38.	Bitter Gourd	Green Karela	1994	India	Released
39.	Ladies Finger	Parbati	1994	India	Released
40.	Spinach	Haripate	1994	India	Released
41.	Oat	Amritdhara	2015	New Zealand	Released
		Nandini	2015	India	Released
		Parbati	2012	New Zealand	Released
		Ganesh	2012	New Zealand	Released
		Kamdhenu Jai	2004	New Zealand	Released
		Netra Jai	2004	Canada	Released
42.	White Clover	Pauli White Clover	2012	UK	Released
43.	Berseem	Berseem Green Gold	2015	India	Released
44.	Rye Grass	Dhunche Rye Ghansh	2015	New Zealand/UK	Released

Sourc : NARC 2014, SQCC 2013.

Annex 2. Crop varieties that are developed from introduced parent material in Nepal

SN	Crop	Cultivar/line/accession	Registered year	Country of origin	Status
1.	Rice	Sindhuri	2015	India	Registered
		Sundaram	2015	India	Registered
		Delta Rani	2015	India	Registered
		Akash	2015	India	Registered
		Garima	2015	India	Registered
		DRH-775	2015	India	Registered
		DRH-748	2015	India	Registered
		Arize-6444 Gold	2015	India	Registered
		Arize Taj Gold	2015	India	Registered
		GK-5017	2015	India	Registered
		Super-125	2015	India	Registered
		Super -115	2015	India	Registered
		Shanti	2015	India	Registered
		Sudha	2015	India	Registered
		US-323	2015	India	Registered
		US-382	2015	India	Registered
		Barkhe -1027	2011	The Philippines	Registered
		Sawa Mansuli	-	India	Not registered
		Malesiy	-	Indian	Not registered
		Sarju- 52	-	Indian	Not registered
		Sona Mansuli	-	Indian	Not registered
		Kanchhi Mansuli		Indian	Not registered
2.	Cowpea	Double Harvest	2010	China	Registered
3.	Potato	TPS-1	2014	CIP	Registered
		TPS-2	2014	CIP	Registered
4.	Radish	Rocky-45	2013	Bangladesh	Registered
		All Season White, OP	2010	Korea	Registered
		Mino Early Long White, OP	2010	Korea	Registered
		Any Season, OP	2010	Korea	Registered
5.	Mustard (Rayo)	Mike Giant, OP	2010	Japan	Registered
		Red Giant, OP	2010	Japan	Registered
6.	Onion	Nasik-53	2011	India	Registered
7.	Tomato	Jina, OP	2012	Vietnam	Registered
8.	Carrot	New Koruda, OP	2010	Japan	Registered
9.	Asparagus Bean	Karma Stickless	2013	Thailand	Registered
		NO-324	2013	Japan	Registered
		Sila-464	2013	Thailand	Registered
		Chandra 041, OP	2010	Thailand	Registered
10.	Pole Bean	Mandir, OP	2010	Thailand	Registered
11.	Capsicum	Sagar, OP	2010	Thailand	Registered
12.	Brinjal	Arka Keshav, OP	2010	India	Registered
13.	Ladies Finger	Arka Anamika, OP	2010	India	Registered
14.	Coriander	American Long Standing	2013	Italy	Registered
		Lotus, OP	2010	Thailand	Registered
		Suravi, OP	2010	India	Registered
15.	Asparagus	Meri Washington 500W, OP	2010	Japan	Registered
16.	Parsle	Parsle Green Carpet, OP	2010	Japan	Registered
		Soi Sim, OP	2010	Japan	Registered
		Seleri Utah Tall Green, OP	2010	Japan	Registered
17.	Knol Khol	Samrat, OP	2010	Japan	Registered
18.	Pakchoy	Choko, OP	2010	Japan	Registered
		Cyantong White, OP	2010	Japan	Registered
19.	Lettuce	Green Span, OP	2010	Japan	Registered
		Green Web, OP	2010	Japan	Registered
		New Red Fire, OP	2010	Japan	Registered
20.	Sugar Beet	Mathur, OP	2010	India	Registered

Source: NARC 2014, SQCC 2013.

Custodian Farmers, Agrobiodiversity Rich Areas and Agrobiodiversity Conservation Initiatives at Grass Root Levels in Nepal

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ABSTRACT

Agricultural biodiversity is one of the most used subset of biological diversity in securing foods and nutrition globally. In recent decades, there is rapid loss of functional agrobiodiversity from the farming systems, threatening the future sustainability of food systems and livelihoods of smallholder farmers. To halt the process, ex-situ, in-situ and on-farm conservation strategies are developed and applied for agrobiodiversity conservation. In recent years, the value of local crop genetic resources conservation and use are being recognized due to its ability to adapt changing climatic and agro-ecological environment. In Nepal, there is incredible partnership established among LI-BIRD (Research and development NGO), national research and extension systems and CGIAR centers particularly the Bioversity International to develop, validate and scale up successful on-farm agrobiodiversity conservation approaches and methods. In early 2000, a number of community-based practical approaches for promoting on-farm management of local crop varieties had been developed focusing on documentation, awareness raising, improving performance of local crops, diversifying niche production systems and increasing market-based incentives. In addition, identification and supporting custodian farmers who continuously grow, select, maintain and disseminate seeds/planting materials is found effective for on-farm conservation of locally rare crop varieties in the production environment. Similarly, community seed bank and participatory plant breeding have demonstrated as the grounded and scalable approaches in terms of providing direct benefit to communities, empowering local communities and building collective action which is vital to ensure community participation and make conservation effort sustainable. Agrobiodiversity rich farmers (ARFs) and agrobiodiversity rich areas (ARAs) of Nepal are described in this paper along with community seed banks as an effective conservation initiative. ARAs along with ARFs should be extensively identified, characterized and documented as a national priority for enhancing on-farm conservation of agrobiodiversity in the country.

Keywords: Agrobiodiversity conservation, agrobiodiversity rich farmer, community based approaches, custodian farmers

INTRODUCTION

Agricultural biodiversity is one of the few resources available to ensure sustainable food production and livelihoods for the humankind. Much of the world's crop diversity is conserved in traditional smallholder farming systems where farmers cultivate and select their crops to fulfill the needs of local production, maintaining livelihoods and socio-cultural uses (Gruberg et al 2013). The continued cultivation of traditional crops and landraces on-farm is necessary to preserve knowledge associated with the crop varieties and the continuation of dynamic processes of crop adaptation to changes in climate, crop pests, disease which are not possible under ex-situ genebank conditions (Jarvis and Hodgkin 2000, Caillon and Degeorges 2007). Despite these realities, there is rapid loss of agricultural biodiversity from the production systems in almost all part of the world that has increasingly threatened the future sustainability of food systems and livelihoods of smallholder farmers who primarily depend on farming.

In early 1990s, Convention on Biological Diversity (CBD) came into force and emphasizing the importance of in-situ and on-farm conservation as a complementary strategy for halting the rapid loss of biodiversity including crop genetic resources from the farming system. International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) developed provisions on recognizing contributions of farming communities for conservation of traditional crop varieties and landraces and also facilitating exchange of crop genetic resources. From early twenties, scientific communities realized the urgency adopting and implementing multiple strategies and approaches to promote on-farm conservation and sustainable utilization of agricultural biodiversity so that we could reduce over-reliance on handful of crops posing great risk to our food system in the face of climate change.

Agricultural biodiversity is the backbone for the sustainable agricultural development, food and nutrition security and poverty elimination (Maharjan and Joshi 2011). In-situ and on-farm conservation of agricultural biodiversity was started in Nepal during late nineties through In-situ Global project which has developed a number of community based methodologies and practices in promoting on-farm conservation and utilization of agricultural biodiversity. Agrobiodiversity rich farmer (ARF) and diversity rich areas are the key factors to consider for effective on-farm conservation. Involving ARFs in conservation works, different conservation initiatives could have great impact on maintaining agrobiodiversity.

CONSERVATION IN PARTNERSHIP AND FARMERS

A unique partnership between national research system (Nepal Agricultural Research Council /Genebank, international research organization (Bioversity international) and the non-government organization-Local Initiatives for Biodiversity Research and Development (LI-BIRD) has been demonstrated to work on this areas in the country. There is continuous partnership among these organizations to work together in developing on-farm conservation approaches and tools, national policy drafting and amendment processes, implementing of ITPGRFA provisions and documenting and disseminating knowledge and information nationally and globally.

From the late 1990s public private partnership had successfully implemented and developed many conservation initiatives on-farm (**Table** 1). In Nepal, through establishing and promoting community seed banks along with other conservation efforts, we have been able to demonstrate role of local communities and their institutions to maintain and manage local genetic resources for food and nutrition (Upadhyay et al 2008). In recent years, community seed bank has been emerged as an effective rural institution at the community level to strengthen farmer's access to diversity of crop genetic resources as well as provisioning seeds of local needs that has significantly contributed to local food security and conservation of agricultural biodiversity on-farm.

Farmers are increasingly recognized as stakeholders in conservation as they possess the knowledge of cultivating and using their agricultural plant genetic resources (APGRs) traditional crops and landraces which are usually well adapted to the local conditions. Not all farmers or households are equally involved in the conservation of agricultural biodiversity. There are certain men and women playing a crucial role in the management and use of agricultural biodiversity within farming communities (Ruiz and Vernooy 2011). Understanding the greater role of custodians in agrobiodiversity conservation is unique area of research nationally and globally.

When we talk about on-farm conservation of agricultural biodiversity, conservation through use is the most fundamental element to make sure there is continued cultivation of traditional crops and landraces in the production system. The motivation and engagement of individual farmers and community based organizations plays crucial roles to sustain and promote conservation and use of traditional and local crop varieties through multiplying and increasing access to seeds, planting materials and transferring production skills locally. It is therefore necessary to recognize and support custodian farmers who make exceptional contributions to on-farm conservation.

Table 1. Synopsis of the engagement of LI-BIRD, NARC, MoAD/DoA and Bioversity International in areas of conservation and utilization of agricultural biodiversity on-farm in Nepal

Timeline	Priorities	Contributing projects	Collaborating partners	Funding partners
1996-2003	Understanding the dynamics of on farm management agrobiodiversity Development of approaches, methods and tools for assessment and promotion of on farm conservation and utilization of agrobiodiversity • Diversity fairs, Community Biodiversity Register, Participatory Plant Breeding (PPB), CSB	In-situ crop conservation NUS-finger millet	LI-BIRD, NARC, Bioversity International	IDRC, IFAD
2004-2010	Testing/validation and refinement of good practices management of agricultural biodiversity on farm • CSB and other CBM approach and	Western Tarai Complex Landscape Linking Biodiversity with markets	LI-BIRD, NARC, Bioversity International, MoAD, DoA/DADO	DF Norway, UNDP, SDC

Timeline	Priorities	Contributing projects	Collaborating partners	Funding partners
	practices • PPB/GB-development and release of PPB varieites (pokhareli JB) Formulation of Agrobidoveristy policy and amendment of seed policy and regulation	Community based Biodiversity Management (CBM) Community Biodiversity Register		
2011-2016	Mainstreaming/scaling up, integration and replication approaches and large scale implementation • CSB and CBM practices • PPB/Grass-root breeding, registration and seed production of local crops • Custodian farmers	Community Based Biodiversity Management (CBM) Westen Tarai Complex Landscape NUS Amaranth Diversifying availability of Diverse seeds Local Crop Project	LI-BIRD, NARC/NAGRC, Bioversity International, DoA/DADOs	DF, UNEP, SDC, IFAD

PPB, Participatory plant breeding; LI-BIRD, Local initiatives for biodiversity, research and development; CSB, Community seed bank; DoA, Department of agriculture; DADO, District agricultural development office; NARC, Nepal agricultural research council; NAGRC, National agriculture genetic resources center; DF, Development fund; UNEP, United nations environment programs; SDC, Swiss agency for development and cooperation; IFAD, International fund for agricultural development; NUS, Neglected and underutilized species; IDRC, International development research center; UNDP, United nations development program; MoAD, Ministry of agricultural development.

AGROBIODIVERSITY RICH FARMERS

Farmers across the country continue growing crop varieties/ landraces and select and save seeds. There are some farmers who stand out in farming communities due to their unique characteristics. They usually maintain large amount of crop diversity on their farms. They deliberately grow local crop varieties and prefer to continue cultivation, selection and use unique and locally threatened crop varieties. Through their engagement, they usually hold rich traditional knowledge on production, seed management and uses of local crops and also share information and materials without expecting anything from others. They are usually innovative and active to acquire new information about crop varieties. Community people are well known about such farmers and usually recognize them as leader farmers.

Agrobidiveristy rich farmers (ARFs) also known as "custodians of agrobiodiversity" or custodian farmers (CFs) are those who have maintained large numbers of crop landraces and species, are active to maintain, adapt and promote local crop varieties and have conservation mind. They are the strategic actors in on-farm conservation who, for various reasons, distinguish themselves from others by their contribution to conserving crop diversity (Gruberg et al 2013, Sthapit et al 2013). Some features of ARFs are given in **Box** 1.

> **Box** 1. Key characteristics of agrobiodiversity rich farmers (ARF)
> - Driven by conservation ideology and use of genetic resources
> - Knowledge holder on agricultural biodiversity
> - Recognized source of plan materials and seeds
> - Motivated, committed, self-directed
>
> *Source: Byrnes and Sthapit 2016*

LI-BIRD in collaboration with Bioversity International, USC Canada and other partners in Nepal have identified characteristics of Nepalese custodian farmers, validated them through organizing custodian's survey, workshops and initiated profiling some of them. These findings have been documented for wider dissemination and application at national and international levels (Sthapit et al 2015). Field verification through survey has confirmed that custodian's farmers grow and maintain rich diversity of crops and varieties than any other farmers in the communities. They are the source of seeds and planting materials of locally available crop varieties (**Figure** 1).

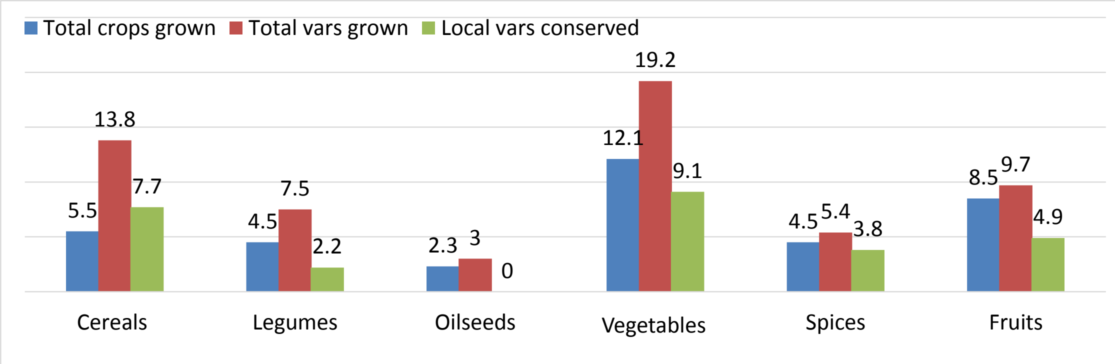

Figure 1. Average number of crops and varieties conserved and maintained on-farm by custodian farmers in Nepal.

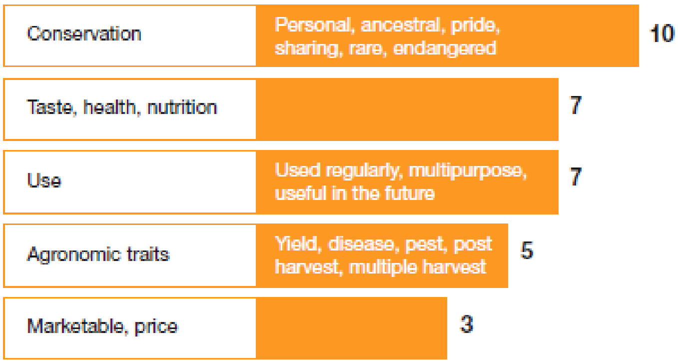

Figure 2. Selection criteria used by custodian farmers to select their top 10 varieties to share with others.

In a custodian workshop (2013), participating farmers were asked to bring seeds of top ten varieties that they considered the most important and noteworthy to share with others. Sthapit et al (2013) documented the selection criteria of the farmers used to identify their preferred varieties (Figure 2). The most commonly reported criteria were conservation of rare and unique variety followed by taste and nutrition and multiple uses. Agronomic traits such as yield and market price are the least referred criteria. It has indicated that custodian farmers have high motivation to conserve local crop varieties that have good taste, nutritious and have multiple uses values.

Custodian farmers have greater role in on-farm conservation of agrobiodiversity. They are self-motivated, committed and engaged in conservation even without external support. They are valuable resources both for seed and traditional knowledge. They motivate other farmers to engage in conservation. However, the roles of custodian farmers are not adequately recognized, harnessed and supported by society. Identification and profiling of custodian farmers spread over the country is very important initial step to recognize and engaging them. A simple six step procedure has been proposed by Sthapit et al (2013) for identification and documentation of custodian farmers (Figure 3). Profiling ARFs has been realized useful as it provides information about the person or families to share with others. ARFs feel recognized themselves if profiles are prepared with information listed in Box 2. There is a greater role of ARFs to establish and functions community seed banks. The interlink between CSB and ARFs are presented in Figure 4.

Box 2. Custodian's profiling

- Introduction – household, landscape, farm, livelihood activities
- Maintain – which crops and landraces?
- Promote – share knowledge and seeds – what, which and how?
- Adapt – improve, evaluate or select seeds – which and how?
- Motivations – Anecdotal stories showcasing why?
- Unique features – why is this person special or different than others?
- Continuation – involve younger generation?
- Support – needs and requests

Source: Sthapit et al 2013

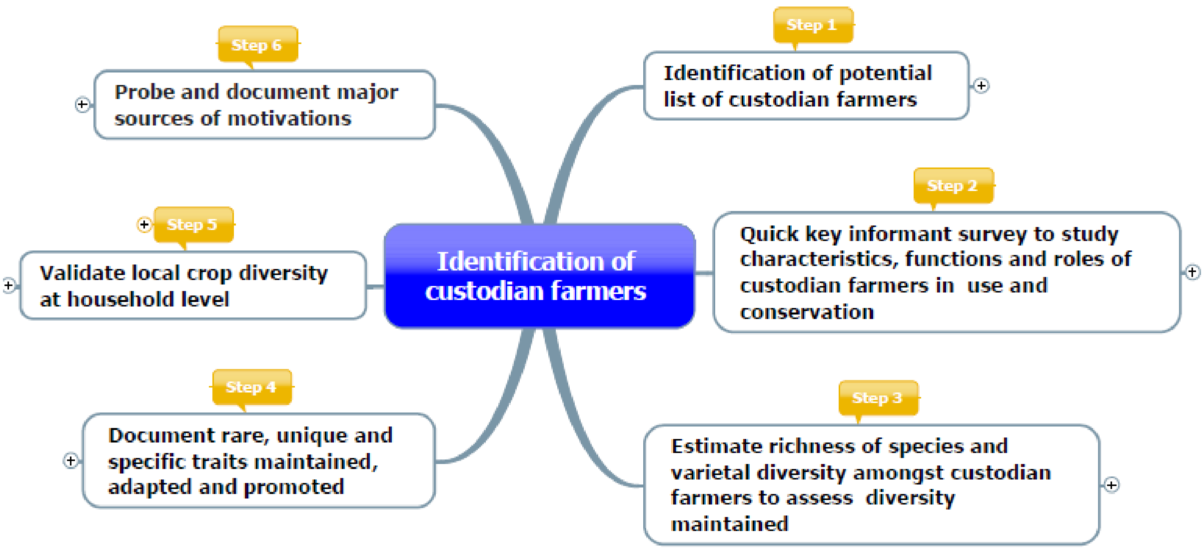

Figure 3. Suggested steps for documenting custodian farmers, their resources and motivation.

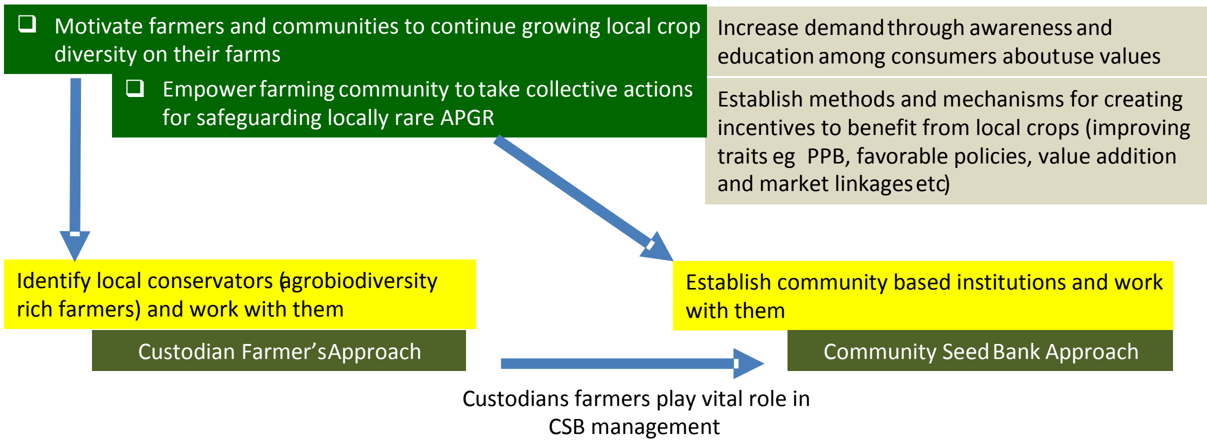

Figure 4. Community seed bank, custodian farmers and interlinks in promoting conservation and utilization of agricultural biodiversity on-farm.

DIVERSITY RICH AREAS AND FARMERS

Nepal is very rich in agrobiodiversity. Among three agroecozones (Tarai, Mid Hill and High Hill), Mid Hill is relatively higher on agrobiodiversity. Based on the information collected from District Agriculture Development Offices and Regional Workshop, some of agrobiodiversity rich areas and custodian farmers are presented in **Table** 2. Some ARFs have maintained very unique crop landraces (**Figure** 5). However, systematic documentation and verification of the information has been realized necessary. This is the unique area of work which the country should prioritize for promoting conservation and utilization of agricultural biodiversity on farm.

Table 2. List of some agrobiodiversity rich areas and farmers

District	Agrobiodiversity rich area	Custodian farmer	Address
Baglung	Gagantudanda, Damak, Rangknani	Vimala Gharti Magar	Righa-4
		Mayer Singh Paija	Gwalichaur-7
Bara	Kochrwa, Basbariya, Katahariya, Ramnagar		
Bardia	Padanaha, Dhodari	Hariram Tharu	Padanaha-3
		Radhav Chadra Singh	Dhodari-1
		Karma Prasad Chaudhari	Patabhar-6
		Kaliram Tharu	Beluwa
Sindupalchok	Helambhu, Marming	Pashupati Neupane	Bhimtar-1
		Doyng Dolma	Helambhu-2

District	Agrobiodiversity rich area	Custodian farmer	Address
Dolakha	Jugu	Keshav Kadka	Jugu-2
Darchula	Dhusa, Kandeshowri, Rapla	Gore Bohora, Amarsingh Bohora, Krishna Dutta Bhatta	Ranisikhar-7
		Dhanbahadur Mahar	Latinath-9
		Ganga Dutta Joshi, Ganesh Raj Joshi	Latinath-7
Dhading	Tipling, Jharlang, Setung, Mahadevsthan	Iswori Prasad Bhatta	Maidi-1
		Radhika Rijal	Ni na pa-3
Kapilbastu	Badganga, Bhrijuti, Sivaraj	Ramsebak Kahar, Ram Kishor Teli	Sauraha-8
Laitpur	South Lalitpur (Dalchowki, Chughare, Kaleshowr, Manikhel, Bungmati)	NA	
Lamjung	Ghanpokhara, Bajhakhet	Nanda Bahadur Gurung, Khageshor Gurung	Ghapokhara-5
Tanahu	Purkot Community Seed Bank	NA	
Syanja	Pakabadi, Aruchaur, Chapakot	Chudamani Regmi	Pakabadi-8
		Dinesh Chandra Poudel	Chapakot-1
		Jhapad Bahadur Chettri	Aruchaur-5
Nawalparasi	Devchuli, Kumarbarti	Om Narayan Chaudhari	Madhyabindu Mu.
		Rishiram Kadel	Bulingtar
Nuwakot	Sikharbesi, Khimtang	Khadka Bahadur Raila	Madanapur-6
Okhaldhunga	NA	Tej Bahadur Bogati	Mulkharka
Palpa	Barhaguma	Krisha Bahadur Kunwar	Nayarnamatles-1
		Asara Gaire	Pokharathok-3
Rupandehi	NA	Kulananda Pande	Sainamaina-4
		Dunaraj Sharma	Amuwa-1
Kailali	Gadariya, Masuriya	Khem BahadurChand	
		Parbati Sapkota	Musariya-5
		Shovapati Chaudhari	Gadariya-3
Parbat	Pangrang, Dharing	Buddiram Sharma	Kurgha-2
		Gum Bahadur Pun	Salija-9
Parsa	Biruwagathi, Bagbana	Nayan Kumar Chapagai	Gadi-7
		Yogendra Chaudhari Tharu	Biruwagatthi-6
Udayapur	Triyouga, Lekhani, Saune	Som Bahadur Danuwar	Triyouga-13
Saptari	Fattepur, Sitapur, Dharmapur, Terahauwa, Jandol, Chhinamasta	Dhaniklal Shah	Haripur
		Suku Kumar Shah	Khochabkhari
		Indradev Chaudhari	Pansera-5
Rasuwa	Thuman	Singidorje Tamang	Goljung-5
		Kami Chhirng Tamang	Haku-3
Sankhuwasawa	Tamaphok, Jaljala	Sanaman Poudel	Bana
		Rama Kafle	Sitalpati
Bhojpur	Timma	Shambhu Raj pandey	Sidheswor-4
		Rabindra Karki	Gupteshowr
		Balananda Dhakal	Bhojpur-11
Solukhumbu	Lokhim, Salyan	Khumbudhan Rai	Lokhim-4
Dhankuta	Patle, Khoku, Mulghat, Sanne	Dev Prakash Shrestha	Sanne-4
		Narayan Bhandari	Belhara
		Gopal Thapa	Ghorlikharka
Illam	Girmale, Kannyam, Antu	NA	
Taplejung	Khewang, Thukimba, Tapethok, Lelep, Olangchunggola	Budhalal Limbu	Tapethok-2
		Milan Saba	Papung-4
		Jyabu Sherpa	Lelep-7
Terahthunm	Laligurang, Samdhu	Chadra Bahadur Maden	Sudap-8
		Ram Krishna Niraula	Manglung-5
Panchthar	Tharpu, Yangnam, Nangin		
Morang	Motipur, Patheni	Lila Magar	Pati
		Mukti Baral	Rajghat

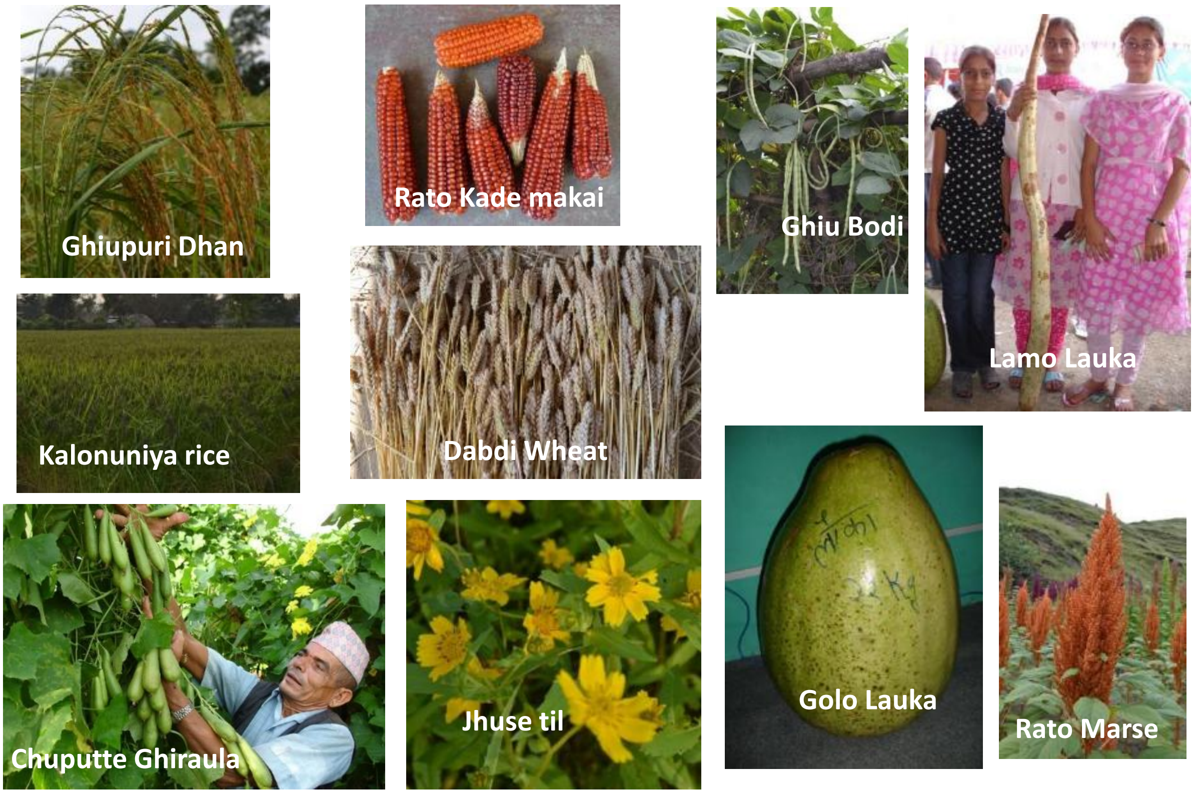

Figure 5. Some unique local landraces conserved by custodian farmers.

CONSERVATION INITIATIVES

Different conservation initiatives have been developed and implemented at grass root levels starting from late 1990s by NARC, LIBIRD, DoA and Bioversity International. Some of initiatives are Aqua pond genebank, Landrace as geo indicator, Landrace enhancement and conservation (LEC), participatory plant breeding, Community genebank (community seed bank and community field genebank), Landraces catalog, Conservation ladder, Livestock farm genebank, Crop specific park, Cultivar mixture (varietal blend), Pre breeding, Diversity block, Red listing APGRs (Joshi et al 2004), Diversity fair, Rescue collection mission, Diversity field school, Diversity kit, School field genebank, Seed herbaria, Village level field genebank, Household genebank (household seed bank, household field genebank), etc (Joshi et al 2016, Joshi 2017). Among them community seed bank is very effective for on-farm conservation in Nepal.

Community Seed Bank

Community seed bank (CSB) is a community based mechanism to enhancing local seed security, responding to local seed demands, enhancing farmers' access to quality seeds, and promoting on-farm conservation of local crop diversity. The need of CSB has been realized worldwide due to following reasons:

- Supply of quality seeds of portfolio of crops and varieties produced locally, which will strengthen local seed systems to increase diversity and production by providing easy access and availability of adapted crop varieties suitable to the locality
- Increase awareness and education on importance of PGRFA for current and future food and nutrition security which will help conserve local PGRFA and associated knowledge and practices that are rapidly being lost from farmers' field and natural habitat
- Empower farmers' and their institutions and promote farmers' rights and food sovereignty

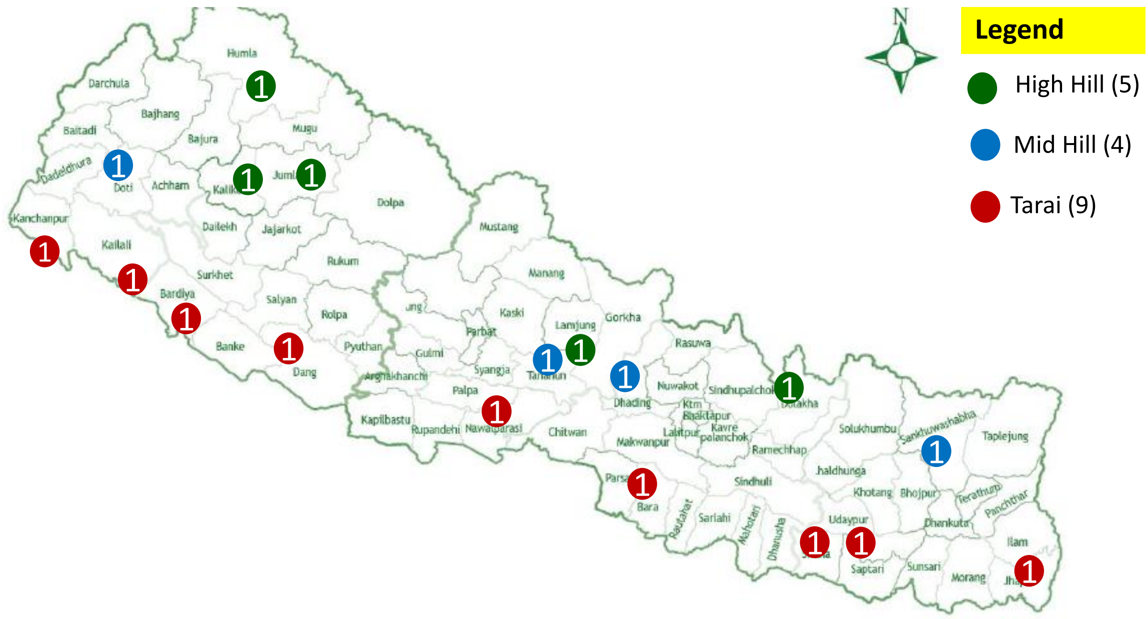

Figure 6. CSBs established by LI-BIRD and other organizations where APGRs have been managed.
Figure in parenthesis indicates the number of crop species.

In Nepal, USC Canada initiated community seed bank in 1990s (Joshi 2013) and later NARC, LIBIRD and DoA have established CSBs across the country to enhance on-farm conservation (**Figure** 6). These community seed banks have formed a national CSB committee as a platform to share information, seeds and experiences. Details of CSBs are documented by Shrestha et al (2013). In Nepal, CSBs have been maintaining 1,331 varieties of 62 crop species (**Table** 3). Few CSBs are also engaged in improving local rice varieties through adopting simple form of participatory plant breeding and some involve on seed production of modern varieties.

Table 3. Number of crop species and varieties conserved by CSBs supported by LI-BIRD

SN	Location of CSB	Year of CSB establishment	No of local varieties conserved
1.	Kachorwa, Bara	2003	115 (23)
2.	Belawa, Bardiya	2007	6 (6)
3.	Gadariya, Kailali	2007	119 (16)
4.	Shankarpur, Kanchanpur	2007	18 (8)
5.	Pathraiya, Kailali	2008	95 (30)
6.	Masiruya, Kailali	2008	14 (6)
7.	Tamaphok, Sankhuwasabha	2009	53 (24)
8.	Jogimara, Dhading	2009	48 (19)
9.	Ghanteshwor, Doti	2009	69 (31)
10.	Talium, Jumla	2011	46 (26)
11.	Rampur, Dang	2011	107 (42)
12.	Agyauli, Nawalparasi	2009	68 (25)
13.	Purkot, Tanahun	2009	121 (34)
14.	Shivagunj, Jhapa	2009	167 (41)
15.	Lahan, Siraha	2015	55
16.	Katari, Udayapur	2015	64
17.	Jugu, Dolakha	2016	29 (11)
18.	Ghanpokhara, Lamjung	2016	36 (12)
19.	Haku, Jumla	2016	25 (12)
20.	Chhipra, Humla	2016	55 (27)
	Total		1,310

The linkage between CSBs and national genebank has been emphasized in Nepal which is the unique example for sustainably managing APGRs and institutions. Fifteen CSBs has contributed 908 accessions of 62 crop species of food crops, vegetables, roots and spices to National Genebank for long term conservation and use (**Figure** 7). CSBs play vital role to supply seeds at the time of crisis which has been demonstrated in 2015 mega earthquake in Nepal. Three CSBs which are situated close to the most earthquake affected district supplied 9.9

tons rice seed to farming communities of Gorkha, Lamjung and Tanahun benefitting 1,807 households to immediately transplant rice in the season.

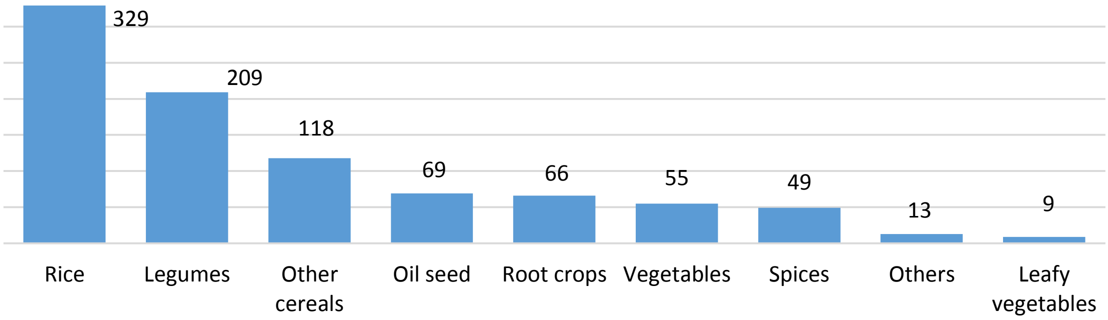

Figure 7. APGRs exchanged with National Genebank by the community seed banks in Nepal.

WAY FORWARD

All farmers are de facto conservationist of crop diversity as long as they continue producing crops and select seeds and planting materials for next season growing. There are some custodian man and women farmers who are dedicated in growing crop diversity, including rare and endangered varieties and hold extensive traditional knowledge associated with crop varieties. In fact, they are the source of materials and knowledge reservoir regarding local varieties, species and their unique traits or uses. However, most of them have remained in low profile and rarely participate in workshops and meetings and therefore difficult to immediately identify by the outsiders. Some farmers with the highest levels of crop diversity do not necessarily share their knowledge and materials with the communities. It is a poorly explored and utilized territory of research nationally and globally. It is therefore necessary to identify and document the role of custodian in conservation and local seed system and make them entry points when targeting interventions of agrobiodiversity programs and projects.

Custodian farmers are the knowledge source to be utilized by communities and researchers. Use of custodian farmers in on-farm conservation of agricultural biodiversity is the low cost approach and complements ex-situ genebank conservation approach. These farmers function as nodal point for field testing, multiplication and popularizing promising materials identified through national research and extension programs. Custodian farmers are the ones who are very active to operate house hold genebank as well as community seed banks locally and therefore play crucial role for empowering communities, building local institutions and ensuring famers' rights. However, the key issue is how policy can support and create adequate space for custodian farmers as conservationists, innovators and promoters of agricultural biodiversity on-farm. National policies and programs needs to recognize and engage custodian farmers in agrobiodiversity conservation. Some of suggestions are:

- Organize ARFs workshops, participatory seed fairs to promote seed exchanges, document local diversity and associated knowledge and collect seeds for genebank conservation
- Promote networking of ARFs and link them with CSBs and national genebank to establish effective in-farm and ex-situ linkages
- Strengthen house hold genebank by supporting custodian farmers both technically and financially
- Agrobiodiversity rich areas should be identified and considered such areas for on-farm and in-situ conservation sites. Community seed banks needs to be established and promoted in strategic and agrobiodiveristy rich areas representing agroecological zones.
- Documentation of ARFs, unique crop landraces, traditional knowledge and agrobiodiversity rich areas along with geo-linked traits are necessary
- Conservation initiatives should be expanded at wider scale
- National policies and programmes should recognize contributions of custodian farmer's and CSB communities for on-farm conservation and provide support to sustain them.

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Community and Public Orchards, and Community and School Field Genebanks in Nepal

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ABSTRACT

From millennia, farmers of Nepal have been conserving, managing and utilizing the different agricultural plant genetic resources. This has resulted Nepal to be one of the richest country in biodiversity. Among different methods of on-farm conservation, public and community orchards, and school and village level field genebanks are least used and explored methods for conservation and utilization. Public orchards have been established from ages and farmers have been developing different traditional practices for sustainable use and maintenance of fruit diversity in such orchards. This study tries to gather information about the different form of public orchards and grass root level field genebank existing in country along with some private orchards. The role of such orchards are thoroughly reviewed mainly aligned with its conservation role and tries to suggest some future perspective. There are more than 100s of such public orchards broadly categorized into community orchards, public orchards; school field genebank (school orchard), village level field genebank. It reveals that community orchards are mainly managed by community efforts and mainly aid to conservation and utilization of plant genetic diversity along with preservation of traditional knowledge. These serves as reservoir for local plant genetic resources and traditional knowledge and are platforms where people come together to plant and cultivate local and other varieties of fruit trees, using as focal point for community activities and are established in public land. School orchards are generally established in school area and used as educational resources for student and children. In contrary, private orchards are established by individual. Private farms are for commercial production to maximize profit but have important role in APGRs conservation. Public and community orchards should be converted to community field genebank and they should be managed following the standard practices of community forestry. Most of orchards have very old fruit trees that need to rejuvenate. School field genebank and village level field genebank are the very potential and effective methods of conserving non-orthodox crops.

Keywords: Community field genebank, community orchards, mango orchard, public orchards, school field genebank

INTRODUCTION

APGR is playing a key role in climate change adaptation and mitigation, ecological resilience, and environmental sustainability (Altieri 1999, UNEP 2008, FAO 2011, Mijatovic et al 2013, Vanek and Drinkwater 2013, Zimmerer 2013, Upadhya et al 2016). Farmers and communities have been playing important role in enhancing APGRs biodiversity throughout the history of world agriculture (Hue et al 2005, Global alliance for future of food 2016) including Nepal. Acknowledging the importance of APGRs conservation, government and non-government organization are deploying three major strategies of conservation: in-situ conservation, on-farm conservation and ex-situ conservation (Joshi 2017b). Strategies differ in terms of the degree of human intervention in the natural system, ranging from highly managed ex-situ conservation at genbank and seed bank to maintain landraces or traditional varieties of crops to their local environments so called on-farm conservation (Engelmann 2012). The third, in-situ approach of conservation is at the level of ecosystems and natural habitats, which includes maintenance and recovery of viable populations of species in their natural surroundings, or in case of domesticated species, in surroundings where they have developed distinctive properties.

It can be found that under different approaches of conservation, based upon the feasibility, different methods have been deployed. Among different in-situ conservation methods, orchard has been found best fitted under the on-farm conservation approach (Paprstein et al 2007, Maxted et al 1997). Generally, in traditional orchards, old cultivars have been planted, cultivated and maintained in either home or village gardens, within the precinct of temples and on public sites such as schools. Generally, old orchards are maintained naturally and used by any one. In the past orchards were established to provide fruit or local needs to the community people. Also, our ancestors shared us that in Nepal it was common to find more than 10 landraces within an orchard. Ancestors' knowledge was found similar to USDA (1897) report, which reported that at that time orchards contain a number of varieties. Similarly, Rajan et al (2013) found around 40 different varieties planted for around 100 years.

There have been relatively negligible records and almost no studies on the status of orchards in Nepal. Thus, threat of extinction of such genetic resources is common these days. To help to fill this gap, present study attempted to bring technical clarity on typology of orchards and create preliminary database on orchards. The present study was conducted involving a combination of methodologies which included two levels reviewing of literatures, number of telephoning and emailing. Checklist of simple questions were the main instruments to facilitate the proper gathering of the information under each methods.

Among the two levels literature reviews, at first level, relevant studies were reviewed and used to comprehend different methods of conservation and locate the best fitting position of orchard based conservation. At second level relevant annual reports of different government and non-government organizations and research articles were reviewed and used to gather the technical understanding about public orchard, community orchard, community field genebank, village field genebank, school field genebank and private orchard. After comprehending the typologies of orchards, team conducted number of telephone calls to the District Agriculture Development Offices, International/National Government Organizations, and community based organizations across different districts to see the possibility to collect information. District Agriculture Development Offices of number of districts where telephone conversation happened and orchards exists were emailed with simple checklist of questions such as name of orchard, and its address, area occupancy, cultivating fruit species, establishment year and remarks, if any. I/NGOs like Parivartan Nepal, and community based organization like Agriculture Development Conservation Society, Bara, Community Seed Bank, Rainas Tar, Lamjung were consulted and communicated.

HISTORY

The history of orchard in Nepal is as old as the nation's history of human settlement and development. It has found that the first orchard was laid out by that time his Majesty King Ran Bahadur Shah before 1845 AD or during Pre-Rana regime (Devkota 2016). It was established at Seraphant of Nuwakot district named Sera Bagaincha where Mango, Litchi, Papaya, Pineapple, Banana, Guava and Mandarin were planted. Thereafter, the Prime Minister Bhimsen Thapa opened fruit orchard at Jalbire, Kavre district (Devkota 2016). Similarly, history depicts that hundreds of hectares of Hill and Tarai have been maintained under the protection of the elite case, such as Shah and Rana. However, status of orchards in Nepal cannot be told as one story. On the other hand, generally, the national efforts of conservation are mainly focused on orthodox crops (mainly cereals and vegetables) making such traditionally diversity rich orchards neglected and under estimated. Plant genetic resources of such orchards have rarely been used by scientific circle. Generally multipurpose orchards are established in Nepal by farmers in small scale (**Figure** 1).

TYPOLOGY OF ORCHARDS

There are several methods that have been practiced in conservation of non-orthodox crop species. Many fruit falls under this categories. Some differences among different types of orchards are given in **Table** 1. Although the conservation methods differ in typology, area, nature of crop conserves, dynamics of user groups and in many aspects, they all share one common idea of conservation. Some of the common functions they share can be summarized as

- Traditional public orchards are regarded as the center of village life and a cornerstone of the rural economy
- Public orchards are platform where people come together to plant and cultivate local and other varieties of fruit trees, used as focal point for community activities
- It allows dynamic conservation of landraces, traditional varieties and locally adopted commercial varieties serving as instrument for regeneration of genetic resources
- An example of long term in-situ conservation of plant genetic resources (specially fruit trees)
- Reservoir of enormous traditional knowledge of local plant genetic resources in terms of both cultivation practices and their utilization
- Proper utilization of fallow land as they are established in public lands

- These serve as source of family nutrition to community including landless and poor members of community.

Table 1. Differences among different orchards

Particular	Public orchard	School orchard	Private orchard
Definition	Orchards established in public land for purpose of sharing resources among members of community not mainly for profit making	Orchards established by school and used as educational resources for students and children	Orchards established by individuals/ private farms for commercial production to maximize profit
Who takes care	Communities and its member	School (teachers and students)	Individual (family)
Objectives	For sharing resources among the different members of community rather than making profit	To teach students about the importance of orchards through knowledge sharing and managing; sometimes profit making too	To maximize profit through commercial production
Knowledge	Farmers/ community knowledge about the plant genetic resources are shared and conserved	Scientific knowledge are shared more	These are not primarily meant for knowledge sharing, with some exceptions

Figure 1. Multiple crop orchards in Samibhanjyang, Lamjung.

ORCHARDS

Fruits garden is generally termed as orchards. It is the tradition in Nepal to establish orchard in public land, community land and private lands. Main types of orchards are community orchard, public orchard, government orchard and private orchard. Both indigenous and exotic fruit species are grown in such orchards, and dominant crop is mango.

Community Orchard

In simple definition, community orchard is the continued growing of fruit diversity in community owned land and managed by community (Joshi et al 2016). Community orchards are generally leased or owned by community, sometimes held in agreement by community group (**Figure** 2). In such orchards the use of fruits and other products are used by the managing community. Major focus in such orchard is to commercialize the products rather than focusing diversity maintenance. The ownership remains in particular community (King and Clifford 2008).

Community orchards sustainably benefits social, economical and environmental aspects to community. Apart from economic benefit, the importance of community orchards are significant to landscape, ecology and cultural heritage of community (Rotherham 2008b). Some of their roles are:

- Community orchards are manifestation of relation of community with fruit cultivation (King and Clifford 2008). So they are reservoir of local knowledge about local varieties, its cultivation and uses.

- These are also a way of conservation of distinct, unique and traditional varieties which otherwise may be lost.
- Orchards are important aspect of farms and small holdings for growing wide range of fruit (Rotherham 2008a, Porter 2010).
- Community orchards can be a method for raising awareness and inspire people for environmental and sustainability issues (Pinkerton and Hopkins 2009, Quayle 2008)
- It can be used as an effective way to engage people in community for environmental issues and community resilience.
- Can be a source of planting materials

Figure 2. Community mango orchard in Tinpiple, Lamjung.

List of some community orchard are given in **Table** 1. We could able to list a total 14 community orchards from 6 districts. Altogether 5 fruit species were found cultivated in these community orchards. Among these fruit species, orange has been cultivated in 6 orchards followed by mango (3 orchards), and litchi and walnut in 2 orchards each. Such orchards should be converted to community field genebank and managed following the system of community forestry.

Table 1. List of community orchard in Nepal

SN	Name of orchard	Address	Area (Ropani)	Fruit species	Established year (AD)
1	Ichhakamana suntala utpadan krishak samuh	Jogimara-4,Dhading	175	Orange	1996
2	Mankamana Suntala utpadan krishak samuh	Nalang-5, Dhading		Orange	2001
3	Mahalaxmi suntala utpadan krishak samuh	Mahadevsthan-1, Dhading	100	Orange	2001
4	Maidi falful utpadan krishak samuh	Maidi-1 and Maidi-2, Dhading	40	Litchi	2003
5	Panchkanya krishak samuh	Kiranchowk-6, Dhading	40	Litchi	2005
I6	Pragatisil suntalabali krishak samuh	Be.Na.Pa-2, Lamjung	100	Orange	1973
7	Lali Gurans Krishak Samuh	Be.Na.Pa-2, Lamjung	100	Orange	1973
8	Himali alaichi jadibudi krishi sahakari sanstha limited	Bajhaket-5, Lamjung	500	Cardamom	1988
9	Kolhawa tharu samudaya	Madhyabindu-1, Nawalparasi	6	Mango	1966
10	Thotneri suntalajat utapadak bagaicha	Salija-9, Parbat	18	Orange	2005
11	Sukhlahi	Madhupati-4,5,6, Saptari		Mango	
12	Baraha, Ghodabas	Baraha, Ghodabas, Dailekh		Walnut	
13	Danda Mango Bagaicha	Chupra, Dailekh		Mango	
14	Khadgabada-2, Dailekh	Khadgabada-2, Dailekh		Walnut	

Public Orchard

These type of orchards are similar to that of community orchards but ownership do not resides on single community. These are generally grown in public or government land and sometime on forest (**Figure** 3). The benefit of such orchards is shared by several communities and any one can harvest the products. The ownership belongs to local government offices, sometime district levels too. Like community orchards these also serve with similar roles, some are given below.

- Serve as natural habitat of different flora and fauna
- Center of recreational activities and public gathering
- Provide pasture and grazing land to domestic animals of the communities
- Contribute more in conservation of APGR
- Unlike community orchards, these are open to general public too, so will act as common platforms for sharing traditional and new knowledge between different actors including community members. This allows flow of knowledge from generation to generation and in wider scale
- Community needs for food and agriculture, even other requirements such as fire wood and shade are also fulfilled by public orchards

Figure 3. Public mango orchard in Dhamilikuwa, Lamjung.

There are hundreds of public orchards in Nepal, which were established from ancient time. In this study altogether, information on 31 public orchards from 11 districts have been collected, compiled and tabulated (**Table** 2). It was observed that about 10 different types of fruits (Mango, Mandarin, Wood apple, Walnut, Orange, Litchi, Black Plum, Plum, Peach and Apple) were found growing across the public orchards. Broadly, Mango was dominant fruits cultivated in 25 orchards followed by Orange, Black Plum and Litchi grown in 3 orchards each.

Table 2. List of public orchards in Nepal

SN	Name of orchard	Address	Area (Ropani)	Fruit species	Established year (AD)
1	Kalika Mandir Parisar	Baglung Muncipality-1	5	Mango, Wood apple	
2	Niray Ghat	Baglung Muncipality-1	3	Mango, Wood apple	
3	Narayansthan	Narayansthan-2,Baglung	2	Mango	
4	Devtal Pokhari Basbariya	Kachorwa-9, Bara	52.43	Mango (5 varieties) and Black plum (1 variety)	1953
5	Ram Janaki Mandir	Mahendra Adarsha-4, Bara		Mango and Litchi	
6	Ranibas Mandir	Simraungaud-2, Bara		Mango and Litchi	
7	Siddeshwor Mandir	Kalaiya-6, Bara		Mango and Litchi	
8	Parbhas Bagaicha	Tansen Muncipality-14, Palpa	10	Mango	1966-1976
9	Pantar Bagaicha	Hugi-4, Palpa	12	Mango	1973-1983
10	Satmule Suntala Bagaicha	Kughara-7,Parbat	7	Orange	
11	Gunte Suntala Bagaicha	Salija-9, Parbat	20	Orange	1983
12	Dhaulapara Suntala	Lekhfat, Parbat	12	Orange	1984

SN	Name of orchard	Address	Area (Ropani)	Fruit species	Established year (AD)
	Bagaicha				
13	Lapsi Bagaicha	Shankarpokhari, Parbat	10	Hog plum	2012
14	Brabal	Syafru-5, Brabal, Rasuwa	20	Apple, Peach, Plum and walnut	1977
15	Surnga	Kushala VDC, Saptari		Mango	
16	Gilling Apple Orchard	Ghiling village, Mustang		Apple	
17	Sepa Garden	Bhanu Muncipality, Tanahun		Mango	
18	Uppalo Bhotewadar Garden	Bhotewadar, Sundarbazar Municipality, Lamjung		Mango	
19	Thati Mango Garden	Bichaur VDC, Lamjung		Mango	
20	PaudiSundar Bazar, Mane Chauka	Paudi, Sundar Bazar, Lamjung		Mango	
21	Katbhote Mango Garden	Malcha Kharka-3, Lamjung		Mango	
22	Bhuwane Mango Garden	Harmi-8, Gorkha		Mango	
23	Tinpiple Mango Garden	Rainaas Muncipality-7, lamjung		Mango	
24	DhamiliKuwa Mango Orchard	Rainaas Muncipality-3, Lamjung		Mango	
25	Garambesi Mango Orchard	Rainaas Muncipality-4, Lamjung		Mango	
26	Bhimsen Mango Orchard	Gorkha		Mango	
27	Lahare Pipal Mango Orchard	Madhy Nepal Munciplality-9, Lamjung		Mango	
28	Kusunde Orchard	Alkataar Rainaas Muncipality-7, Lamjung		Mango	
29	Bhorletaar	Bhorletaar, Lamjung		Mango	
30	Malika	Malika, Dailekh		Mango and Mandarin	
31	Bhimsen Thapa mango orchard	Namjung, Gorkha		Mango	

Private Orchard

Simply, private orchard is defined as orchard with different horticultural crop species especially fruit species maintained by individual farmers in their own land. Such orchards are established with production, sale and conservation objectives but its main motive was to fulfill household need and increase profits. Generally, private orchards are crop specific like banana orchard, mango orchard, litchi orchard, citrus (**Figure** 4), etc and are either owned and/or managed by private person or household or family. In Nepal, many of such orchards are registered with District Agriculture Development Office as fruit growing groups such as apple grower group, mandarin grower group etc. In private orchards, there are some old cultivars/varieties. But, now days many innovative commercial farmers have started large scale orchards with modern varieties. They are generally monocrop orchards with few cultivars eg apple in Manang, Banana in Kailali and Bardiya. Though, private orchard is established with profit motive it has directly and indirectly plays important role in maintaining the fruit and its genotype diversity.

Figure 4. Private orchard.

The concept of private orchard has been received much attention from the people because the ownership remains in the hand of individual and profit is the main motive of its establishment. There are numerous such private orchards established and widely scattered across the countries. The effort was only given for collecting details of popular private orchard, in this study. Information on 22 private orchards of 5 districts have been gathered, compiled and presented in **Table** 3. Data show that mango is the most widely grown in private orchard (20 orchards) followed by Kiwi which is grown in 3 orchards. Most of the orchards are dominated by improved varieties of fruit species.

Table 3. List of popular private orchard in Nepal

SN	Name of orchard	Address	Area (Ropani)	Fruit species	Established year (AD)
1	Farhan EkwalKha	Shivpur, Harhawa, Kapilvastu	157.28	Mango, Jackfruit, Wood apple	1968
2	Bhandara Krishna Dhawj Joshi	Bhandara Madhyabindu-6, Nawalparasi	5	Mango	2001
3	Yagya Subedi Kiwi Bagaicha	Lekfat-1,3, Parbat	10	Kiwi	2012
4	Ratinga Kiwi Bagaicha	Lekfat-4,5, Parbat	5	Kiwi	2012
5	Som Bahadur Tilija Kiwi Bagaicha	Baskharka-9, Parbat	5	Kiwi	2013
6	Kirpa Nidhan Tiwari	Bagaha-3, Rupendehi	6.67	Mango	1986
7	Dhirendra Kumar Chaudhary	Shadsari-6, Kewataliya, Rupendehi	4.5	Mango	1994-1996
8	Kanhai Chaudhari	Shadsari-6, Kewataliya, Rupendehi	4.5	Mango	1992-1996
9	ParbhatSukhala	Karauta-4, Chauri, Rupendehi	26.67	Mango	1992-1996
10	Suwas Kurmi	Aasuraina-3, Rupendehi	20	Mango	1992-1996
11	Sarbendranath Sulka	Farena-8, Juguna, Rupendehi	25	Mango	1992-1996
12	Raipur-2, Showwarasi	Raipur-2, Showwarasi, upendehi	13.3	Mango	1992-1996
13	Dr. Rajendra Regmi	Pashim Amuwa-8, Gorhaba, Rupendehi	16.67	Mango	1996
14	Ram Janaki Mandir	Harniya-09, Visakhadar, Rupendehi	26.67	Mango	1962-1966
15	Ram Dhani Lodh	Manmateriya-8, Belhiwa, Rupendehi	2.5	Mango	1991
16	Radheshyam Chaudhary	Cho Ramnagar-6, Rupendehi	40	Mango	1981-1986
17	Bhadari Bhuj	Patkholi-5	26.67	Mango	1981-1986

SN	Name of orchard	Address	Area (Ropani)	Fruit species	Established year (AD)
18	Narendra Chaudhary	Patkholi-5, Rupendehi	20	Mango	1981-1986
19	Ramachal Chaudhary	Patkholi-5,Rupendhi	20	Mango	1981-1986
20	Subraratan Shrestha	Siktahan-1, Rupendehi	4.5	Mango	1981-1986
21	Manohar Chaudhary	Siktahan-7, Rupendehi	4.5	Mango	1981-1986
22	Binay Kumar Pandey	Mayardpur-5, Rupendehi	19	Mango	1986-1991

FIELD GENEBANK

Joshi (2014) has described field genebank in detail along with guidelines for establishing field genebank. It is the system of conserving APGRs live in the fields over the years. Basic components in the field genebank are listed in **Figure** 5. The main importance of field genebank are diversity conservation, production and income generation, source of propagating materials, natural evolution, healthy environment, research and study, diversity options and selection opportunity, access to all from anywhere and pre-breeding. It has different form eg community field genebank, school field genebank and village level field genebank.

Community Field Genebank

Community field genebank is a part of community genebank, targeting to manage (conserve and use) recalcitrant crops and crops that do not produce seeds, eg banana (Joshi et al 2016). This is operated in the same was as community seed bank. Community field genebanks have been established in Kalilai, Lamjung and Lalitpur districts.

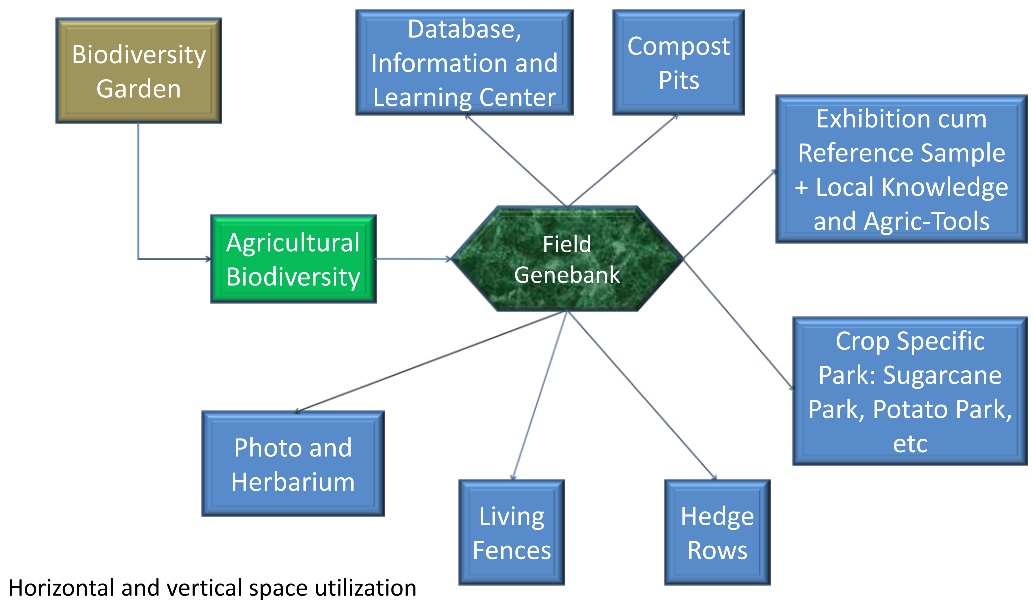

Figure 5. Components in field genebank.
Source: Joshi 2014.

Village Level Field Genebanks

With the increase in knowledge and awareness about the conservation and sustainable use of plant genetic resources among the farming communities, village level field genebank has also been evolved as one of the method during the recent years (Joshi et al 2016, Joshi 2017b). This is a system of conserving and managing total diversity of a species through continue growing at least on landrace by each household by village members in their private land (Joshi 2017b). Village members regularly organize meeting and discuss about status and use of diversity (**Figure** 6). Apart from main objective of conservation of genetic resources, village level field genebanks have following roles on:

- Conservation of local plant genetic resources in evolutionary way (Genebank 2014)
- Diversity monitoring and diversification of products along with comparative study at a single village
- Documentation of traditional and local knowledge and share a common platform for knowledge about crop

- Source of propagating materials among the farmers of village
- Income generation, chances on minimizing the risk from lost

Figure 6. Village level field genebank in Hatauda.

The level of collective efforts at village level by members of village for conservation and utilization of plant genetic resources has been least studied. Although several organizations have been providing support for custodian villagers and farmers, the national database of such village level field genebanks are either inadequate or not studied. This resulted in lacking of compiled information of such efforts. Thus in the present study we tried to compile the information of village level genebanks at one place. The information collected about six village level field genebanks are presented in **Table** 4.

Table 4. List of village level field genebank in Nepal

SN	Name of village level field genebank	Address	Fruit species	Established year
1	Jabik Bibidhata Samiti	Purkot, Tanahun	Banana (44 accession)	2065/66
2		Sindhuli	Citrus (9 species)	2065/66
3	Singhnath Krisak Samuha	Nawalparasi	Yam (12 landraces)	2066
4	Jabik Bibidhata Samiti	Doti	MAPS (57 species)	2065/66
5		Mustang	MAPs (25 species)	
6	Krishi Bikash tatha samrakshan krisak samuh	Agyouli, Nawalparasi	Vegetables and legumes	2065

School Field Genebank

In recent years, mostly perennial and recalcitrant seeds are planted in the premises of school, which is called school field genebank. Parivartan Nepal, a NGO, has started School Field Genebank in Hetauda and Sunsari. National Genebank has also supported to establish school field genebank in Budanilkantha High School, Kathmandu and in Lamjung (**Figure** 7). The school field genebanks are managed by teachers, students and school committee members (Joshi et al 2016, Genebank 2014). Generally, students collect plant materials from their localities or from school's command areas with passport data. These are very important sources for education, conservation, as source of planting materials and for crop harvest. The main functions of school field genebanks are,

- To teach students about the importance of agricultural genetic resources through knowledge sharing
- Common platform for sharing knowledge about the different aspects of crop production from cultivation practices to its agro-morphology
- Product can be used for sale and consumption and for generating income
- Such genebanks are useful for generating awareness to students and children about the importance of PGRs, environmental issues and conservation.

Figure 7. School field genebank in Tinpiple, Lamjung.

Students are the future of nation. If they gain and have proper knowledge on agrobiodiversity conservation, management and utilization, then it would be the cornerstone for APGRs enhancement which eventually contributes on maintaining food security and ecosystem resilience. Some school field genebanks have been established in 4 districts (**Table** 5). Fruits were the more prominent in school field genebank, except in Gauri Shankar Secondary School where medicinal and aromatic plants are growing. GoN and I/NGOs should invest a certain amount to establish school field genebank.

Table 5. List of school field genebank

SN	Name of orchards	Address	Area (Ropani)	Fruit species
1	Budhanikantha School Biodiversity Program	Budhanilkantha		Generally deciduous fruit (peach, pear, citrus) including cereal (seed museum) and sugarcane
2	Pattharkot School	Sarlahi		Banana, Mango
3	Janata Higher Secondary School	Phaparbari, Makwanpur	3.33	Mango (18 accession) and litchi (5 accession)
4	Gauri Shankar Secondary School	Ghanteshwor, Doti		Cinnamomum, Empblica, Sugandhakokila
5	Alkataar School	Tinpiple, Lamjung		Banana, Guava
6	Shree Bhairab Kali MV	Dui Piple, Lamjung		Banana
7	Saubhagya Mavi	Alkataar, Lamjung		Banana, Coffee

CONCLUSION

The orchards were established by traditional people in certain places like religious land, school premise, government fallow land (Ailani land) etc to gain diversity of taste and qualities of fruit, fuelwood, and temporary shelter during rain and excessive hot. In addition to that it conserve, maintain and enhance the plant diversity, supporting evolution, conserving soil and water resources, reducing sheet or top soil erosion, and increasing the biomass and providing shelter to the birds, small plants and micro-organisms (Lush et al 2009, Thompson 2016). Any can have different mango flavors and children enjoy a lot around the orchards. Orchards though have diverse landraces of mango, and other fruits, the existence of such orchards and its fruits diversity has reduced considerably during. Devkota (2016) wrote that before and during Rana regime fruit orchards were established in Jalbire and Kakaitar of Kavre district, Kapan of Kathmandu district and Angutar orchard at the bank of Trishuli River; however, even with our numerous effort we couldn't able to find any details on it. This is only one of the typical example on loss of traditional orchards from Nepal. On the other hand, despite its importance, till date, very limited effort has been made by the GoN and I/NGOs for management, analyzing orchards and its role, and the status in Nepal. Question remain unanswered why mostly mango are planted in such public orchards. Followings are some future agendas.

- If such public orchards can be established and managed they can be used as common platform for collective action of utilization and conservation of plant genetic resources.
- The national Research system has to exploit available diversity of cultivars of orchards in the country through identification, evaluation, characterization and promotion of good cultivars.
- Farmers' local varieties serve as the repositories of fruit tree genetic diversity and represent a vital source of genes that can be utilized in research and breeding programs.
- Community forest approach is very much successful in Nepal. Such approach can be deployed for establishing public orchards
- There is scope of systemic study and mapping public orchards available in Nepal which has been contributing in utilization and conservation of plant genetic resources.
- In some countries, government provides technical and financial support to establish such public orchards. This can be applied in Nepal too.

WAY FORWARD

Public orchards (habitat for fruit trees) have been degenerated (Subedi et al 2008) contributing to some 50% loss of local landraces. The habitats of local mangoes have been destroyed due to various factors, leading to threat of genetic erosion. Although community orchards are valued for creating and enhancing community by encouraging knowledge in local nature, history and culture (Clifford and King 2000), such platforms have been destroyed by different human activities. We want to reinforce the importance of such platforms for conservation of genetic resources, conservation of knowledge and their role in contributing food and nutrition security. Followings are potential future arena for enhancing orchard conservation, utilization through communities.

- **Common platforms for utilization and conservation**: Such public and community level platforms can be established and managed so that they can be used as common platform for collective action of utilization and conservation of plant genetic resources. Growing interest in community gardens and community orchards has led to an increase in community-oriented agriculture.
- **Research efforts:** The national research system has to exploit available diversity of cultivars of orchards in the country through identification, evaluation, characterization and promotion of good cultivars.
- **Source of genes:** Farmers' local varieties serve as the repositories of fruit tree genetic diversity and represent a vital source of genes that can be utilized in research and breeding programs.
- **Managing approach:** The main reasons for loss of such community level platforms are lack of proper management system deployed for their conservation and utilization. Community forest approach is very much successful in Nepal. Such approach can be deployed for establishing public and community orchards.
- **Scope of Study:** There is scope of systemic study and mapping public orchards available in Nepal which has been contributing in utilization and conservation of plant genetic resources. The level of diversity and knowledge preserved in such orchards are enormous and yet to be explored. The folk taxonomy has not been dig out and demonstrated.

Lastly, in some countries, for instance UK, government provides technical and financial support to establish such public and community orchards. This can be applied in Nepal too. We expect that this document will provide a curiosity to several researchers, students, scientists and government officials for exploring and conducting intensive studies in these related fields. From the collective efforts of such studies we will be able to explore, conserve and utilize the plant genetic resources available from ancient time to fulfill the need of food and nutrition security. All public orchards should be managed by the local communities in similar ways as managed community forest. Most of such orchards are very old and need to rejuvenate along with documentation of each orchard.

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Government Farms and Agricultural Plant Genetic Resources

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ABSTRACT

The history of farm center development in Nepal can be said to be initiated in the Rana Regime by establishing an agriculture demo farm in Singhadurbar premises in 1982 BS and followed by fruit nursery establishment in Godawari in 1994 BS. Since then, several attempts have been made to establish and functionally run the farm centers in the country. Presently, there are altogether 46 farms under the Department of Agriculture, which are almost evenly distributed across all development regions and agro-ecological belts. Categorically these farms are governed by different directorates, such as 13 horticultural farms under the Fruit Development Directorate, 10 horticultural farms under the Vegetable Development Directorate, 10 fisheries farms under the Fishery Development Directorate, 9 sericulture farms and 2 beekeeping farms under the Industrial Entomology Development Directorate, and the remaining 2 crop farms are under the Crop Development Directorate. These farms primarily work on production and distribution of quality seed, tubers, saplings and seedlings of crops, fruits, vegetables, and fry/fingerling of fish to farmers. In addition to these programs, farm centers collect, conserve and utilize important native and exotic cultivars/breeds of fruits, vegetables, crops and fish. So far, hundreds of native and exotic cultivars of fruits, vegetables, crops and other plant materials have been collected and conserved in government farms.

Keywords: Crops, exotic cultivars, farm, fruits, native, vegetables

INTRODUCTION

The history of farm center development in Nepal is not very long. It was initiated in Rana Regime by establishing an agriculture demo farm in Singhadurbar premises in 1982 BS and followed by fruit nursery establishment in Godawari in 1994 BS (AICC 2013). Since then, several attempts have been made to establish and functionally run the farm/center in the country. Government had given high priority to establish and run agricultural farms in the past years. Some of the farms were inaugurated by the Royal family of Nepal (**Figure** 1) which is an indication of priority of government to establish farm centers in the country. Likewise, some farms used to get a good access with Royal Family. The farm centers have been utilized to demonstrate agriculture technology, supply seed, seedlings, saplings, fingerlings and others. As a result, some farms showed very good model for the technology dissemination in the surrounding areas. Moreover, these farms have been utilized to collect and conserve high yielding varieties of agricultural plants. At the same time, the farms also collected some important species of native and exotic plants and were conserved in the farms. Therefore, the farm centers are rich source of biodiversity for agricultural plants.

The aim of this paper is to familiarize the existing situation of collection, conservation, and utilization of plant genetic resources and reveals the richness of agricultural biodiversity in the government farm center in Nepal.

GOVERNMENT'S FARMS AND THEIR CATEGORIES

Presently, there are altogether 46 farms under the Department of Agriculture, which are almost evenly distributed across all development regions and agro-ecological belts in the country. Of the 46 farms, 13 farms are under Fruit Development Directorate, 10 farms are under the Vegetable Development Directorate, 10 farms are under Fisheries Development Directorate, 9 sericulture development farms and 1 beekeeping farms are under the Industrial Entomology Development Directorate and 2 field crop farms under Crop Development Directorate. Though the command of horticultural farms are under two directorates, these farms work on both fruits and vegetables, their seed, seedling and sapling production and distribution, technology verification and conservation and maintenance of the germplasm of horticultural crops. These farms are solely managed and operated by Ministry of Agricultural Development, Department of Agriculture. In addition, some agriculture farms are governed by National Agriculture Research Council (NARC), which are explicitly designated for research purposes. Locations and distribution of farms under the Department of Agriculture are presented in **Figure** 2, 3, 4, 5, 6, and 7.

Figure 1. A historical monument about inauguration by King Mahendra in Daman far.

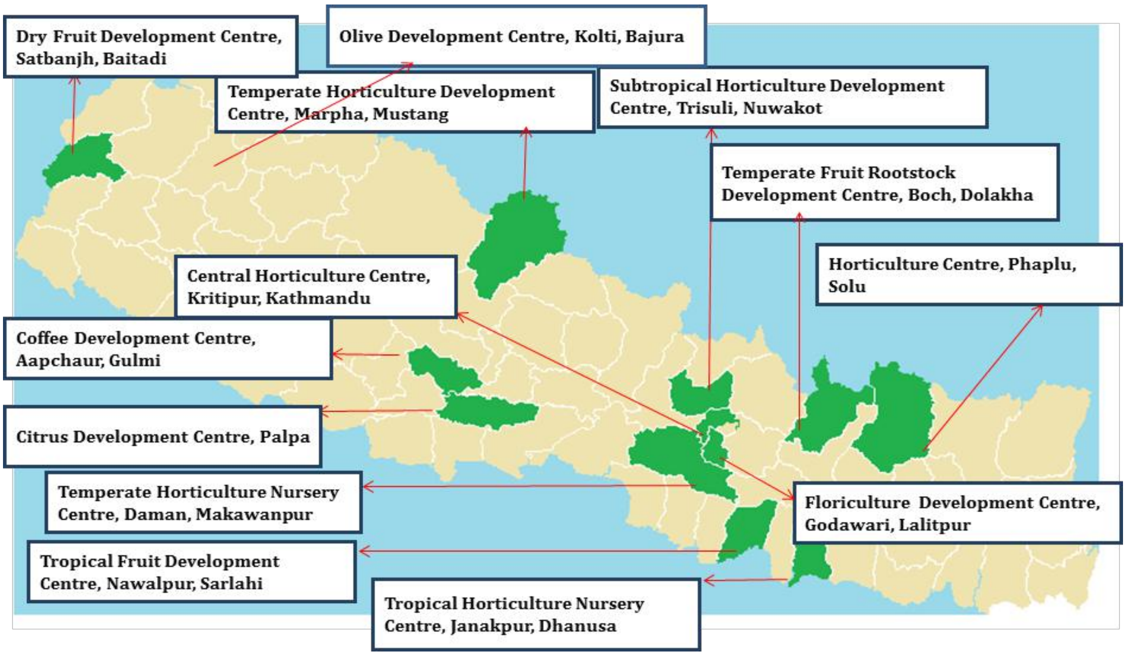

Figure 2. Farms under Fruit Development Directorate.

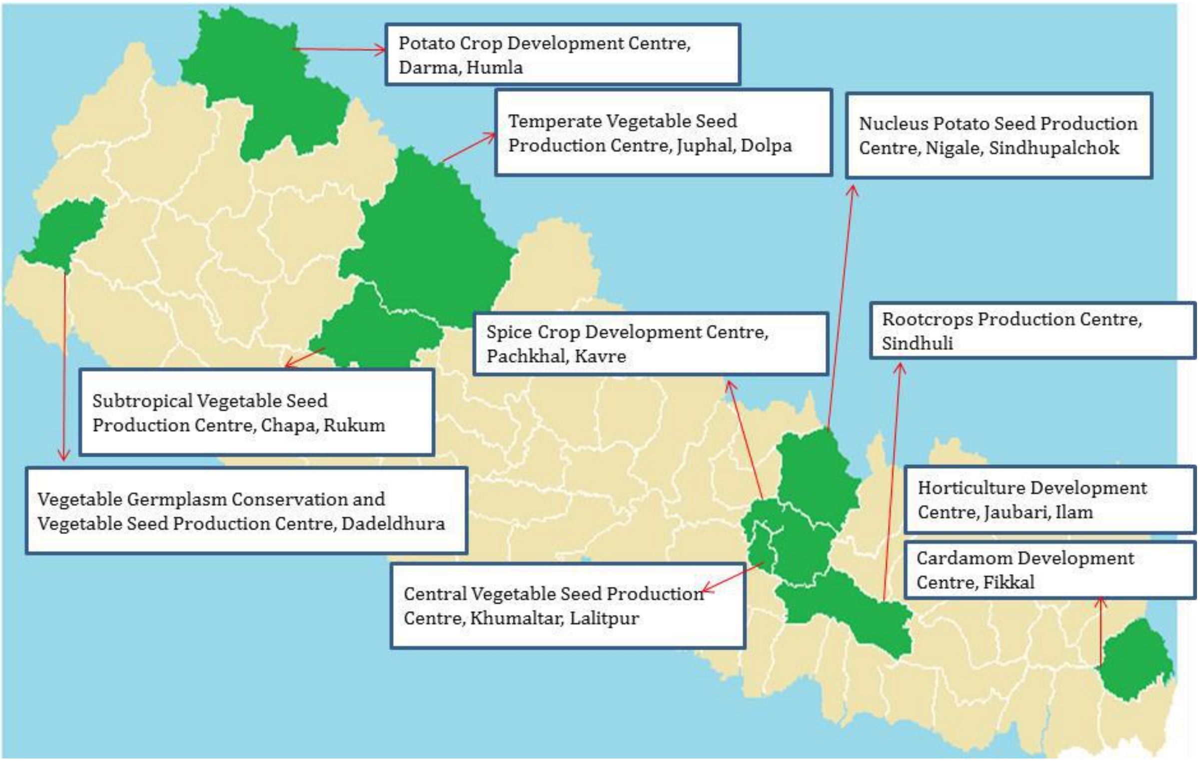

Figure 3. Farms under Vegetable Development Directorate.

Figure 4. Farms under Fisheries Development Directorate.

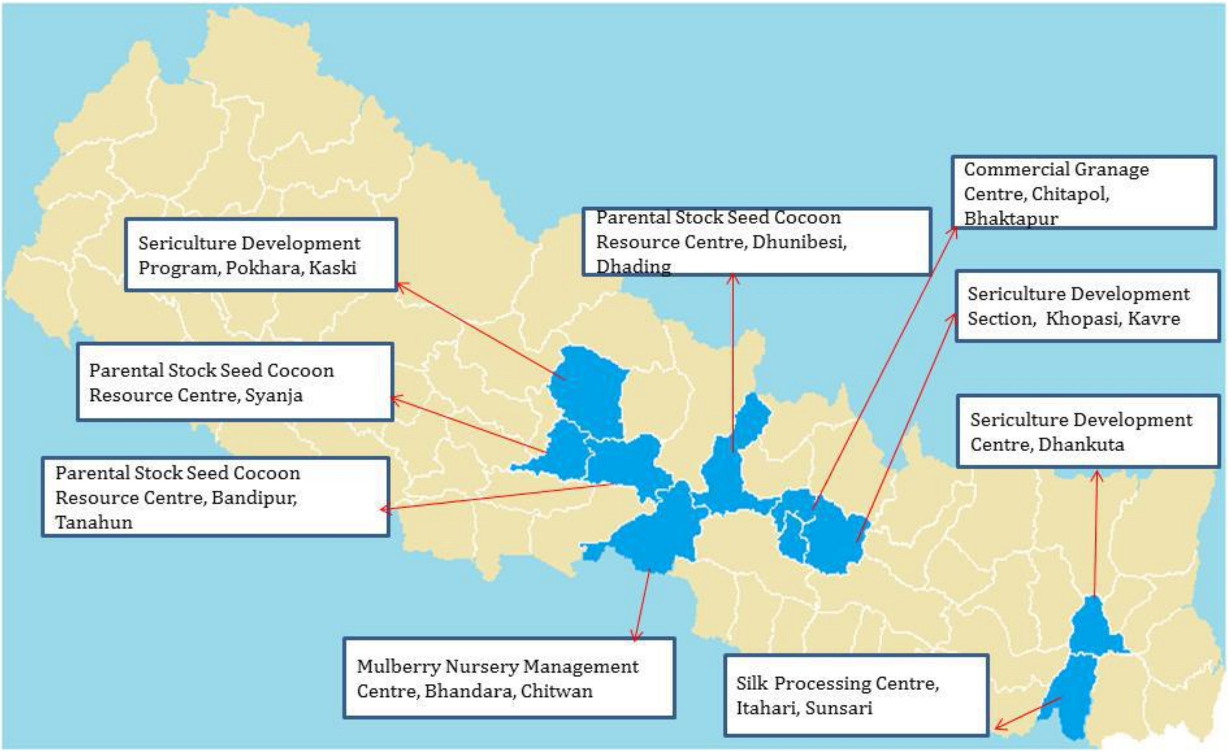

Figure 5. Sericulture farms under Industrial Entomology Development Directorate.

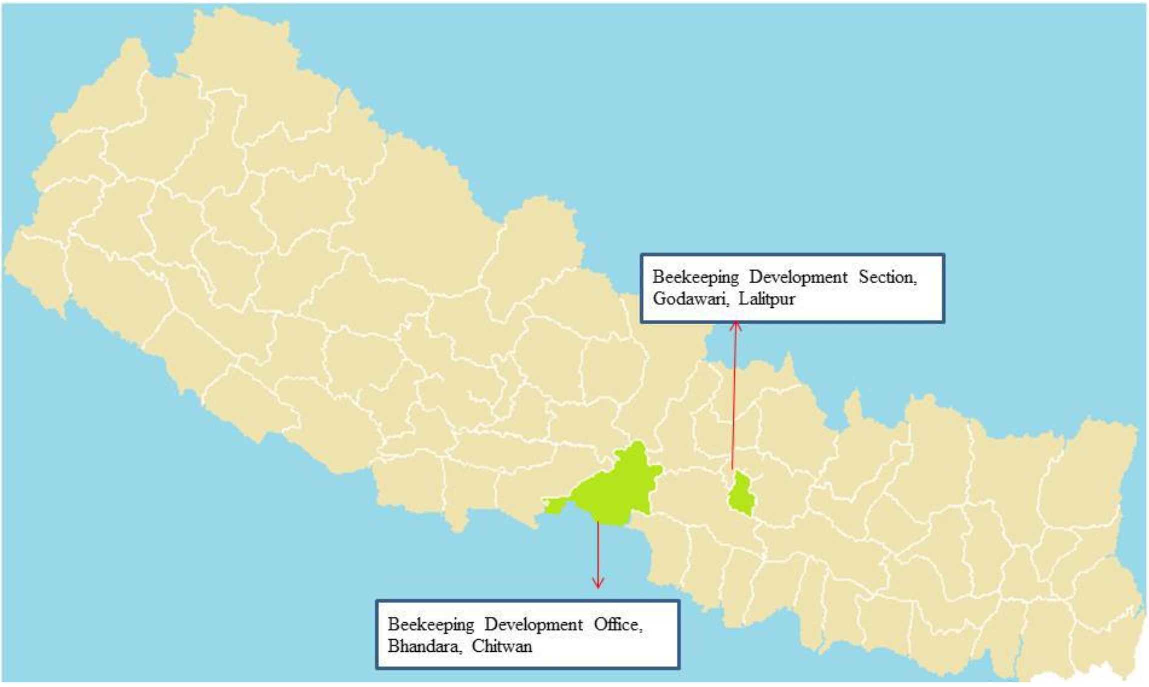

Figure 6. Apiculture farms under Industrial Entomology Development Directorate.

Figure 7. Field crop farms under Crop Development Directorate.

WORKING MANDATES OF FARMS CENTERS

The government farms primarily work for the production and distribution of quality seed, tubers, sapling, seedlings, fry and fingerlings and similar inputs to the farmers. Likewise, the farms conduct adaptive trials of new varieties and technologies generated from NARC and other research institutions. Farms also work on technology dissemination; ie provide technical supports to farmers. Moreover, these farms involve in collection, conservation and utilization of important native and exotic cultivars of fruits, vegetables, field crops, ornamental plants and others. As these farms are located in different agro-ecological regions, the potentiality of the location and climate has been considered to give the mandates to the farms.

PLANT GENETIC RESOURCES IN THE GOVERNMENT FARMS

There are hundreds of plant genetic resources collected and conserved in the government farms. Some are native (local and improved) varieties, while others are exotic ones. For easiness, we can group plant genetic resources of farms into field crops, vegetables, fruits, root and tubers, spices, ornamental plants and other plants.

Fruits Genetic Resources

Apple Genetic Resources

Marpha, Solu and Bonch farms are assigned for the promotion of temperate fruits. These farms have been working on apple fruits orchards establishment and maintenance and the farms collect, conserve and utilize apple genetic resources. The available genetic resources of apple plants are presented in **Table** 1 and pictures related apple are presented in **Figure** 8.

Table 1. Apple varieties collected and conserved in the government farms

1.	Anna	24.	Cox's orange pippin	47.	Star Crimson
2.	Bell Spur	25.	Bell Flower	48.	Millberg
3.	Coup 12	26.	Winter banana	49.	Liberty
4.	Coup 13	27.	Kashmiri	50.	Kullu
5.	Crab apple	28.	Vance Delicious	51.	Binauni
6.	Golden Delicious	29.	Summer Pippin	52.	Red Gravastein
7.	Granny smith	30.	Red gold	53.	Red Chief
8.	Granny Smith	31.	Amri	54.	Aiken
9.	Hello Summer	32.	Bright and Earl	55.	Melo Galas
10.	Honey Crisp	33.	Spur Gold	56.	Star
11.	Jonathan	34.	Stark all bleze	57.	Ambri
12.	Kullu	35.	Green Gravestein	58.	Edimayal
13.	Liberty	36.	Pineapple	59.	Spintzenberg

14.	M9, MM106, MM111 for rootstock	37.	Scarlet	60.	Gala
15.	MP (*Malus prunifolia* (Willd.) Borkh.)	38.	McIntosh	61.	King of pippin
16.	Mutsu	39.	Fall Russet	62.	Bramlays
17.	Origon Spur-2	40.	Co-op-12-2	63.	Red Chief
18.	Red Delicious	41.	Fuji	64.	Honey Crisp
19.	Rich-a-red	42.	Top red	65.	Red Spur
20.	Royal Delicious	43.	Red June	66.	Gala
21.	Saune	44.	Ushyu	67.	Tsugura
22.	Star Crimson	45.	Red spur	68.	Summer Pippin
23.	Veered	46.	Star super gold	69.	Asadi

Pear Genetic Resources

Pear orchards are maintained and managed in Marpha, Baitadi, Godawari and Kirtipur farms. The collected varieties of pear in those farms are shown in **Table** 2 and picture of pear plant are presented in **Figure** 9.

Table 2. Pear varieties collected in the government farms

1.	Waseka	2.	Hawana	3.	Kosui,
4.	Patal	5.	Anju	6.	Chojuro
7.	Golden Nijisekki	8.	Kikusui	9.	Sinko
10.	Aatago	11.	Yakumo	12.	Waseka
13.	Nitaka	14.	Hawana	15.	Patal
16.	Hosui	17.	Red Bartlett	18.	Mayal and Bhote Mayal for rootstock purpose
19.	Okisankichi	20.	Pharping Local		

Figure 8. Pictures of apple nursery in the government farm

Figure 9. Hosui pear plant in Daman farm

Peach Genetic Resources

Peach orchards are maintained and managed in Kirtipur, Godawari, Daman, Solu, Marpha and Baitadi farms. The collected varieties of peach in those farms are shown in Table 3.

Table 3. Peach varieties collected and conserved in the government farms

1.	Pere green	2.	Spring time	3.	Arm gold
4.	Early red	5.	Orion	6.	Panamint (Nectarin)
7.	Texas	8.	Alberta	9.	Florida Bell

Mango Genetic Resources

Mango orchards and their genetic resources are maintained and managed in Trisuli, Sarlahi, Janakpur, Sindhuli and Panchkhal farms. The collected varieties of mango in those farms are shown in **Table** 4. Pictures of mango genetic resources are presented in **Figure** 10.

Table 4. Mango varieties collected and conserved in the government farms

1.	Dashehari	2.	Gulabkhas	3.	Rajbhog
4.	Mallika	5.	Madhukupiya	6.	Ladyu Madhurai
7.	Sukul	8.	Radi Bathuwa	9.	Himsagar
10.	Amrapali	11.	Sipia	12.	Bharatdarsan

13. Maya	14. Krishnabhog	15. Vaskar
16. Kent	17. Brahamase	18. Fajali
19. Chausa	20. Langra	21. Kullu
22. Maldah	23. Lalmaldhaha	24. Top red
25. Bombay green	26. Alfonso	27. Culcuttiya
28. Langda	29. Nilam	30. Anawartaul
31. Sipiya	32. Jarmaraikarewa	33. Nurjaha
34. Amar rataul	35. Sworna rekha	36. Abehayat
37. Jarda	38. Ratna	39. Dakai
40. Safeda	41. Kohinur	42. Kent and hegan
43. Local Biju	44. Mumbasa	45. Sindure
46. Dalia		

Figure 10. Mango genetic resources maintained in Trishuli farm.

Figure 11. Hayward cultivar of Kiwi fruit maintained in Daman farm.

Figure 12. TPS-7 line of true potato seed variety.

Litchi Genetic Resources

Litchi fruit promotion is being done in Trisuli, Panchkhal, Janakpur, Sindhuli and Sarlahi farms. The maintained varieties of litchi fruit are listed in **Table** 5.

Table 5. Litchi varieties collected and conserved in the government farms

1. Early large red	2. Seedless	3. Calacattia
4. Bombai sahi	5. Mujafarpur	6. Mechilin
7. Rose scented	8. Large red	

Kiwi genetic resources

The Kiwi fruit orchards are primarily maintained in Daman, Bonch, Solu and Kritipur farms. The maintained varieties of Kiwi fruit are listed in **Table** 6 and a picture is shown in **Figure** 11.

Table 6. Kiwi varieties collected and conserved in the government farms

1. Hayward	2. Matsuwa	3. Abbott
4. Alison	5. Kohi	6. Matsuwa
7. Monty	8. Tomori	9. Bruno
10. Red Kiwi		

Genetic Resources of Citrus

The mandarin, sweet orange and pomelo fruit orchards are maintained in Palpa and Kirtipur farms. The maintained varieties of citrus are listed in Table 7.

Table 7. Citrus fruit species and their varieties collected and conserved in the government farms

Mandarin Varieties		
1. Local Mandarin	2. Thai tangerin	3. Murcott
4. Yasida Pongkan	5. Kinnow	6. Nagpur
7. Otapongkan	8. Khoku	9. Hayaka
10. Deko Pongkan	11. Clementine	
Sweet Orange Varieties		
1. Local Junar	2. Washington Navel	3. Malta Blood Red
4. Seminol	5. Tarakko	6. Yoshida Navel
7. Fukuhara	8. Valencia Late	9. Pineapple
Pomelo Varieties		
1. Local Nepali Pumelo	2. Otachibana	3. Amanatatsu
4. Thai Pumelo	5. Kawachiwankan	
Lime Varieties		
1. Eureka	2. Sunkagati-1 (NCRP 53)	3. Sunkagati-2 (NCRP 49)
3. NCRP 55	4. NCRP 107	5. Mexican lime
6. Banarashi Lime		

Vegetable Genetic Resources

There are several vegetable species collected, conserved and utilized in the government farms under the Department of Agriculture. Among them some of the varieties of major vegetable species are maintained and distributed to the farmers as a quality seed. Most of the farms (Dadeldhura, Rukum, Dolpa, Humla, Marpha, Palpa, Khumaltar, Daman, Panchkhal, Nigale, Bonch, Solu, Sindhuli, Sarlahi, Ilam (Pandam and Jaubari)) are working on conservation and maintenance of vegetables, tuber crops and spice crop varieties. Humla, Nigale, Bonch, Solu, Sarlahi, Panchkhal and Jaubari are responsible for potato germplasm conservation whereas Pandam, Ilam for cardamum, Sindhuli for root crops and Panchkhal for spice crops. The major varieties that are conserved in the government farm are shown in Table 8.

Table 8. Vegetable species and their varieties collected in the government farms

Bean Varieties		
1. Chidke	2. Jumli Pahelo	3. Sikkime
4. Trishul Simi	5. Jumli Kaude	6. Jumli Vatmase
7. Cahumase Simi	8. Jumli Rato	
9. Jhynge	10. Jumli Kalo	
Radish Varieties		
1. Mino Early	2. Local Choto	3. Puthane Rato
4. Tokinashi	5. 40 days	6. Chetki
Broad Leaf Mustard Varieties		
1. Khumal Chaudaptat	2. Khumal Ratopat	3. Marpha Chaudapat
Cowpea Varieties		
1. Malepatan	2. Indonesian	3. Khumal Tane
4. Sarlahi Tane		
Tomato Varieties		
1. C.L. Selection	2. C.L. 2037	3. Pusa Rubi
4. Lapsi gede	5. Achami Hira	6. Monprecos
7. HRD 1 and 7		
Cauliflower Varieties		
1. Jyapu local	2. Snowball 16	3. Kathmandu local
Pea Varieties		
1. Sikkim local	2. Singapure	3. NLP
Other Vegetable Varieties		
1. Cucumber: Bhaktapur local	2. Palungo: Patane	3. Carrot: New coroda
4. Brinjal: Pusa Kranti and PPL	5. Okra: Arka anamica, Parwani Kranti	6. Bitter gourd: Coimbatore long

Roots and Tuber Plant Genetic Resources

There are several species of root and tubers genetic resources collected, conserved and utilized in the government farms. Sindhuli farm is specially designated for root and tubers; however; the Nigale, Sindhupalchowk and Sarlahi farms is designated for True Potato Seed production and promotion. The major potato varieties that are conserved in the government farm are shown in **Table** 9 and a picture of true potato seed variety is illustrated in **Figure** 12. Likewise some species of roots and tubers and their varieties are presented in **Table** 10 and related pictures are presented in **Figure** 13, 14, 15, 16 and 17.

Table 9. Potato crops and their varieties collected and conserved in the government farms

True potato seed varieties		
1. HPS 7/67	2. HPS I/13	3. HPS II/67
4. Serena		
Improved varieties		
1. Janakdev	2. Dejire	3. IPY-8
4. Khumal rato	5. NPI-106	6. Khumal Ujjal
7. Cardinal	8. Khumal Laxmi	9. Khumal Upahar
10. Kufri Jyoti	11. Cardinal	
Local varieties		
1. Sailung Seto	2. Mustang Local	3. Rozita
4. Kirne Rato	5. Jiri Chakre	6. Marma Local
7. Cot local	8. Sailung Nilo	9. Mira
10. Dandapakhar Seto	11. Lanthe	8. Jiri local
12. Melung Seto	13. Gajale	9. Khimti
14. Perikoli	15. Nigale seto	16. Nilprasad Rato
17. Tune Local	18. Thote kali	19. Bigu local

Table 10. Roots and tubers crops and their varieties collected and conserved in the government farms

Taro, Dasheen, Cocoyam Varieties		
1. Panchamukhe	2. Dudhe	3. Hattisude
4. Bameli	5. Rato khajur	6. Thado mukhe
7. Rato Vale	8. Khajure	9. Lahure
10. Sathmukhe	11. Hattipau	12. Vaisi Khutte
Yam Varieties		
1. Hattipaile	2. Seto Pangnam	3. Sarlahi Seto
4. Sarlahi Rato		
Sweet Potato Varieties		
1. Local Seto	2. CIP 440099	3. Pangnam Seto
4. Local Khairo	5. CIP 440020	6. Sarlahi Rato
7. Local Rato	8. CIP 440015	9. Sarlahi Seto
10. Japanese Sato	11. CIP 440513	
Cassava, Tapioca, Manioc		
1. Local Red	2. Local White	
Elephant Foot Yam/Telagu Potato		
1. Local Red	2. Improve White (Gajendra)	
Yam Bean		
1. Local		

Figure 13. Dudhe and Panchamukhe cocoyam variety in Sindhuli farm.

Figure 14. Different varieties of yam in Sindhuli farm.

Figure 15. Different varieties of sweet potato in Sindhuli farm.

Figure 16. Different varieties of Casava in Sindhuli farm.

Figure 17. A picture of elephant foot yam in Sindhuli farm.

Genetic Resources of Spice Crops

Panchkhal and Fikkal farms are specially assigned for the promotion of spice crop in Nepal. Additionally, other farms also collect, conserve and utilize the spice crop genetic resources and distributed to the farmers. The varieties of spice crops conserved in the government farms are presented in **Table** 11 and some glimpses are presented in **Figure** 18.

Table 11. Spice crops and their varieties collected and conserved in the government farms

Cardamom varieties					
1.	Golsai	2.	Dambarsai	3.	Jirmale
4.	Ramsai	5.	Asare	6.	Bharlyange
Ginger varieties					
1.	Ilam Selection	2.	Dhankuta Selection	3.	Kapurkot 1
Turmeric varieties					
1.	Kapurkot Selection	2.	Panchkhal Local		
Garlic varieties					
1.	Bhote	2.	Panchkhal Local	3.	
Chili varieties					
1.	Akabare dale	2.	Lamche	3.	Bhotjalokiya
4.	Jire				

Figure 18. Cardamom seedling production in screen house Fikkal farm (a) and Garlic Production in Panchkhal farm (b).

Figure 19. Mulberry varieties demonstration orchard in Bhandara farm.

Genetic Resources of Coffee

Gulmi farm is assigned for coffee promotion in Nepal. The varieties of coffee collected, conserved and utilized in government farms are presented in Table 12.

Table 12. Coffee varieties collected and conserved in the government farms

1.	Borbon Amarelo	2.	Katuwai Amarelo	3.	Tekisis
4.	Borbon Varmelo	5.	Katuwai Varmelo	6.	Ketisis
7.	Coitemore	8.	Mundonovo	9.	Kaweri
10.	Katura Amrelo	11.	Pakamara	12.	Selection- 8
13.	Katura Varmelo	14.	Pakas	15.	Selection- 10

Mulberry Genetic Resources

There are 9 sericulture farms in Nepal. All farms are assigned for the promotion of sericulture to raise the income level of farmers. Mulberry leaves are essential to rear the silk worm. Thus, these government farms simultaneously promote mulberry plantation. Therefore, these farms collect, conserve and utilize and distribute quality saplings of mulberry to the farmers. Most of the mulberry germplasms are maintained in Bhandara and Khopasi farms, only some selected varieties like Kanva-2 or Maisure local are cultivated in other farms. Kanva-2 is widely grown variety in Nepal. The varieties collected so far in the Bhandara farm are shown in Table 13 and some glimpses are presented in the Figure 19.

Table 13. Mulberry varieties collected and conserved in the government farms

1.	Kanva-2	2.	D.D.	3.	Chinese
4.	Kalingpug	5.	S.B.N.B-2	6.	Roman (France)
7.	Maisur Local	8.	Khopasi-1	9.	Mering-2 (France)
10.	S.K.B.	11.	Khopasi-2	12.	Kokuso-2 (France)
13.	C.S.N.B-2	14.	Khopasi-4	15.	Seven K. M. G.
16.	African	17.	Khopasi-6	18.	Mereri (France)
19.	N.R.-2	20.	Khopasi-7	21.	Bhandara-2
22.	R.F.S-135	23.	Khopasi-10	24.	B-125

25. S-54	26. Khopasi-12	27. B-122
28. S-36	29. Khopasi-14	30. B-124
31. S-34	32. Khopasi-15	33. Lan-40
34. S-13	35. Samalbunge	36. T.J.
37. Bhote		

CONCLUSION

At the beginning, government farms were given high priority due to the support of Royal Family of Nepal. Later, the farms were paid less attention for their development and maintenance. In the recent years again the government has started to pay priority to maintain physical resources and plant genetic resources. Hundreds of fruits, vegetables, spices, ornaments and other economically important plant species and their varieties collected, preserved and utilized in the government farms but are poorly maintained. The first reasons behind the poor conservation are due to less budgetary support for the farms. The second reason behind is the staffs in these farms are having low level of motivation due to negligence in giving the importance to these farms. Most of the technical human resources in the farms have inadequate knowledge on biodiversity conservation and its utilization aspects. As a result, biodiversity rich farms are at the deteriorating stage. Due to overflow of hybrid varieties of vegetables in the country, most of open pollinated varieties and local landraces are in crisis now. In some case, some of the fruit varieties in the farms are still unidentified. However, many farms have conserved and maintained the different germplasm of the crops. Agrobiodiversity park establishment program has been proposed in several farms in view of conserving APGRs.

WAY FORWARD

- Allocation of sufficient budget along with skillful and motivated technical human resources in the farm centers.
- More attention should be given for the maintenance of already established orchard and expansion of new orchards in the potential areas.
- Orientation of human resources towards the agrobiodiversity conservation and utilization is necessary.
- Conversion farm center towards resource centres of modern technologies and also the agrobiodiversity park for APGRs conservation.
- Formation of a technical task groups is very necessary to listing out the plant species and their varieties found in the local communities.
- Identification and tagging of the fruit germplasm in the farm is necessary.
- Varietal Diversity Park/in-situ conservation programs should be made mandatory to each farm.
- Maintenance of local landraces of vegetables is must for APGRs conservation.

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Plant Genetic Resources for Food and Nutritional Security and Nepal's Role in their Management and Conservation

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ABSTRACT

This paper sheds light on what are plant genetic resources (A/PGRS) and how these resources are shared and exchanged among countries. Nepal has shared 607 accessions of crop varieties in the multilateral systems globally in 2017. At the same time, efforts have been made to discuss about the different methods of in-situ and ex-situ conservation of APGRs. Nepal, being one of the oldest countries in the world, has been involved in conservation and management of APGRs since the Vedic period which is recorded in the Vedic literatures as well. In Nepal, known record shows that more than 20,000 APGRs from Nepal have been conserved, preserved and used by more than 6 dozen nations/institutions across the world up to the day and Nepal has also been using APGRs from across the world as well to develop and use modern varieties of crops. So far as Nepal is concerned with respect to genetic resource conservation and management, there has been given detailed analogies of these genetic resource conservation and management not only for indigenous crop but also for crop wild relatives and their collection and management at a glance. Likewise, Nepal ranks 10th in terms of richest flowering plant diversity in Asia, and 31st in the world despite her 0.03% of global land mass and how these genetic resources are used and conserved globally has also been discussed in gist. Nepal has involved immensely supplying food and nutrition to the global community through APGRs.

Keywords: Agricultural plant genetic resources, conservation, food and nutritional security, genetic erosion, management

INTRODUCTION

FAO (1991, 1999) defines PGRs as "mean the reproductive or vegetative propagating material of the following categories of plants: (i) cultivated varieties (cultivars) in current use and newly developed varieties; (ii) obsolete cultivars; (iii) primitive cultivars (landraces); (iv) wild and weed species, near relatives of cultivated varieties; and (v) special genetic stocks (including elite and current breeder's lines and mutants". A similar definition given by FAO (1989) states that plant genetic resources refer to the economic, scientific or societal value of the heritable materials contained within and among species. This includes materials used in cytogenetic, evolutionary, physiological, biochemical, pathological or ecological research on one hand, accessions evaluated for their agronomic or breeding propensities on the other. In general, genetic material means any material of plant origin, including reproductive and vegetative propagating material, containing functional units of heredity (FAO 2009). Therefore, the term APGRs refers as the resources for food and agriculture which are the raw materials upon which the world relies to improve the productivity and quality of crops, livestock, forestry and fisheries, as well as to maintain healthy populations of wild species. The conservation and sustainable use of genetic resources for food and agriculture is therefore at the core of food security and nutrition. APGRs are the biological basis of food security and, directly or indirectly, support the livelihoods of every person on earth.

PGRs have been defined by various scientists and institutions. These can be defined as all materials that are available for improvement of a cultivated plant species (Becker 1993). In classical plant breeding, genetic resources may also be considered as those materials that, without selection for adaptation to the target environment, do not have any immediate use for the breeders (Hallauer and Miranda 1981). Despite growing demand for food and fiber to feed a growing world population, mainly living in urban areas are relying on a decreasing rural labor force In present day, agriculture has been facing a number of challenges. Agriculture has been forced to produce more feedstock for a potentially huge bio-energy market. At the same time it has to immensely contribute to overall development in the many agriculture-dependent developing countries, while adopting more efficient and sustainable production methods (FAO 2010). Natural resources are not infinite amount and are facing increasing pressure at the global, regional and local levels. Due to anthropogenic activities of human being global warming and climate change threatening the increase of the number of hungry people even further in the future, and creating new and difficult challenges for agriculture. Plant genetic resources are also threatened by the accelerated change for raw materials to improve the capacity of crops to respond to climate change and must be protected without any compromise to satisfy present demand fulfill future needs judiciously. An enhanced use of plant genetic diversity is essential to address these and other future challenges brought about by anthropogenic activities and natural changes.

Agriculturists are mainly concerned on genetic resources for food and agriculture. Accordingly plant genetic resources are to be defined on the basis of their use in one way and on the other way these should be defined in their technical aspects as well. In such scenario as defined by the international treaty on food and agriculture (ITPGRFA) 2001 has defined PGRs for food and agriculture as "means any genetic material of plant origin of actual or potential value for food and agriculture". It also defines genetic materials as "any material of plant origin, including reproductive and vegetative propagating material, containing functional units of heredity". In this paper we take PGRs and APGRs synonymously in order to avoid confusion among readers.

SCENARIO OF PGRS PROVIDERS AND RECIPIENTS COUNTRIES

Both developed and developing countries are net recipients of PGRs; they receive more diversity than they contribute to international genebanks. Developing countries are contributing more number of PGRs to developed countries in one hand and on the other hand there is an exchange of PGRs between developing countries as well (Galluzzi et al 2016). The global exchanges of germplasm are facilitated by the CGIAR genebanks (**Table** 1). Compared to her geography and benefit sharing, Nepal comes one of the top 25 providers of PGRs globally and despite this reality the economic benefit from shared PGRs has not been harnessed by Nepal in a way it should be. India, Peru, Ethopia, United States and Iran are 5 top most countries of providers of PGRs while India, United States, China, Ethopia and Australia are 5 top most recipients of the PGRs (**Table** 1). Nepal has not explored her potentiality of PGRs despite important contribution for providing PGRs globally through CGIAR system.

Table 1. Top 25 provider countries and top 25 recipient countries of PGRs originally sourced (1985–2009) by the CGIAR genebanks

Provider country	Total samples provided	Accessions provided	Genera provided	Recipient countries	Recipient country	Total samples received	Accessions received	Genera received	Provider countries
India	188,911	48,635	35	144	India	284,454	115,849	70	181
Peru	67,899	16,216	23	158	United States	45,992	39,963	97	178
Ethiopia	40,143	13,683	94	120	China	33,690	18,664	48	151
United States	36,652	6294	30	156	Ethiopia	28,863	17,572	175	150
Iran	29,829	9779	26	87	Australia	20,218	17,566	63	150
Turkey	29,579	9634	29	83	Japan	17,628	12,022	32	141
Syrian Arab Republic	26,029	7487	27	78	United Kingdom	17,231	14,283	89	144
Sudan	24,262	3457	17	61	Morocco	16,362	14,618	38	97
The Philippines	21,626	4016	7	109	The Philippines	16,332	8798	50	107
Côte d'Ivoire	20,494	3037	4	78	Tunisia	13,399	9706	18	70
China	18,559	7225	21	125	Iran	13,083	12,301	18	135
Nigeria	16,060	3462	27	126	Austria	12,703	12,657	24	92
Zimbabwe	15,477	4500	19	62	Italy	12,345	10,003	36	116
Cameroon	15,216	2942	13	67	Syrian Arab Republic	10,598	8610	19	92
Jordan	12,328	3319	20	66	South Korea	10,195	8423	26	137
Morocco	12,257	4106	34	69	Russia	9614	8636	12	92
Bangladesh	12,092	3839	14	94	Pakistan	9512	7901	64	139
Indonesia	11,696	3774	12	93	Turkey	9295	7221	25	96
Uganda	11,172	2565	13	103	Canada	9160	7709	38	121
Tunisia	10,799	3523	22	74	Indonesia	8965	8395	32	110
Pakistan	10,587	2950	23	99	Peru	7953	4053	33	75
Kenya	10,509	2205	38	104	Egypt	7921	6685	54	126

Provider country	Total samples provided	Accessions provided	Genera provided	Recipient countries	Recipient country	Total samples received	Accessions received	Genera received	Provider countries
Algeria	9743	3522	24	65	Germany	7276	6253	63	130
Tanzania	8438	2132	37	96	Brazil	6903	6030	34	129
Nepal	7725	2745	19	73	Thailand	6821	4899	27	103

Source: Galluzzi et al 2016.

There has been massive increase of germplasm in ex-situ conservation between the year 1996 to 2009 (**Figure** 1). The comparison between 1995 and 2009 for ex-situ conservation of germplasm clearly indicates that there is noteworthy surge of percentage for advanced cultivars, research on breeding materials, landraces and wild species of PGRs (WIEWS 1996, 1999). Whatever conflict is seen in these parts of the world is mainly due to fight for food and completion among haves and have-nots to occupy natural resources including energy and natural resources. This has been aggravated by climate change and increase in temperature brought about the anthropogenic activities of humans and excessive fossil fuel burning in the developed countries.

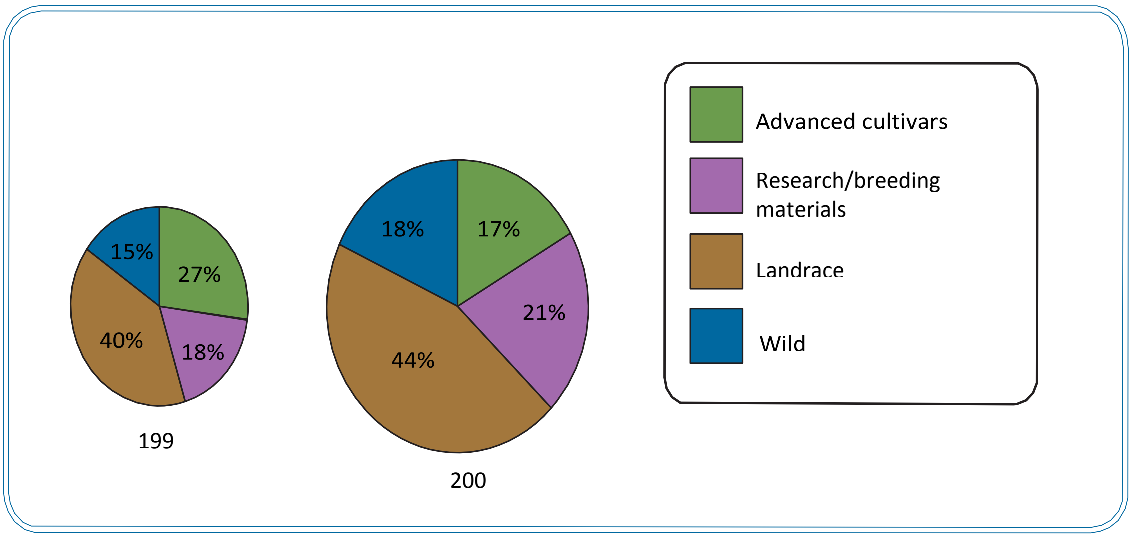

Figure 1. Types of accessions in ex-situ germplasm collections in 1996 and 2009 (the size difference in the charts represents the growth in total numbers of accessions held ex-situ between 1996 and 2009).
Source: WIEWS 2009.

GENETIC EROSION, VULNERABILITY AND FOOD SECURITY

Biological diversity of food is largely untapped resources because of the 250000 plant species known to mankind, more than thirty thousand are edible (http://www.fao.org/english/newsroom/highlights/1997/IMG/970509-e.gif). Out of this pool of diversity, some 120 species are cultivated today and 9 provide more than 75% of human food and only 3 of them (wheat, rice and maize) provide more than 50% of the human food in the world. Therefore, how vulnerably human food is rested on very few plant genetic resources in the world. On the other hand, these very few food crops are handled by a few of the food corporate giants of the developed countries (http://www.globalagriculture.org/typo3temp/pics/6bf2cee61a.jpg).

Because of advanced technology developed by CGIARs and seed corporate and other R&D institutions working on agriculture have helped increase food production in the world. However, the negative consequences of advanced technology including Green Revolution, there is massive erosion of genetic resources in the world. If due attention is not given to conserve, mange and utilize judiciously genetic resources available in the poor and developing countries for food and agriculture there is likely catastrophic of food and nutritional insecurity in the already vulnerable countries of Asia, Africa and Latin America.

The country report of FAO (2010) has documented a wide variety of concerns and measures of loss or reduction in genotypes of many crops. In Zimbabwe, recurrent droughts, most notably the 2002 cropping season, and flooding induced by cyclones have resulted in substantial loss of in-situ plant diversity. Same report has stated that there is genetic erosion for *Hedysarum humile* sensu auct.Eur., chickpea, pea, lupin, and lentil and for wild, endemic taxa attention is not paid to diverse biotypes in Algeria. Disaster recovery programs led by the government have, in most cases, focused on providing chiefly hybrid seed of cowpea, beans, and groundnuts, and fertilizers. There is gradual disappearance of landraces of cowpea and of native cultivated species such as *Vigna angularis* (Willd.) Ohwi & H.Ohashi and *Lathyrus sativus* L. Various local races/cultivars of chickpea, lentil, mung, and mash were observed to be lost in recent years from farmer's fields in Pakistan. There is genetic erosion in mung bean, yard long bean, and cowpea in the Philippines.

FAO (2010) reported that in the case of genetic erosion, the country reports of many countries mention a substantial number of causes; in general these were the same as those identified in 1996. Major causes of genetic erosion of crops included; replacement of local varieties, land clearing, over exploitation, population pressures, environmental degradation, changing agricultural systems, overgrazing, inappropriate legislation and policy, as well as pests, diseases and weeds. From an analysis of country reports, it also appears that genetic erosion may be greatest in the case of cereals, followed by vegetables, fruits and nuts and food legumes (**Table** 2). There have also been genetic erosions of high number of crops of root and tuber, medicinal and aromatic plants, stimulants and spices and many other crops. If the situation continues for genetic erosion of crops a day will come there will be scarcity of food and nutritional crops required to nourish the human population in the world. This calls for immediate measures to be adopted to check accelerated loss and erosion of crop diversity in the world.

Table 2. Crop groups and number of countries that provide examples of genetic erosion in a crop group

Crop group	Number of countries reporting genetic erosion
Cereals and grasses	30
Forestry species	7
Fruits and nuts	17
Food legumes	17
Medicinal and aromatic plants	7
Roots and tuber	10
Stimulants and spices	5
Vegetables	18
Miscellaneous	6

Source: FAO 2010

Inter-dependency of PGRs

Today in the world no country is self-sufficient in the genetic resources for food and agriculture (FAO and Bioversity 2011). It has been found that food and energy supply in the national diet provided by individual crops for different regions of the world was highly interdependent on genetic resources from elsewhere (**Table** 3). This table shows that average degree of interdependence among countries for most important crops is around 71%. Ironically, many economically poor countries are among the richest in terms of genetic diversity needed to ensure human survival. However, matters related to the conservation and sustainable use of genetic resources and the management of related technologies may appear to be technical in reality, strong socio-economic, political, cultural, legal, institutional and ethical implications. Problems associated with these issues in these fields can put at risk the future of humanity. It is not only a matter of conservation and utilization of genetic resources for one country/region rather there must be holistic international cooperation in this area.

Table 3. Estimated range of interdependency for regions' agricultural development on genetic resources from elsewhere

Region	Inter dependency (%)	
	Minimum	Maximum
Africa	67.24	78.45
Asia and the Pacific region	40.84	53.30
Europe	76.78	87.86
Latin America	76.70	91.39
Near East	48.43	56.83
North America	80.68	99.74
Mean	65.46	77.28

Source: Flores Palacios 1997

Because of striking data on PGRs, in 1820's the Russian geneticist Vavilov had identified Asia as one of the regions in the world where there is the highest genetic variability of cultivated food crops. It was also mentioned by Vavilov that Asia has several important centers of origin including Central Asia, China, India and Indo-Malaysia. FAO commission (1997) reported that Asia is the primary centre of origin of many important crops such as rice, wheat, sugar, soybean, banana and plantain, grapefruit, rye, pea and onion. Likewise, Kloppenburg and Kleinman (1987) reported that the Asian and Pacific regions are the least dependent upon crop species originating in other regions of diversity for their food production. The example of Mediterranean where most of cereals, legumes and fruit crops have been originated is becoming highly dependent on crop species. This rationalizes the value and importance of PGRs not only in their place of origin but also in the other parts of the world equally.

Food and Nutritional Security

There is a high discrepancy of undernourished people in Southern Asia followed by Eastern Asia and Sub Saharan Africa during 1990/92 and 2014/16 (http://www.fao.org/3/a-i4646e/i4646e03.pdf). The rise of poverty and undernourished people in Oceania and Western Asia also rose with smaller margins and low level. This also necessitates that the importance of reducing hunger and malnutrition and under nutrition from the world, of course, has solely rest upon increase of food production and productivity through judicial management of APGRs in general and particular to major food crops which supply bulk of food globally. Bulk of the energy comes from carbohydrates from cereals, root and tubers and crops (**Table** 4).

Finite Resources and Burgeoning Population Growth

Essential resources such as oil and phosphorus are in declined trend compared to corresponding population growth of the world (http://www.mdpi.com/2071-1050/3/10/1742/ag) as predicted (**Figure** 2). Availability of finite resources starts to decline after plateau in 2000 while population growth kept on increasing steadily beyond 2050. This is the case with food production using genetic resources which have already eroded before reaching maximum utilization and potentiality. Therefore, it is imperative to judiciously conserve, manage and use genetic resources in a way it is in pace with population growth to feed the increasing mounts of the world not only in present condition but also for the future time as well. This calls for start of pragmatic and functional initiation of considering the importance and use of genetic resources available beyond the geographical and political boundary of the world where these are available in their niches of origin.

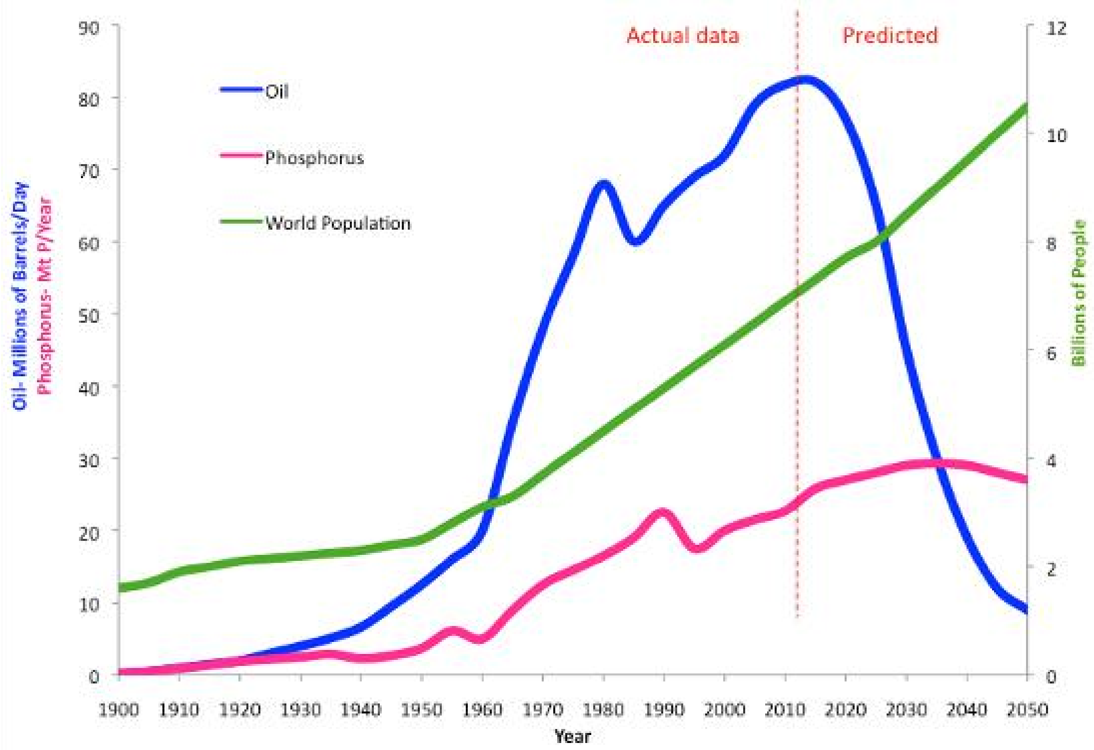

Figure 2. Expected population growth in comparison to population from 1900 to 2050.
Source: http://www.mdpi.com/2071-1050/3/10/1742/ag

STATE OF GLOBAL GERMPLASMS HOLDINGS

Bulk of the ex-situ APGRs is generally held by the genebanks of the CGIARs for germplasm of their mandate crops. For example; wheat and maize collections are held at CIMMYT that of rice at IRRI; sorghum, chickpea, groundnut, and pearl millet at ICRISAT; lentil, faba bean and vetch at ICARDA; beans at CIAT; potato at CIP. Many countries have their own genebanks where they collect and preserve APGRs (WIEWS 2009) as shown in **Table** 4. Major countries holding genetic resources are China, India, USA, UK, Russia, Iran, Brazil, Japan, South Korea Germany, and many more. Even in a country germplasms are hold by different institutions such as research organizations, universities, CBOs community seed banks, farmers' organizations and individual farmers as well. Around 7 million PGRs have been conserved in different CGIAR centers in the world.

Table 4. Global germplasm holdings according to types of groups of crops

Commodity group	No. of accessions	% Wild species	% Landraces	% Breeding materials	% Advanced cultivars	% Others
Cereals	3 157 578	5	29	15	8	43
Food legumes	1 069 897	4	32	7	9	49
Roots and tubers	204 408	10	30	13	10	37
Vegetables	502 889	5	22	8	14	51
Nuts, fruits and berries	423 401	7	13	14	21	45
Oil crops	181 752	7	22	14	11	47
Forages	651 024	35	13	3	4	45
Sugar crops	63 474	7	7	11	25	50
Fibre crops	169 969	4	18	10	10	57
Medicinal, aromatic, spice and stimulant crops	160 050	13	24	7	9	47
Industrial and ornamental plants	152 325	46	1	2	4	47
Other	262 993	29	4	2	2	64
Total/overall mean	6 998 760	10	24	11	9	46

Source: WIEWS 2009.

Cycle of Genetic Resource Conservation

A hexagonal cycle of genetic resource conservation has been suggested (http://www.fao.org/typo3temp/pics/d264dd4302.gif). In this cycle, genetic resource conservation is supported by restoration of germplasms followed by information on elite germplasm in support of genetic diversity. This again has followed by seed production and supply which provide new cultivars developed through plant breeding. Likewise, farmers' ecosystem is maintained through on-farm-in-situ conservation supported by their ex-situ restoration of cultivars. Again farmers' ecosystem should be maintained through trials and breeding with involvement of seed growers for seed saving and seed production in a participatory plant breeding approach. This is how genetic resources are conserved through plant breeding, seed production and supply developing new cultivars using resources in ways there are acquisition of elite germplasms with maintaining of genetic diversity in farmers' friendly ecosystem where it is entangled in a hexagonal cycle as depicted in the **Figure** 3. This is the most sustainable way to manage, conserve and utilize genetic resources for maintaining food and nutritional security.

Food Diversity and Plant Genetic Resources

Hunter-gatherers realized some 12000 years ago that they could save and plant seeds from season to season. Over the millennia, farmers learned to save seeds of crops they deemed easiest to process or store, or those most likely to survive growing seasons or even those that simply tasted the best. As a result, more than 7000 species of plants have been cultivated or collected (www.fao.org/nr/cgrfa). Of this pool of PGRs in the world, humans are dependent on very little stock of these. Among them there are many minor and underutilized crops which are pivotal with respect to nutritional content and have been used by indigenous people residing in their place of origin thereby developing many desirable traits to with stand natural catastrophes such as infestation of insect pests and diseases and tolerant to abiotic stress such as drought, flood, increase temperature and other constraints.

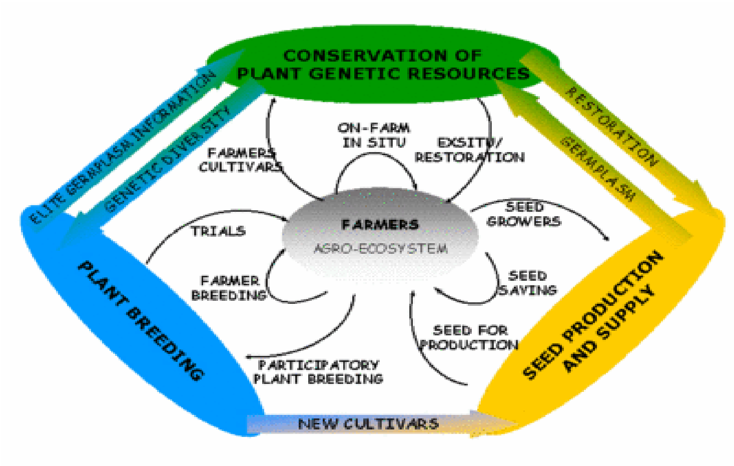

Figure 3. Hexagonal cycle of genetic resource conservation.
Source: http://www.fao.org/typo3temp/pics/d264dd4302.gif

Indigenous PGRs and Respect for Minor Crops for Food Diversity

In many parts of Africa minor crops of cocoa, quinoa, teff, fonio and canihua are underutilized crop species. These crops in certain parts of the world are critically important to household food and livelihood security. These crops are conserved and maintained by local communities, although these have not been given priority by agriculturists for research and development. Their food value and importance are understood by the local communities and consumers in these parts of the world. Yet, they and countless other neglected species have widespread potential to contribute to agriculture and to diet diversification, bringing benefits to farmers and consumers. African farmers felt little need for alarm when the leaves of their cassava plants occasionally became patchy. The importance of minor crops was felt in Africa in 1989 when an aggressive strain of cassava mosaic disease caused decimating harvests throughout the Great Lakes region and in Uganda, for instance, the virus-caused food shortages led to localized famine and major economic losses (http://www.fao.org/nr/cgrfa/cthemes/plants/en/). In response to tackle the disease in cassava, national and international experts went into action and tested some 100000 cassava samples collected and exchanged among gene banks from around the world. Through a process of genetic selection, they identified a series of resistant varieties and set up nurseries in the affected countries to multiply disease-free cassava seedlings which enabled the recovery of cassava cultivation (http://www.fao.org/nr/cgrfa/cthemes/plants/en/). Given the significance of a relatively small number of crops for global food security, it is of pivotal importance to conserve the diversity within these major crops. Farm communities in the Andes cultivate more than 175 locally named potato varieties.

Impact of Biodiversity Losses

There are volumes of literature available with respect to the impact of biodiversity globally, regionally and locally. The International Union for Conservation of Nature (IUCN) (http://www.globalissues.org/article/171/loss-of-biodiversity-and-extinctions) notes that many species are threatened with extinction and the thread of extinction are: 1 out of 8 birds, 1 out of 4 mammals, 1 out of 4 conifers, 1 out of 3 amphibians, 6 out of 7 marine turtles, 75% of genetic diversity of agricultural crops has been lost, 75% of the world's fisheries are fully or over exploited, up to 70% of the world's known species risk extinction. If the global temperatures rise by more than 3.5°C, 1/3rd of reef-building corals around the world are threatened with extinction, and over 350 million people suffer from severe water scarcity. In a nut shell, the direct impact of biodiversity could be seen in increase vulnerability of species extinction, ecological imbalance, reduced source of food, structural materials, medicinal and genetic resources, and cost increases to the society for sustaining livelihood in general and poor and marginal community in particular. Hence, their conservation and management judiciously is not only way for survival of only humans but also the survival of the living beings in the Mother Earth because if there is imbalance of natural resources availability a big question mark arises as to how sustainable existence of living beings in the earth as a whole could be possible in way we are living today in time to come.

Conservation Efforts of PGRs through Genebank

Genebanks are one of the important institutions to conserve ex-situ genetic resources collected from their place of origin and habitats. Genebanks are a type of biorepository which preserve genetic material (https://en.wikipedia.org/wiki/Gene_bank). For plants, this could be by freezing cuttings from the plant, or stocking the seeds (eg in a seedbank). For animals, this is the freezing of sperm and eggs in zoological freezers until further need. With corals, fragments are taken which are stored in water tanks under controlled conditions. In plants, it is possible to unfreeze the material and propagate it, however, in animals; a living female is required for artificial insemination.

By now we came to know that genebanks are the important institutions to preserve APGRs in ex-situ and in-situ forms. To run genebanks effectively, there are some important strategies to be taken into considerations. As depicted in **Figure** 4, these considerations include; data management system, collecting and partnership, germplasm health, policy, and maintaining standards.

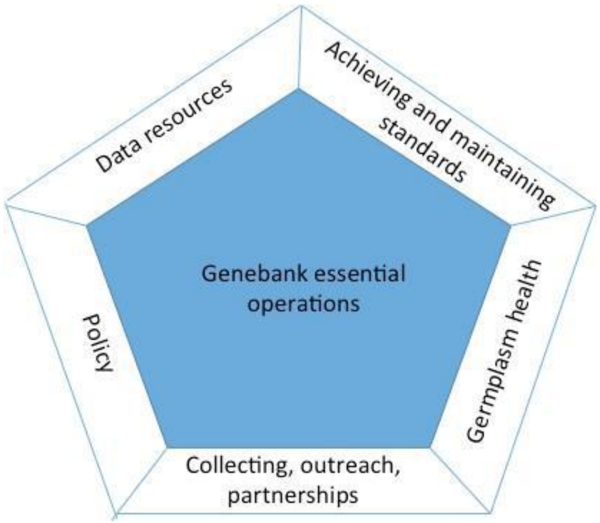

Figure 4. Essentials of genebank.
Source: CGIAR and Crop Trust 2017-2021.

Traditional efforts to counter genetic erosion concentrated on conservation of seeds in crop genebanks (ex-situ). Today, it has become clear that the best strategy combines ex-situ conservation with on-the-ground (in-situ) conservation of PGRs. Conservation by farmers in their agro-ecosystems and of crop wild relatives in, for example, areas protected for their environmental value. Farmers are involved in conservation of genetic resources in their field in both in-situ and ex-situ condition from the dawn of civilization. Therefore, every farmer is a genebank by himself/herself.

PGRs Conservation Systems

PGRs conservation could be done in number of ways and there is no single most perfect way to conserve PGRs and combinations of ex-situ and in-situ conservation should be employed to conserve PGRs. Generally, conservation methods include seed bank, in-vitro bank, cryo bank, DNA bank, field genebank (http://cropgenebank.sgrp.cgiar.org/index.php/procedures-mainmenu-243/conservation-mainmenu-198/in-vitro-bank-mainmenu-200), botanical garden, zoological gardens, farms/parks and so on.

Ex-situ Conservation

This is the conservation of PGRs outside their environment of natural occurrence (Jarmillo and Baena 2002). PGRs conserved in ex-situ could be used for current and/or future time. Ex-situ conservation can be used to protect species, ranging from wild and weedy species (or regressive forms) to cultivate species. This type of conservation has been widely used in recent decades (Hidalgo 1991). Wide ranges of species are conserved including wild and weedy species, traditional and improved varieties, and products of biotechnology and genetic engineering materials as well (Jaramillo and Baena 2002).

Seed bank: In this system, seeds are stored to preserve genetic diversity which is a type of gene bank (https://en.wikipedia.org/wiki/Seed_bank). Generally ex-situ conservation of orthodox seeds is conserved in seed bank. Seeds stored in seed banks are used when there is the need of new varieties to be developed by breeders, in time of natural disaster, war and losses of seeds or indigenous varieties from the place of origin, seeds from genebanks are used to restore those purposes.

In-vitro bank: This involves maintenance of explants in a sterile, pathogen-free environment which is therefore preferentially applied to clonal crop germplasm and multiplication of species that produce recalcitrant seeds, or do not produce seeds. It also supports safe germplasm transfers under regulated phytosanitary control. This modern technique has already been applied for multiplication, storage and collection of germplasm of many germplasms species.

Cryo bank: It is becoming widely used for long-term storage of seeds and in-vitro cultures and is the method of choice for ensuring cost-effective and safe, long-term storage of genetic resources of species which have recalcitrant seeds or are propagated by vegetative methods for propagating such as sugarcane, tuber crops (potato, yams), cassava, papaya, mango, fruits (apple, pear, peach, banana) and so on. Storage is usually in liquid nitrogen (-196°C). In this method all metabolic processes and cell divisions are arrested vegetative propagules of crops mentioned above under cold conditions of 4-20°C for several months between one harvest and the next planting season.

DNA bank: In this system, DNA is routinely extracted and stored from the nuclei, mitochondria and chloroplasts of many plant species. Also this includes along with DNA other cell derivatives such as RNA, cDNA and genes. These molecular techniques are becoming increasingly important in the study and management of genetic resources.

In-situ Conservation

This system of conservation is just reverse of ex-situ conservation and encourages conservation agencies to conserve PGRs in their place of origin and habitat. By doing so, generally, PGRs which are impossible to conserve in ex-situ systems are conserved in the field as live samples and protected from extinction. From such sites these are used for breeding and whatsoever purposes are meant for.

Field genebank: In field genebanks, the plant genetic resources are kept as live plants that undergo continuous growth and require continuous maintenance. They are often used when the germplasm is either difficult or impossible to conserve as seeds (ie when no seeds are formed, seeds are recalcitrant or seed production takes many years, as for many tree species) or the crop is reproduced by vegetative propagation. Under NARC and DoA many research stations and resources centers where there are many indigenous crops and these are to be maintained and preserved as field genebanks. This also includes heritage sites, conservation area and old fruit orchards established in many rural parts of Nepal as religious purposes.

In-situ seed banks managed by farmers: Similarly in-situ conservation could be on-farm conservation of PGRs by growers these in their farm lands in the form of household seed bank, community seed bank and community field Genebank. In developing country like Nepal in-situ conservation are in different forms adopted by farmers which are house hold seed bank where farmers conserve different types of crops including cereals, legumes, root and tubers, spices and condiments, forage and fodder, medicinal and aromatic plants (MAPs), non-timer forest product (NTFPs) and many more from the time immemorial. Even in a small kitchen in the eastern hills of Nepal a farmer was reported maintaining more than two dozen crops of vegetables. In a pragmatic way one can see crops such as rice (different indigenous varieties), maize (pop corn, flint corn dent corn, early corn, main season corn), wheat which is relatively a new crop, beans/legumes (soybeans, mung bean, faba bean, pole beans, four season bean, rice bean, black gram, lentil, horse gram, red gram, peas and so on), cucurbits (ridge gourd, snake gourd, pumpkins, water and musk melon, bitter gourd, chayote), chilly, potato, yams and different crucifers (cabbage, cauliflower, knoll khol, broad leaf mustard, radish, turnip), coriander, onion, garlic, leek, fenugreek, carom/thyme seed (jwano), zinger, turmeric are grown by a single farmer mostly in homestead garden in rural farming of Nepal.

IMPORTANCE OF APGRs CONSERVATION AND MANAGEMENT

Plant genetic diversity may also provide valuable traits needed for meeting challenges of the future, such as adapting our crops to changing climatic conditions or outbreaks of disease. A variety of Turkish wheat, collected and stored in 1948 was ignored until the 1980s when it was found to carry genes resistant to many disease-causing fungi. Plant breeders now use those genes to breed wheat varieties that are resistant to a range of diseases. Tungro virus in rice spreading in ASEAN region was controlled by resistance gene available in wild rice *Oryza nivara* S.D.Sharma & Shastry obtained from southern Himalaya (Nepal and India). Wild botanical relatives of our food crops – often found on the periphery of cultivated lands – may contain genes that allow them to survive under stressful conditions.

Submergence gene- identified in Swarna-Sub-1 Indian rice variety has been introgressed with improved variety of rice in IRRI and popularized in many parts of ASEAN and SAARC region to grow rice in flood prone areas. This has helped increased rice productivity in these regions and even in Nepal Swarna Sub-1 variety has been released to grow in flood plain areas of Tarai region (CDD 2015). Dwarf gene (Norin-10) of wheat from Japanese germplasm Akakomugi helped Green Revolution to introduce this gene into improved varieties of wheat in CIMMYT and these wheat varieties brought dramatic yield increase in India, Pakistan and other parts of the world where wheat is massively grown as staple crop. Similarly, rice blast (*Magnaporthe oryzae*) resistance present in the *aus* type cultivar AS20-1 (India) and numerous genes for resistance have been found in both *japonica* and *indica* rice germplasm as well.

Climate Change and Adaptation

Plant genetic diversity may also provide valuable traits needed for meeting challenges of the future, such as adapting our crops to changing climatic conditions or outbreaks of disease. Wild botanical relatives of our food crops – often found on the periphery of cultivated lands – may contain genes that allow them to survive under stressful conditions. These genes can add important traits to their cultivated relatives, such as robustness or frost resistance. BPH resistance gene, gall midge resistance and other insect-pests resistance genes of rice have been identified from wild species of rice. Similarly most of the stress such as drought, flood, heat, salinity, and alkalinity and more other stresses are being addressed from resistance genes of wild species and relatives of cultivated crops of major food crops (rice, wheat, maize, potato, and soybean) (Ibid).

PGRs are so important that in 1989, an aggressive strain of cassava mosaic virus caused great losses in Uganda. As a result there was localized famine and major economic losses. In response, experts tested some 100 thousands cassava samples collected and exchanged among gene banks from around the world and identified a series of resistant varieties which enabled recovery of cassava cultivation in the region (http://www.fao.org/fileadmin/templates/nr/documents/CGRFA/factsheets_plant_en.pdf). These are some of the examples how important PGRs are to address stresseses broght by climatic, adaphic and anthropogenic activities to cause irrperable losseses and damage to the cfood rops in question.

NEPAL IN GLOBAL PGRs

According to BPN (1996), Nepal ranks 10th in terms of richest flowering plant diversity in Asia, and 31st in the world, whilst, there are recorded 181 mammal species, 844 bird species, 100 reptile species, 43 amphibian species, 185 freshwater fish species, and 635 butterfly species while the flora recorded are 5,160 species of flowering plants and 1,120 non-flowering plants (Ibid). Nepal has 7000 flowering plant species and out of them 370 species are endemic and about 600 food plants species have been estimated to be grown within the altitude range of 60 m to 4200 m above sea level (MoFSC 2002, Upadhyay and Joshi 2003).

Nepal, compared to her geographical size, encompasses a wide range of physiographic regions, ecosystems and vegetation from flat lowlands to steep mountain slopes which is endowed with rich biodiversity. BPH resistance gene, gall midge resistance and other insect-pests resistance genes of rice have been identified from wild species of rice available in Asia and southern lap of the Himalaya including, Nepal, India, and Bangladesh (Paudel 2016). Resistance genes for quantitative resistance to late blight are present in the germplasm of wild and cultivated potato (http://onlinelibrary.wiley.com/doi/10.1046/j.1365-313X.2001.01292.x/pdf). Likewise, Joshi et al (2017) reported that of the collected rice germplasms in IRRI, Nepalese rice germplasms of 7353 accessions have been distributed in sixty countries of the world and among them most commonly used germplasms were Jumli Marshi and Chhomrong *Dhan* (cold tolerance and blast resistance), *Oryza nivara* (brown plant hopper resistance and Tungro virus resistance) and in the same way some of the released rice varieties in Nepal have directly been released in Bhutan, India and Madagascar. Aside from this, Nepalese rice germplasms have been used for breeding with different breeding objectives of fine and aromatic, drought tolerance, diseases and insect pest resistance to develop varieties for commercial purposes.

Joshi et al (2017) reported that for rice only there is a vast contribution of genetic resource maintained and available in Nepal in global perspective with respect to rice science. They found that a total of 8389 rice accessions collected from Nepal are conserved in nine different genebanks across the world including Nepal, IRRI, Japan, India, Korea, Bhutan, USA, Vavilob institute Russia, and Benin (British Museum). PGRs collected for other crops such as wheat, barley, oat, maize, potato, legumes, forage and fodder, and other cultivated and wild relatives crops have been collected and conserved in different genebanks including CGIARs, Millennium Seed Bank (Kew, Garden), UK, World Seed Vault, Korea and many other institutions across the world. There is high diversity of vegetable crops is Nepal which include wild relatives of *Colocasia, (*three spp.), *Amaranthus* (four spp.), *Chenopodium* (two spp.), *Rumex* (three spp.), *Pisum* (three spp.), *Alium* (three spp.), *Ipomoea* (five spp.), *Dioscorea* (four spp.), *Mentha* (three spp.), *Trigonella* (two spp.), *Solanum* (two spp.), *and Curcuma* (five spp.). Nine species of *Prunus*, three species each of *Castanopsis, Malus, Morus* and *Rubus* and two species each of *Barberies, Ficus, Hippophae, Olea, Pyrus* and *Vitis* are documented as temperate wild fruit relatives. Also there is abundance of subtropical and tropical wild fruit relatives of *Annona, Citrus, Mangifera, Musa, Foenix* and *Rhus* (Upadhyay and Joshi 2003)

GENETIC RESOURCE CONSERVATION IN NEPAL

Nepal is one of the oldest contries in the world. For Nepal, so far as PGR conservation is concerned, she has given due importance for conservation and management of PGRs from the Vedic period. The epic describes that food crops of rice, mung, sesame, oat, garlic and sugarcane thrive well true to their seeds. Along with this in the same Manusmriti still clearly gives analogy how important seeds are for farming even in the ancient times. Meaning to say that Manusmriti was aware of the condition that good seeds shown into good land yield abundantly. There are many such examples about farming and conservation of PGRs in our ancient orient literatures which are parts and parcel of our daily life. In these literatures, there has given ample importance for agriculture and PGRs conservation and management in detail. In this respect some 10 National Parks, 3 Wild Life Reserve, 1 Hunting Reserve, 3 Conservation Area, 4 Ramsar Sites and 6 World heritage Sites represent habitat conservation of many flora and fauna in in-situ condition. For ex-situ conservation Nepalese APGRs are conserved in many parts of the world. Nepal established the genebank in 2010 under NARC (Joshi et al 2013). In genebank, there is a collection of more than 11,000 accessions of 29 crops under ex-situ conservation and of this collection, sixty nine accessions of barley from Nepal have been safety duplicated in the World Seed Vault, Suwon Korea in 2014 (Genebank 2016).

In-situ Conservation

This includes protected areas established in Nepal for the protection of wildlife, especially endangered wildlife. These areas include the preservation of natural, historic, scenic, and cultural values that encompasses about 26,695 square kilometer (km^2), 20.73% of the total area of Nepal (MoFSC 2002). This includes in-situ conservation of genetic resources in those sites (**Table** 5).

Protected Areas of Nepal

Almost in every country there are certain protected areas, national parks, conservation areas, wildlife reserves, hunting reserve, world heritage sites, Ramsar sites and other conservation initiatives. In such sites whatever genetic resources are present these are conserved in their place of origin and habitat. In these reserve and national parks one can see endemic flora and fauna including, crops and their wild relatives, terrestrial, aquatic, amphibians, microbes both autotrophs and heterotrophs, many more species which are given shelter and protection by the respective governments whatever and wherever these are available in these protected areas. This also indicates the sincere and pragmatic initiatives taken by Nepal to preserve genetic resources holistically. Nepal should get PGRs tax from other countries which are massively using these genetic resources in lieu of PGRs conservation for the world.

In Nepal protected areas included for the world heritages sites are Lumbini, the Birth Place of the Lord Buddha (area 64.5 km^2), Chitwan National Park, Kathmandu Valley, Swayambhu Monument Zone (0.6 km^2) Pashupati Monument Zone (2.64 km^2) Changunarayan Monument Zone (0.5 km^2), and Sagarmatha National Park (Nepal Biodiversity Resource Book 2007).

Table 5. Details of protected areas of Nepal

Category of protected areas and established year	Area, km^2	Altitude, m
A. National Park (NP)		
a. Royal Chitwan NP (1973)	932	150-815
b. Royal Bardia NP (1976/1988)	968	152-1,494
c. Shivapuri NP (2002)	144	1,366-2,732
d. Khaptad NP (1984)	225	1,000-3,276
e. Makalu Barun NP (1991)	1,500	435-8,463
f. Sagarmatha NP (1976)	1,148	2,800-8,850
g. Langtang NP (1976)	1,710	792-7,245
h. Shey Phoksundo NP (1984)	3,555	2,000-6,885

Category of protected areas and established year	Area, km^2	Altitude, m
i. Rara NP (1976)	106	1,800-4,048
j. Shey Phoksundo NP (1984)	3555	2,130-6,885
Total	13843	
B. Wildlife Reserve (WR)		
k. Koshi Tappu WR (1976)	175	90
l. Parsa WR (1984)	499	150-815
m. Royal Suklaphanta WR (1976)	305	90-270
Total	979	
C. Hunting Reserve (HR)		
a. Dhorpatan HR (1987)	1,325	2,850-7,000
Total	1,325	
D. Conservation Area (CA)		
a. Kanchenjunga CA (1997)	2,035	1,200-8,598
b. Manaslu CA (1998)	1,663	1,360-8,163
c. Annapurna CA (1986, 1992)	7,629	1,000-8,092
Total	**11,327**	
E. Buffer Zone		
a. Royal Chitwan NP	750	
b. Royal Bardia NP	328	
c. Makalu Barun NP	830	
d. Langtang NP	420	
e. Shey Phoksundo NP	449	
f. Sagarmatha NP	275	
Total	3,051	
Total Area Protected (% of Nepal Territory)	26,970 (20.73)	

Source: MoFSC 2002.

Despite harboring huge genetic resources in Nepal, there is likelyhood of genetic erosion of such important materials both indigenous and wild relatives of many crops mainly due to replacement of these local landraces by modern *v*arieties (Joshi et al 2013). There are very strong chances of genetic erosion of species due to other anthropogenic activities such as temperature rise due to climate change, deforestation, losses of habitat from clearing of forest and construction, population rise, natural calamities of drought, flood, land slide, forest fire and so on.

Ex-situ Conservation

To conserve genetic resources, Nepal has preserved ex-situ conservation of more than 11000 accessions of orthodox seed (**Table** 6). These PGRs have been characterized, multiplied and provided as breeding stocks for breeders to develop improved varieties on the demand basis. Also, growers, in case of demand, are also supplied seeds for their use from different parts of the country. More than 25000 Nepalese PGRs accessions have been conserved in ex-situ by the different countries and institutions across the world (Joshi et al 2015).

Table 6. Plant genetic resources conserved in Nepal up to 2016

SN	Crop	Accession (n)	SN	Crop	Accession(n)
1	Rice	2400	D.	Oilseeds	185
2	Wheat	1700	31	Tomato	20
3	*Barley	1230	32	Pumpkin	50
4	Maize	220	33	Okra	125
A.	Cereals	5550	34	Bitter gourd	15
5	Finger millet	600	35	Sponge gourd	20
6	Foxtail millet	35	36	Barela	25
7	Proso millet	30	37	Lettuce	10
8	Pearl millet	5	38	Brinjal	25
9	Buckwheat	230	39	Cucumber	40
10	Amaranths	200	40	Leaf mustard	30
11	Sorghum	50	41	Coriander	25
B.	Pseudo cereals	1150	42	Cress	30
12	Lentil	300	43	Chilli	100
13	Chickpea	300	44	Radish	50

SN	Crop	Accession (n)	SN	Crop	Accession(n)
14	Cowpea	150	E.	Vegetables	565
15	Grass pea	120	45	Taro	30
16	Pigeon pea	20	46	Yam	15
17	Field peas	125	47	Ginger	80
18	Beans	430	48	Turmeric	75
19	Rajma bean	20	49	Chayote	15
20	Broad bean	25	50	Potato	10
21	Soybean	150	51	Sugarcane	6
22	Rice bean	40	52	Garlic	50
23	Horse gram	60	53	Fruit trees	20
24	Greengram	10	F.	Field Gene Bank	301
25	Blackgram	50	54	Others (miscellaneous)	1500
C.	Pulses	1800	Sub total		11051
26	Rapeseed/mustard	90			
27	Sarsoon	20			
28	Sesame	40			
29	Niger	15			
30	Linseed	20			
G.	Sub total	185			
H.	Grand total	11236			

**Sixty nine accessions of barley from Nepal have been safety duplicated in the World Seed Vault, Suwon, Korea in 2014 (Paudel 2016).*

Genebank established at Khumaltar in 2010 under NARC has regularly been collecting indigenous as well as crop wild relatives from different parts of the country (**Table** 7). Up to 2016, there are collections of 29 species of 46 accessions (**Table** 7) crop wild relatives and sent to safety duplications in Millennium Seed Bank (MSB), UK. Nepal, being one of the signatories of ITPGRFA, has kept 607 accessions of crop varieties including 7 accessions of forage crops in the multilateral systems (MLS). Similarly 185 local accessions of different vegetables have been collected and sent to NIAS.

Table 7. Collection of crop wild relative gene pool by genebank, Khumaltar, Nepal up to 2016

SN	Crop name	Scientific name	Subsp. var.	Total
1.	Alfalfa	Medicago sativa L.	Falcate (L) Arcang	1
2.	Alpine strawberry	Rubus calycinus Wall. ex D.Don		1
3.	Amaranthus	Amaranthus spinosus L.		2
4.	Amaranthus	Amaranthus viridis L.		2
5.	Apple	Malus sikkimensis (Wenz.) Koehne ex C.K.Schneid.		1
6.	Banana	Musa sp.		2
7.	Barberry (Chutro)	Berberis asiatica Roxb. ex DC.		2
8.	Bay Barry	Myrica esculenta Buch.-Ham. ex D. Don		1
9.	Buckwheat	Fagopyrum tataricum (L.) Gaertn.	Potanni	2
10.	Carrot	Selinum candollei Edgew.		1
11.	Cow pea	Vigna nepalensis Tateishi & Maxted		1
12.	Egg plant	Solanum virginianum L.		1
13.	Field Pea	Lathyrus aphaca L.		1
14.	Finger Millet	Eleusine indica (L.) Gaertn.		2
15.	Ladys finger	Abelmoschus manihot (L.) Medik.		3
16.	Pearl Millet	Pennisetum orintale Rich.		1
17.	Pigon Pea	Cajanus scarabaeoides (L.) Thouars		1
18.	Rape Mustard	Rorippa indica (L.) Hiern		1
19.	Rice	Oryza granulata Nees & Arn. ex Hook. f.		1
20.	Rice	Oryza rufipogon Griff.		5
21.	Rice	Oryza nivara S.D.Sharma & Shastry		1
22.	Sweet potato	Ipomoea cairica (L.) Sweet		2
23.	Swiss chard	Rumex nepalensis Spreng.		1
24.	Swiss chard	Rumex acetosella L.		1
25.	Wild Cucumber	Mukia *maderaspatana* (L.) M.Roem.		2
26.	Wild Peach	Prunus persica (L.) Stokes		1

SN	Crop name	Scientific name	Subsp. var.	Total
27.	Wild pear	Pyrus pashia Buch.-Ham. ex D.Don		3
28.	Wild Pomrgranate	Punica granatum L.		1
29.	Wild walnut	Juglans spp.		2
			Total	46

Source: Genebank 2016.

Community Seed Bank

Community seed bank (CSB) as defined by Shrestha et al (2013) is designed to enhance access to local varieties and associated knowledge for the benefits of the community. The number of active CSB in Nepal is reported 115 (Ronnie et al 2013, Joshi 2013). However, some of the CSB might have ceased to operate while new CSB could have been emerged without formal notice to the concerned agencies. There is a long history of community seed bank (CSB) in Nepal and it has been supported by a number of N/GOs and can now be found across the country (Ronnie et al 2013). Formal initiation of CSB in Nepal was initiated from 1994 by establishing a CSB in Dalchowki, Lalitpur as the first CSB in the country (Joshi 2013). Nepal including developing countries of the world uses more than 90% of seed transaction in informal way which consists of borrowing seeds from the neighbor. Informal transaction of seeds is mostly done through farmers' kept seeds of crops in their household for coming season planting and very few of them depend upon seeds from market or seed dealers for local crop variety while for improved variety seeds are generally bought from seed dealers which is very low around 5-10% for the improved varieties.

WAY FORWARD

Sincere efforts have been made to manage in-situ and ex-situ conservation of APGRs in Nepal to address climate change and food security status of the country through the judicial use of plant genetic resources for food anfd agriculture. Indigenous crop species and varieties, and crop wild relatives have been collected and safety duplicated through national and international genebanks. This signifies how important this country is from the point of APGRs globally. Nepal should not be ranked in the least developed and poor countries of the world as she is one of the riches countries with respect to availability and management of APGRs.

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Minor Fruits in Nepal: Utilization and Conservation Efforts

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ABSTRACT

Varied topography and diverse micro-climatic conditions of Nepal allow cultivation of all types of fruit species ranging from tropical to subtropical to temperate. More than 100 indigenous fruit and nut species have been reported in Nepal. This diversity is rapidly declining as farmers grow selected varieties of few fruits such as banana, mango, litchi, apple, and mandarin orange which are more productive and marketable. These fruits are cultivated at large scale and are commercially available throughout the country, whereas, fruits such as kafal (*Myrica esculenta* Buch.-Ham. ex D.Don), lapsi (Nepalese Hog Plum, *Choerospondias axillaries* (Roxb.) B.L.Burtt & A.W.Hill), amala (*Emblica officinalis* Gaertn.) harvested from forest are sold in local markets which generate a considerable amount of income to the vulnerable communities by selling them at a good price. Other fruits like pummelo (*Citrus maxima* (Burm.) Merr.), citron (*Citrus medica* L.) and walnut (*Juglans regia* L.) are used during special rituals such as for Bhaitika in Tihar and are sold during those festival times. Bael (Wood apple, *Aegle marmelos* (L.) Correa) is used by Newari community during the Bael Bibah of their daughters. Similarly, certain fruits like avocado, almond, pear, peach, plum, prunes, berries, persimmon, cherry, strawberry, and nuts are not extensively cultivated in Nepal, and their consumption and trade are limited. Fruits which are not commercially cultivated or not adequately utilized but have great potential for commercialization are referred to as the "minor fruits." Minor fruits are of considerable economic importance in their locality due to their nutritional, medicinal and cultural values. Pharping Naspati (*Pyrus pyrifolia* (Burm.f.) Nakai), a local pear in Nepal has low chilling requirements and hence is adaptable to grow even at lower altitudes. Likewise, several indigenous fruit plants and their wild relatives such as Mayal or Mel (*Pyrus pashia* Buch.-Ham. ex D.Don), Jyaamir (Rough lemon, *Citrus jambhiri* Lush.) and local olive which are resistant to diseases, pests, and climatic adversities have been used as rootstocks for grafting scions of high yielding varieties. We don't have an integrated digital database of the available fruit germplasm collection which is constraining the researchers from maximizing the use of the valuable genetic resources in research and varietal development. There is an urgent need for identification, evaluation, conservation, registration, and protection of the indigenous fruits through *sui generis* system as per the Trade Related Aspects of Intellectual Property Rights (TRIPs) and their promotion to increase cultivation, domestic consumption and export.

Keywords: Backyard, conservation, database, diversity, germplasm, minor fruits

INTRODUCTION

Fruits are an integral part of the Nepalese agriculture, and form prestigious and serene component of culture and tradition. Fruits have been widely used for rituals and cultural purposes since ancient time in the country. Recently, fruit cultivation has been emerging as a commercial enterprise. Nepal is center of the origin for many fruit species and is rich in local fruit germplasm. Several genus, species and cultivars of fruits are found in Nepal. There are no complete records of edible fruits growing in the wild. Geographic situation and topography of Nepal has given rise to diverse climatic conditions that provide required micro-climatic condition to a large biodiversity (Pradhan et al 2016). Tropical fruit species such as mango, jackfruit, litchi, and custard apple are grown in Tarai region while subtropical to warm and cold temperate fruits and nut species grow well in Mid Hill and High Hill of Nepal. Gotame et al (2014) reported 107 indigenous fruit and nut species in Nepal. At least 45 species belonging to 37 genera are reported as wild edible fruits (Kaini 1994). These fruits are consumed fresh, pickled, roasted or preserved in various forms (Shrestha 1998). Kafal, amala, lapsi, aiselu, katus fruits harvested from the forests are sold in local markets by the local people at a good price. Similarly, the local peach, pear, plum, walnut, citron, nibuwa (Hill lemon), pummelo, etc are grown in scattered locations and mainly sold in the local markets. These fruit species and their wild relatives can be used in breeding programs to improve fruit varieties to suit the local environment (Regmi and Shrestha 2005). Commercial cultivation of fruits in Nepal started only in the 19th century. Department of Agriculture (DoA) was established in 1925. Several temperate fruits were introduced to Balaju and Godawari orchards. Nepal received assistance from USAID in the 1950s and from India in 1960s. Promotional activities on fruit development started after 1950. Horticulture Development Section under DoA was established in 1955. Within a decade, improved cultivars of apple, cherry, pear, peach, persimmon, plum, etc were introduced in Nepal and grown at Singhadurbar and Kakani farms. Cultivar performance studies and propagation activities were carried out. The Government of Nepal began to emphasis fruit development in the Hills. Fourteen horticulture farms/stations were established during the 1960s at different agro-ecological zones and 10 more were added during the seventies (HDP 1999). Cultivar performance studies, planting material production and distribution, and training of farmers were also started resulting in commercial fruit cultivation in Nepal (Shrestha 1993). Between 1977 and 1980, the Hill Agriculture Development Project assisted by Food and Agriculture Organization (FAO) helped in the cultivation of both deciduous and temperate fruits. Similarly, in 1988/89 Hill Fruit Development Project under the loan assistance of Asian Development Bank and technical assistance of United Nation Development Program (UNDP) was launched in 11 hilly districts of Eastern development region. Focus of these programs was on a few selected fruits that rest of the fruits became minor fruits because of their limited utilization and availability. Cultivation and characterization of the indigenous and wild fruits are not exploited and studied.

Government bodies like National Agricultural Research Council (NARC) and DoA have been introducing a few exotic cultivars of major fruits from abroad. They are well researched and characterized. Similar documentation, characterization, conservation and evaluation of indigenous fruit species are still lacking. There is an urgent need of identification, registration and evaluation of neglected and underutilized fruit species of Nepal which are referred to as the “minor fruits.” Aim of this paper is to gather available information related to various aspects of the minor fruit species of Nepal, their existing conservation and utilization practices.

DIVERSITY OF FRUITS IN NEPAL

Nepal is very rich in fruit diversity. Due to diverse eco-climatic conditions in Nepal, there are certain kinds of seasonal fruits available in nature and thus the country has one kind or the other kind of fruit throughout the year. All the seasonal fruits in Nepal are tree-ripened and have a delicious taste, texture, flavor and color. Different types of citrus fruits such as suntala (mandarin orange or tangerine, *Citrus reticulata* Blanco), nibuwa (lemon, *Citrus limon* (L.) Osbeck), mausham (sweet orange, *Citrus sinensis* (L.) Osbeck), bimiro (citron, *Citrus medica* L.), kagati (lime, *Citrus aurantifolia* (Christm.) Swingle), chaaksi (sweet lime, *Citrus limettioides* Yu. Tanaka), bhogate (pummelo, *Citrus grandis* or *Citrus maxima* (Burm.) Merr.), junar (sweet orange, *Citrus sinensis* (L.) Osbeck), muntala (kumquat, *Fortunella japonica* (Thunb.) Swingle), jyaamir (rough lemon, *Citrus jambhiri* Lush.) grow in Mid Hill of Nepal out of which only mandarin, sweet orange and acid lime are commercially cultivated. Many cultivars of lime and lemon are indigenous to Mid Hill of Nepal and are popular even in neighboring countries India and Bhutan. These cultivars perform better than exotic clones due to many desirable economical characters. Likewise, tropical fruits such as aamp (mango), rukh katahar (jackfruit), litchi (lychee), kera (banana), sarifa/ seetaphal (custard apple) and many other varieties are grown in the southern belt of the country. While few varieties have been grown in large scale, there are cultivars of the same species that are either grown just in home gardens or grow as stray fruit. Many fruit trees are not grown in large scale due to their lower yield than the imported improved varieties, but are still preserved for their aromatic or delicious traits.

Numerous indigenous or endemic fruit species flourish in diverse landscape of Nepal. Many wild relatives of domesticated fruit species are found in Nepal (Table 1).

Table 1. Wild species of cultivated fruits found in Nepal

English name	Nepali name	Botanical name
Wild apple	Jangali syau	Malus baccata var. himalaica (maxim.) C.K.Schneid.
Wild apricot	Jangali khurpani	Prunus cornuta (Wall. ex. Royle) Steud.
Wild banana	Jangali kera	Musa nepalensis Wall.
Wild cherry	Paiyun	Prunus nepalensis Hook.f.
Wild grape	Jangali angur	Vitis lanata Roxb.
Wild mango	Jangali aamp	Mangifera sylvatica Roxb.
Wild pear	Jangali naspati	Pyrus pashia Buch.-Ham. ex D.Don
Wild strawberry	Bhui aiselu	Duchesnea indica (Jacks.) Focke

CLASSIFICATION OF FRUITS

Exact classification of fruits is a challenging task as these are highly diverse commodities which have different centers of origin. A broad classification of the entire fruit germplasm available in the country is proposed in this article (Figure 1).

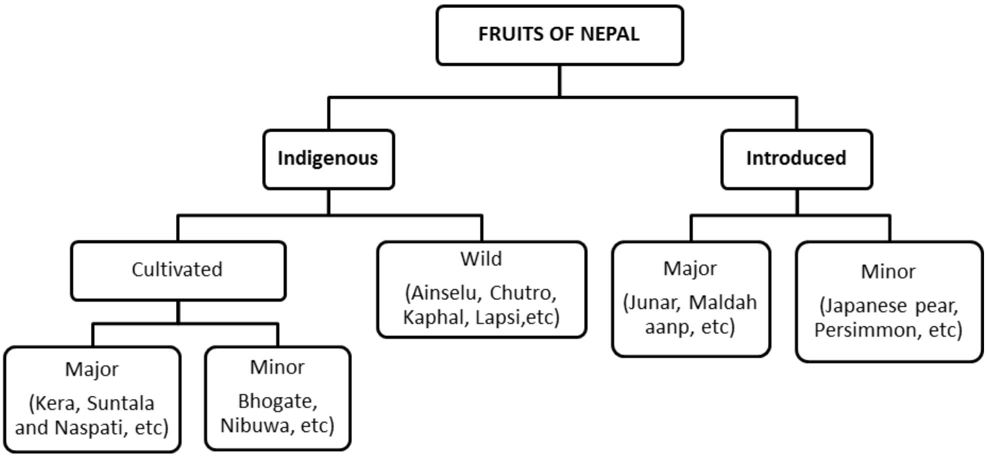

Figure 1. Classification of fruit germplasm in Nepal.

Depending on the scale of cultivation, consumption, and marketing; domesticated fruits in Nepal can be broadly divided into two categories: major fruits and minor fruits.

Major Fruits

Major fruits cultivated commercially in large areas include apple (*Malus pumila* Mill.) in High Hill from 1800 to 2800 meter above sea level (masl) of Jumla, Kalikot, Mugu, Mustang, Manang, Solukhumbu (Amgai et al 2015); banana (*Musa* spp.), mango (*Mangifera indica* L.), litchi (*Litchi chinensis* Sonn.), papaya (*Carica papaya* L.), pineapple (*Ananas comosus* (L.) Merr.), water melon (*Citrullus vulgaris* Schrad.) in the southern parts of the country; and citrus fruits mainly suntala (mandarin orange or tangerine, *Citrus reticulata*) and junar (sweet orange, *Citrus sinensis*) in the Mid Hill from east to west. Suntala (Figure 2) is Nepal's indigenous citrus fruit whereas junar was introduced in Sindhuli from England during Rana regime which has been well adapted and performing well (DB Thapa 2017, personal communication) in Sindhuli and Ramechhap areas. Similarly, Pharping pear is popular among farmers in Kathmandu valley and is exported to India. It is high yielding with large fruit size and long storage life. Local limes of Tehrathum district are large in size and rich in juice content. It can be cultivated up to the elevation of about 1,500 masl. Local banana varieties, namely `Malbhog' and `Siukera', have higher market price. The `Malbhog' variety has good flavor and sweet taste when ripened, and is considered healthy to consume even for the sick people. Grapes (*Vitis labrusca* L.) and pomegranate (*Punica granatum* L.) are popularly consumed all through the year but are cultivated only in few districts of Nepal. These fruits are consumed throughout the country and their demands remain largely unfulfilled from the domestic production. Therefore, we still need to expand area of cultivation and practice good orchard management technologies as well as develop high yielding improved varieties to increase the production of major fruits as well.

Figure 2. Banana, mango, mandarin orange, lychee (or litchi), grapes and pomegranate are some of the major fruits of Nepal which are widely consumed throughout the country and are commercially cultivated.

Minor Fruits

Minor fruits are those which are important locally or regionally thus are cultivated in limited amount of land and sold during their maturity season. Popular minor fruits of Nepal cultivated in scattered areas within the warm temperate regions of Nepal include local peach, plum, persimmon, pear (**Figure** 3), and apricot. Similarly, some citrus fruits like pummelo, grapefruit, kumquat, nibuwa, chaaksi are grown in limited areas in Mid Hill of Nepal. Katus (local chestnut) are collected from forest during October/ November and are roasted to consume as popular afternoon snacks in the hilly areas, however a few improved Japanese cultivars are grown in horticultural farms of the nation. Botanical (scientific) names of these fruits are provided in **Table** 1.

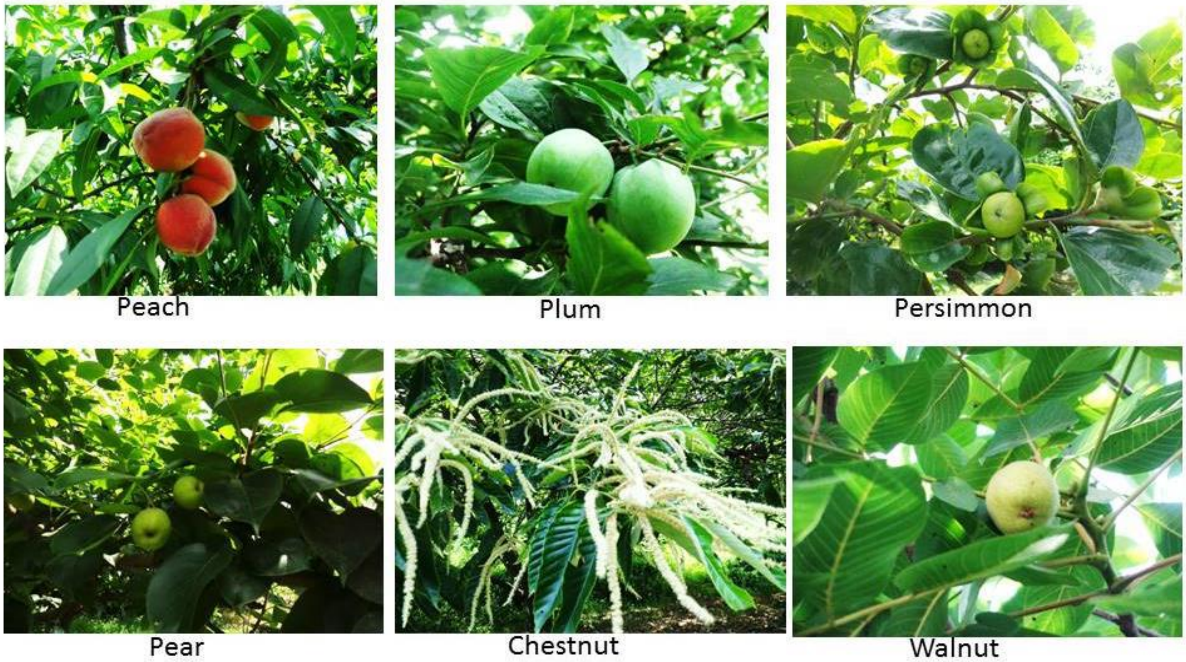

Figure 3. Representative minor fruits of Nepal. These fruits have scope for wider cultivation and trade.

Major Fruit in other Countries but Minor in Nepal

Avocado, almond, cashew, chestnut, custard apple, cherries, hazelnut, kiwi, macadamia nut, mangostein, pecan nut, persimmon, pummelo, sapota, strawberry (Figure 4), walnut are major fruits in international market. They are not extensively grown at a commercial scale in Nepal. Kiwi and avocado are emerging fruits which are now considered by many farmers to go for a commercial plantation. Nuts have high nutritional and economical value. They can be stored as dry nuts for a long time. Climate of Mid and High Hills of Nepal is suitable for macadamianut, hazelnut and chestnut cultivation. Avocado (*Persea Americana* Mill.) and strawberry (*Fragaria x ananassa* (Duchesne ex Weston) Duchesne ex Rozier) are considered to be very good fruits for heart health, therefore increasing their production would provide good nutrition to people. Commercial cultivation of such nutritionally demanded fruits will provide good income to the growers.

Figure 4. Representative major fruits in the international market but are minor fruits in Nepal.

Figure 5. Green fruits of Padel, a wild fruit that grows in the Mid Hill of Nepal is slowly disappearing. It needs to be conserved and utilized.

Wild Fruits of Nepal

There are indefinite numbers of indigenous wild fruits in Nepal which remain as unresearched thus underutilized fruit germplasm of the country. Ainselu (*Rubus ellipticus* Sm.), commonly known as the golden Himalayan raspberry or yellow Himalayan raspberry (Figure 6) grows in Nepal as well as in China, India, Indo-China region and the Philippines. No research or molecular verification has been carried out to study the origin and distribution of this Asian thorny shrub species. There are unverified reports that roots of aiselu contain nodules, which fix nitrogen. If this could be confirmed by further study and research, such trait could be widely used to reclaim the marginalized and degraded lands.

Similarly, fruits of kafal, katus (*Castanea indica* Roxb. ex Lindl.), jamun (*Syzygium cumini* (L.) Skeels), and kyamuna (*Cleistocalyx operculatus* (Roxb.) Merr. & L.M.Perry) which grow in jungles play a significant role in supplying nutrition, particularly to poor and marginalized people in Mid Hill and High Hill. In addition to the ripened fruits, these plants are chief sources of fodder, fire wood and timber for the local community. Lapsi (*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill and bael (*Aegle marmelos* (L.) Correa) fruits are unique to

Nepal. Local people of Kathmandu, Bhaktapur and Kavre make candies using lapsi fruit which are very popular. Amala, lapsi, and tamarind candies and pickles are popular among the Nepalese people. Commercially grown but in small scale, the bael fruit juice is bottled and marketed as *marmelous* (the name derived from bael's Latin name, *Aegle marmelos*) by some private companies. People drink bael fruit juice for health benefits.

Figure 6. Ainselu, bael, lapsi and mel or mayal are some of the popular wild fruits of Nepal that are seasonally collected by local people.

Rough lemon (*Citrus jambhiri* Lush.) is a citrus hybrid from a cross between citron and lemon. Its traits are similar to mandarin orange. Rough lemon is a cold-hardy citrus and can grow into a large tree. There are several cultivars of rough lemon in farmers' fields. Shrubs are often grown as biological fences. They can be grown around national parks, botanical gardens as eco-friendly fences. They are also effective to reclaim erosion prone hills to prevent soil erosion. Kafal, kali angeri, tindu, bhalayo, padel (**Figure** 5), amaro, phalat, jamun, badahar, archal, local bayer etc are favorite fruits among Nepalese children of rural areas of Mid Hill. The chiuri tree (*Madhuca butyracea* (Roxb.) J.F.Macbr.), a native to Nepal grows mainly in the sub-Himalayan tracts on steep slopes, ravines and cliffs at an altitude of 400 to 1400 masl. Chepang communities process plant fat from chiuri fruit seeds. Another important wild fruit with high potential is chutro (*Berberis asiatica* Roxb. Ex. Dc.), a shrub with many historical uses in Nepal (Komal et al 2011). It has a potential to be promoted internationally due to high quality wine making fruits.

Most of these indigenous fruits are in wild state and some are conserved by the people for their specific consumption. They mostly grow into large trees and there are no recommended practices of training and pruning of these trees and shrubs. Nepal has good quality walnut, prunes, pear, mel, bael, chestnut, citron, figs, olive, etc. Unfortunately, we import these fruits to meet the public demand. It shows an unlimited potential of these fruits in Nepal.

Table 2. Summary of different types of indigenous and minor fruits of Nepal

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
	Ainselu	Rubus ellipticus Sm. Rubus obcordatus (Franch.) Thuan	Fresh fruits consumed by humans and birds	Grown in forests, borders to control soil erosion	Could be promoted as biological fencing with proper maintenance

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
	Angeri, Kali chulesi or kali angeri	Osbeckia nepalensis Hook. f.	Fruits, stems with leaves used as fodder	Grows in the forest, terraces and fallow lands	Sources of anti-oxidants and ink
	Archal	Aporosa octandra (Buch.-Ham. ex D. Don) Vickery	Fruits, stems as fodder	Grows in upland terraces	Should be conserved
	Bayar	Ziziphus jujuba Mill.	Fresh fruit and dried fruit	Grows in the forest	Could be used as biological fence and harvest fruits
	Hade Bayar	Ziziphus incurva Roxb.	Fruits	Grows in the forest	Could be used as biological fence to harvest more fruits
	Satibayar	Rhus parviflora Roxb.	Fruits	Grows in the forest	Could be used as biological fence to harvest more fruits
	Ban timilo	Ficus foveolata (Wall. ex Miq.) Miq.	Fruits	Grows in the forest	Needs conservation
	Chutro	Berberis asiatica Roxb. ex DC. *Berberis sp.*	Fruits	Grows at an elevation between 2000 and 2500 masl	Good for making wine
	Ghumauro-kanda	Polygonum perfoliatum L.	Fruits	Grows in forest	Needs conservation
	Harro	Terminalia chebula Retz.	Fruits have high medicinal value	Grows in forest and in uplands	Potential to commercialize for ayurvedic medicine
	Kusum	Schleichera oleosa (Lour.) Oken	Fruits	Found in wild	Should be conserved
	Barro	Terminalia bellirica (Gaertn.) Roxb.	Fruits (used for stomach disorders and cough).	Grown in uplands	Could be commercially cultivated to make medicines
	Bhakiamilo	Rhus javanica L.	Ripe fruits are used as appetizer	Grows in forest	In situ conservation needed
	Jamuna	Syzygium cumini (L.) Skeels	Fruits	Grows in forest	Fruits and also used for medicinal purpose.
Apricot	Khurpani	Prunus armeniaca L.	Fresh and dried fruits	Grown in home gardens and orchards	Could expand its cultivation. Rich source of anti-oxidants, minerals and vitamins
Bassia	Chiuri	Bassia/Madhuca/ Diploknema butyracea (Roxb.) H.J.Lam	Fruit is eaten fresh and ghee is extracted from seeds	Grows and conserved in the forest	High potential for commercial farming
Bay berry	Kafal	Myrica esculenta Buch.-Ham. ex D. Don	Fruits	Grows in forest	Could be cultivated in fallow lands
Chestnut	Katus	Castanopsis hystrix Hook. f. & Thomson ex A. DC., Castanopsis indica (Roxb. ex Lindl.) A.D.C., Castanea crenata	Fruits (Roasted or as such)	Local landraces grow in forest, some Japanese and Chinese varieties are grown in horticultural centers	Potential to expand its cultivation

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
		Siebold & Zucc.			
Citron	Bimiro	Citrus medica L.	Fresh fruit used during Tihar	Grown in homestead gardens	Needs conservation
Coffee plum	Padel	Flacourtia jangomas (Lour.) Raeusch.	Fruits, leaves and twigs are used as fodder	Grows in forest and marginal lands	Due to large thorns at the base of the tree, farmers are clearing the bushes. Needs conservation
Custard apple	Seetaphal or Sarifaa	Annona squamosal L.	Fruits	Grown in homestead gardens or backyard	Could be commercially cultivated
Fig	Nivaro	Ficus carica L.	Fruits and fodder	Grown in uplands	Needs conservation
Gooseberry	Amala	Phyllanthus emblica L., Emblica officinalis Gaertn.	Fruits are rich source of vitamin C, medicines, pickles and candies	Allowed to grow in forests and grass lands	Has scope for commercial farming
Grapefruit	Sankhatro	Citrus paradisi Macfad.	Fruits	Grown in homestead gardens or orchards	Potential for commercialization
Guava	Amba, Belauti	Psidium guajava L.	Fruits, Medicine	Local varieties grown in homestead, improved varieties in orchards	Scope to increase production exists
Himalayan wild cherry	Painyu	Prunus cerasoides Buch.-Ham. ex D. Don	Fruits	Grows in forest	In situ conservation needed
Hog-plum	Amaro	Spondias pinnata (L. F.) Kurz., Spondias mangifera Willd., Spondias acuminata Roxb.	Fruits, Medicine	Grows in forest	Needs conservation
Jackfruit	Rukh katahar	Artocarpus heterophyllus Lam.	Fruits (both immature and ripe)	Grown in homestead gardens or orchards	Potential for commercialization
Kiwifruit, Chinese gooseberry	Thekifal	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson	Fruits	Few modern varieties have been grown commercially	Scope to further expand cultivation area to increase production
Kumquat	Muntala	Fortunella japonica (Thunb.) Swingle	Fruits	Grown in homestead gardens and in containers in terraces.	Being a small tree and maturity time later than mandarin orange, it could be cultivated to extend availability in the market
Lemon	Nibuwa	Citrus limon (L.) Osbeck	Fruit juice used for making vinegar	Grown in homestead gardens or backyard	Could be commercially cultivated to extract juice
Local/wild strawberry	Bhuinkaphal	Fragaria vesca L.	Fruits	Grows in upland farms	Could be used as cover plant

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
Loquat	Laukaat	Eriobotrya japonica (Thunb.) Lindl.	Ripened fruits	Grown in homestead gardens	Scope to further expand cultivation area
Monkey Jack	Badahar	Artocarpus lakoocha Roxb.	Fodder, fire wood, timber and fruit	Grown on bunds of upland areas and grasslands	Could be planted in upland areas as people leave it barren
Mulberry	Kimbu	Morus alba L., Morus nigra L., Morus rubra L.	Fruits as table purposes, leaves and twigs are used as fodder	Grown in marginal lands as fodder plant, extensively cultivated for silkworm rearing	Postharvest and processing technology is necessary. Used in silk worm rearing for silk production.
Mulberry	Kimbu	Morus alba L., Morus serrata Roxb., Morus indica L.	-Fruits are eaten when ripened - Leaves are used for feeding silkworms	Grown in homestead gardens or backyard	Could be commercially cultivated
Nepalese fire thorn	Ghangaroo	Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	Fruits	Grows in wild	Should be conserved
Nepalese hog plum	Lapsi	Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill	Fruits are used to make pickles and candies	Grows in forest and grown in homestead gardens	Could be cultivated in fallow lands. A rich source of vitamin C
Peach	Aaru	Prunus persica L. Batsch	Ripened fruits	Grown in backyards and small orchards	Has scope for commercial farming
Pear	Naspati	Pyrus pyrifolia (Burm.f.) Nakai, Pyrus communis L.	Fruits	Grown commercially but in small scale	Could be cultivated at larger scales in Mid and High Hills
Persimmon	Haluwabed	Diospyros kaki L.f.	Local varieties less popular due to astringency but tasty when fully ripen. Important during Tihar festival.	Grown in home gardens	Dhaula and Teku are promising Nepalese varieties
Plum	Aaru bakhada	Prunus domestica L.	Ripened fruits	Grown in orchards	Has scope for commercial farming
Pummelo	Bhogate	Citrus maxima (Burm.) Merr.	Fruit used during festivals and also during sunny days	Grown in homestead gardens	Possibility of commercial cultivation of improved varieties for fresh fruit and juice
Rose apple	Gulab-Jamun	Syzygium jambos (L.) Alston	Fruits	Grows in wild	Needs conservation and commercialization
Seabuckthorn	Dale chuk	Hippophae tibetana Schltdl.	Squash, jam, wine syrup prepared from the fruits	Grows in High Hills	God commercial potential
Sweet lime	Chaaksi	Citrus limettioides Yu. Tanaka	Fresh fruit	Grown in homestead gardens	Needs conservation and promotion
Tamarind	Emli	Tamarindus indica	Fruits used to	Grows in wild	Needs conservation,

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
		L.	prepare candies and as souring agent		rich source of vitamins
Thin shelled walnut	Dante Okhar	Juglans regia L.	Fruits	Conserved in forest and personal lands	Has religious importance, rich in unsaturated fatty acids.
Tree fig	Khanayo	Ficus semicordata Buch.-Ham. ex Sm., Ficus cunia Buch.-Ham. ex Roxb.	Ripened fruits	Grown on upland farms	Should be conserved
Wild cucumber	Golkankri	Solena heterophylla Lour.	Fruits	Grows in forest	Fruits and also used for medicinal purpose
Wild pear	Mel or mayal	Pyrus pashia Buch.-Ham. ex D.Don	Fruits	Allowed to grow in the wild and in farms	Used as rootstock for grafting
Wild Persimonn	Tindu	Diospyros malabarica (Desr.) Kostel.	Fruits	Grows in forest and marginal lands	Needs conservation
Wood apple	Bael	Aegle marmelos (L.) Correa	Fruit and leaves are used for religious offerings, and medicine for stomach problems.	Allowed to grow in forests and some households plant in the back yard	Possibility of commercial cultivation of improved varieties for fresh juice and processing

Exotic Fruits with Commercial Potential in Nepal

There are various tropical and subtropical exotic fruits that can be grown in different geographical regions of Nepal. Some of these fruits that can fetch good price in the market but are yet to be introduced for commercial cultivation in Nepal include rambutan (*Nephelium lappaceum* L.), longan (*Dimocarpus longan* Lour.), calamansi (*Citrofortunella microcarpa* (Bunge) Wijnands), durian (*Durio zibethinus* L.), dragon fruit (*Hylocereus undatus* (Haw.) Britton & Rose), lanzones (*Lansium domesticum* Correa) and passion fruit (*Passiflora edulis* Sims). Similarly, high value nuts such as pistachio (*Pistacia vera* L.), cashew (*Anacardium occidantale* L.), and almond (*Prunus dulcis* (Mill.) D.A.Webb) could be commercially cultivated to meet the domestic demand and export high quality nuts abroad.

UTILIZATION OF MINOR FRUITS

Indigenous and minor fruits are utilized in several ways in the rural households. Lapsi, amala, tamarind etc are popularly used to prepare pickles and candies. They are rich sources of vitamins and minerals. They are preserved for long term and used throughout the year. Small quantities of candy and pickles are imported by Nepalese communities abroad. Kafal, aiselu, bael, jamuna are eaten or sold fresh as they ripen. Such fruits contribute substantially to the people's diet.

Bael fruit is used widely by the Newar community to perform "Bael Bibah" of young girls when they are five to nine years old. Leaves of bael tree are offered to Shiva temples as his favorite leaves. Due to medicinal properties of bael, its juice is becoming popular. People drink bael leaf to cure diabetes (Joshi and Joshi 2011). Chiuri fruit is consumed fresh and its seeds are processed to produce ghee, the latter is popular among the Chepang community. Citron and pummelo are used during "Tihar and Chhat" and are also consumed fresh. Apart from them, Newar communities use katus, hadebayer, satibayer, persimmon, walnuts during the Tihar festival. While, in Brahman-Chetri communities, walnut is broken during "Bhaitika" by sisters to symbolically smash the enemies of their brothers. Due to nutritional value and beneficial health effects of nuts, the demands for different types of nuts are increasing.

Recently, people are increasingly aware of the nutritional values, especially the fruits high in various types of vitamins, minerals, antioxidants and several micro-nutrients. The fruit consumption and demand are sharply increasing. Awareness on balanced diet among the people has further raised the demand of fruit all over the country. Availability of nutritional information and awareness on their organic nature from international sources on various fruits is increasing the consumers search for the minor fruits. Similarly, use of juice during parties and family gatherings is encouraging farmers to grow fruits at larger scale for processing. Consumption of fruits and fruit juice by the sick people has increased the demand of fruit products in and around hospitals. Pomegranate is one such kind of healthy fruit which fetches very high price in the market. Walnuts and other nuts are rich sources of dietary unsaturated fats, proteins, vitamins, minerals and low fatty acid oils which are recommended as healthy fats for heart. Therefore, daily consumption of these nuts is sharply increasing thereby increasing their demand.

Most of the indigenous and underutilized fruits have medicinal properties. The bark of ainselu plant is used in Tibetan medicine, mainly as a renal tonic and an anti-diuretic. Root paste is used as wrapping for the treatment of fractured bone. Ripe fruits are laxative and are used in case of constipation. Paste of young fruits, 10-20 gm at a time, is taken twice or thrice in a day in case of gastritis, as an antacid and to check diarrhea and dysentery (Maity et al 2004). Further research works need to confirm such medicinal and nutritious values of indigenous fruit species of Nepal. There is very little information available regarding varietal performance, multi-location yield trials, and genetic evaluation of the germplasm, appropriate propagation methods and integrated insect and pest management of minor fruits. The use of available diverse fruit germplasm has huge potential for improvement of fruit quality and quantity, extension of harvesting season and widening of cultivation area based on micro-climatic niches of the country. However, detailed research works on fruits in Nepal are few and far behind farmer's commercial needs.

CONSERVATION PRACTICES

Cultural Conservation

The growing fruit trees in the home gardens were practiced in Nepal since time immemorial. These plants help in providing essential nutrition to the family and special care is provided. People take such home produced fruits to their relatives and honorable person as gifts. Most of the minor fruits are grown in the backyard or in the homestead garden for their specific usage. Fruits are considered as sacred foods which are consumed during festivals and while undergoing fast. Public and community orchards in temple compound, in guthi land and areas designated for pilgrimages also harbor local fruits.

Chepangs are known for their immense knowledge on forestry products, their collection and preparation methods. They have special relationship with the chiuri trees as they have custom of giving a chiuri tree as dowry to their daughters during marriage. Hence, it is regarded as a private resource. Chiuri is a source of livelihood to this community. Therefore, it is conserved by Chepang community in Chitwan.

In Nepali culture, fruits play an important role in many festive occasions and religious rituals. They are considered one of the most auspicious foods offered to deities as a part of devotional worship offerings. Hence people grow various fruit species in their home gardens, hedges and curtilages. The Nepalese religious rituals are incomplete without offering some fruits (coconut, banana, bael fruit, and sugarcane) along with flowers to the deities. Different fruits are used for specific religious occasions. Fruits like bananas are considered auspicious during travels and are given to people at the start of their journey. People have a culture of preserving the fruit products in the form of dried fruit chips, fermented fruits, pickles, wines, and chuck amilo (locally prepared vinegar used as souring agent and preservative). Therefore, people conserve fruit trees in their grassland and terraces as well.

Nepal is housing not only healthy and delicious indigenous fruits but some poisonous and deadly fruits and shrubs in its wild forest. Such plants need to be well characterized and marked as such to avoid fatal accidents. Some are toxic to animals, birds and some to humans too. Many fruits are allergic and some give minor to major upsets. The fruits of jangali darim (mountain pomegranate, *Catunaregam spinosa* (Thunb.) Tirveng.) are used in Nepal to kill fish in rivers and ponds (Kulakkattolickal 1989). Their toxins can be used as herbal and eco-friendly pesticides.

In-situ Conservation

Indigenous minor fruits like amala, badahar, bael, kafal, katus (local chestnut), and lapsi are selectively allowed to grow in the public and community forests, along the river banks and in the farmer's grasslands. These are also grown in private home gardens, hedges and bunds of upland fields for fodder, fire wood, medicinal use and timber besides their edible fruits. Wild fruit trees are also protected inside botanical gardens, national parks, community forests and protected areas. Chepang communities conserve chiuri (Aryal et al 2009). Cultivated minor fruit species are conserved in homestead gardens, in community and public places around temples as well as in private orchards where the plant was identified. As mentioned above, some communities require some specific fruits in certain occasions thereby requiring them to conserve them in their localities.

Ex-situ Conservation in Government Farms and Research Centers

National botanical gardens, public and private farms, field genebanks and horticultural research and development centers have conserved many but not all the minor fruit crops. Long life span, long waiting period for first fruiting and large land requirement for cultivation has been the constraints in maintaining a fruit germplasm. A dedicated governmental program on the collection and preservation of fruit species is essential to conserve the available vast diversity of the fruits in the country.

CHALLENGES AND OPPORTUNITIES

Changing human perception, stewardship, food habits, market trends and effect of globalization are some of the major factors leading to low priority to the local crop products (Khanal et al 2014). Many fruits that grow in wild are feared poisonous and some of them are indeed deadly. Many minor, indigenous and wild grown fruits are yet to be named, characterized and tested. Even the same fruit is known by different names in different regions. There is no standard single nomenclature both in Nepali and English for such fruits. For the domesticated minor fruits, there are no standard cultivation and management practices developed. They are grown in marginalized and poor soils due to which their production capacity is less than that of modern cultivars. There is no easy access to technical knowledge and facilities of proper harvest and storage. Many temperate fruits like apricot, peach, plum etc grown in remote areas are hard to transport due to lack of basic transportation facility. As a result, markets and customers of minor fruits are unpredictable. Farmers take fruits like green gooseberry, lapsi, guava, and tangerines to market. If the products taken to the market are not sold instantly or within a day, they are thrown into drain because of the lack of storage, costly transportation and short shelf life. The everyday losses indicate that there is a big potential for fruit processing industries in Nepal which can contribute to commercialization of fruit cultivation that will improve people's health and national economy. To convert minor fruits into major fruits, we need to build technical capacity of the farmers, provide them production and marketing support and appropriate value chain development of the products.

Commercial fruit cultivation will help in beneficial utilization of wasted lands in the hilly areas of the country. It requires less labor force than cereal and vegetable cultivation which is beneficial in this labor scarcity period caused by youth migration. Mechanical fruit farming will attract foreign investment. Fruits will adapt better and have wider scope to combat climate change calamity and these minor fruits can cope well with such phenomena as they are hardier than the introduced germplasm. Moreover, nutritive value analysis of forty edible wild fruits of Nepal showed that most of the wild fruits are comparable to cultivated fruits in nutritive values suggesting that these indigenous wild fruits can be considered for cultivation (Bajracharya 1980).

WAY FORWARD

The use of available diverse fruit germplasm has huge potential for improvement of fruit quality and quantity, extension of harvesting season and widening of cultivation area based on micro-climatic niches of the country. However, research works on fruits in Nepal are few and far between. There is very little information available regarding varietal performance, multi-location yield trials, genetic evaluation of the germplasm, appropriate propagation methods and integrated insect pest management of minor fruits. The major constraints of pomology in Nepal and underutilization of the existing natural diversity are: low priority for fruit research programs consequently poor allocation of annual fiscal resources in the agricultural programs, lack of trained human resources, labor shortages, weak extension system, poor record keeping system and unavailability of adequate technical information. For appropriate utilization and commercialization of different fruit crops, we need to have a thorough research on each of the indigenous germplasm regarding their fruit quality traits, physiological characteristics and genetic characterization. We need skilled manpower to implement research activities rationally for which we need to train our technical and extension human power with modern skills of fruit cultivation, orchard management and modern propagation techniques. There is a huge potential for commercialization of different fruit species in the country which will not only meet the domestic demand but also promote export resulting into improvement of the farming community's economy. Establishment of aesthetic orchards or fruit parks will conserve the fruits as well as the environment and generate income. There is equally good scope of fruit technology in order to preserve and process fruits.

There is an urgent need to establish an online inventory system for appropriate documentation, characterization, registration and detailed evaluation of indigenous fruit species in Nepal that can be used for improving our existing fruit varieties. Due to rapid increase in the demand of fruits, the use of diverse fruit germplasm has great potential for improvement of fruit quality, extension of harvesting period and expansion in the cultivation area based on suitable micro-climatic niches in Nepal. Due to unethical use and absence of appropriate conservation mechanisms, genetic erosion of natural resources is occurring at an alarming rate. There should be a well-established legal mechanism to protect our indigenous species. These will serve as future crops as the currently grown high yielding varieties will become saturated in their yield potential in coming few decades. The TRIPs agreement has provision of protecting plant varieties either through plant patents or an effective *sui generis* system or a combination of both. Therefore, it is recommended to develop and implement such system as soon as possible to protect our plant varieties, indigenous knowledge and farmer's rights which will motivate local community to preserve these species and grow them commercially.

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Biotechnology, Geographical Information System and Climate Analog Tool for Management of APGRs

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ABSTRACT

Nepal with 577 cultivated species possesses huge diversity at varietal as well as landrace levels. Biotechnological tools (especially tissue culture and molecular marker technology) are playing effective and efficient roles for conserving, and sustainably utilizing agricultural plant genetic resources (APGRs). Tissue bank has been established through shoot tip culture for the conservation of vegetatively propagated and recalcitrant crops eg potato, sugarcane, banana, etc in NARC. Under the molecular marker technology, currently RAPD and SSR markers have been used for developing DNA profiles, identifying duplicates in the collections, assessing genetic diversity and screening accessions against economic traits. DNA bank has also been created for storing DNA of indigenous crops. The potential uses of in-vitro techniques for conservation agriculture include shoot apical or axillary-meristem-based micro-propagation, somatic embryogenesis, cell culture technologies and embryo rescue techniques, as well as a range of in-vitro cold storage and cryopreservation, in-vitro collection, pathogen free plantlet production and maintenance and efficient germplasm exchange. Molecular marker technology can contribute for duplicates management, determining the sampling strategies, genetic integrity, accelerating the utilization, monitoring study and for seed health testing. Major applications of GIS and CAT are distribution and collection maps generation; gap analysis to identify priorities for further collection; locating diversity rich areas, diversity, unique collections and extreme points of collections; identification of analogous areas and sites among which genetic materials can be shared including repatriation of germplasm; classification of collections based on climatic adaptation; prediction of presence of species; for finding eenvironmentally analogous areas to recommend varieties; to identify new research stations; to select appropriate Farmer Field Trial; analogue sites for community genebank establishment and expanding use area and sites identification for establishing Field Genebank. Analysis in Kaski and Bara using CAT shows current, future, and past analogue sites exist within and outside Nepal, suggesting that genetic materials could be exchanged between such regions. More than 100 potential rice germplasm that can be exchanged were identified from National and foreign genebanks. A genebank conserves crop germplasm collected periodically from different sites and regenerates them in certain time interval. Genetic make-up of genebank materials generally does not change significantly, therefore, adaptability of such germplasm on the matching sites may be high when exchange is done based on corresponding collection year of the germplasm. This is the technique of identifying climate smart germplasm and climate smart plant breeding.

Keywords: Analog sites, collection map, DNA, genetic diversity, tissue culture

INTRODUCTION

Nepal being the party to CBD (convention on biological diversity 1992) and ITPGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture 2001), it is necessary to manage APGRs (agricultural plant genetic resources) available in the country for long term availability to researchers as well as growers and country food security. Rapid genetic erosion has been noticed in most of crops. Over the last 30 years, increasing concern is being expressed over the loss of biodiversity due to human and natural factors. Consequently, worldwide efforts are being made towards conservation of cultivated and wild genetic resources. Therefore, National Genebank (NAGRC) has been established in Nepal. Sustainable management of APGRs requires a multipronged approach and biotechnological tools can contribute significantly for the management and sustainable utilization of APGRs. In addition, advances in biotechnology are occurring at a rapid pace and provide novel opportunities for more effective and efficient management of APGRs (Reed et al 2011, Spooner et al 2005). Biotechnology applications must be integrated with ongoing conventional conservation activities. To effectively conserve, manage and utilize maximum diversity as much as possible, NAGRC has been managing all agricultural biodiversity through five banks namely Seed Bank, Field Genebank, Tissue Bank, DNA Bank and Community Genebank. Many stakeholders collect germplasm from different parts of the country (**Figure** 1) and there are more chance to have duplicates. Such duplicates could not be managed through conventional techniques and needs use of DNA markers.

Large number of collections in genebank make difficult to curators and users for proper management and utilization. Collections should be from all geo-locations covering whole cultivation range that can capture maximum diversity. It is also importance to know the potential distribution sites of crop species and analog sites for introduction. These difficulties faced in the Genebank are increasingly solved using geographical information system (GIS) and climate analog tool (CAT). Many genebanks around the world are applying GIS and CAT for better managing and utilizing APGRs. Here uses of biotechnology, GIS and CAT in National Genebank are described along with potential application for management of Nepalese APGRs.

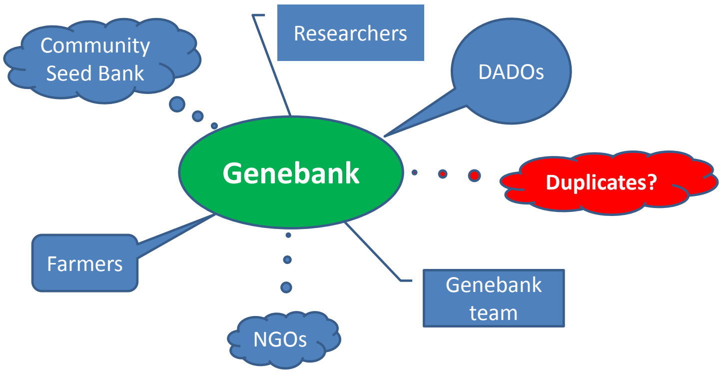

Figure 1. Germplasm collection and exploration partners (high chance of duplicates in the collections).

CONSERVATION BIOTECHNOLOGY

Advances in biotechnology (conservation biotechnology) have generated new opportunities for APGRs conservation and utilization. Biotechnology has contributed significantly by providing complementary in-vitro conservation options through tissue culture techniques (Uyoh et al 2003). Techniques like in-vitro culture and cryopreservation have made it easy to collect and conserve genetic resources, especially of species that are difficult to conserve as seeds (Chauhan 2016). DNA markers on the other hand are very effective to manage all kinds of APGR including orthodox, non-orthodox seed crops and vegetatively propagated crops. Utilization of conserved materials is also being accelerated through the advances made in biotechnology. NAGRC has utilized in-vitro tissue culture and molecular marker technologies to conserve and utilize APGRs in the country (**Figure** 2). General process of handling non-orthodox crop species in NAGRC is depicted in **Figure** 3. Molecular markers are increasingly used for screening of germplasm to study genetic diversity, identify redundancies in the collections, test accession stability and integrity, and resolve taxonomic relationships. The technology is also accelerating the utilization of APGRs.

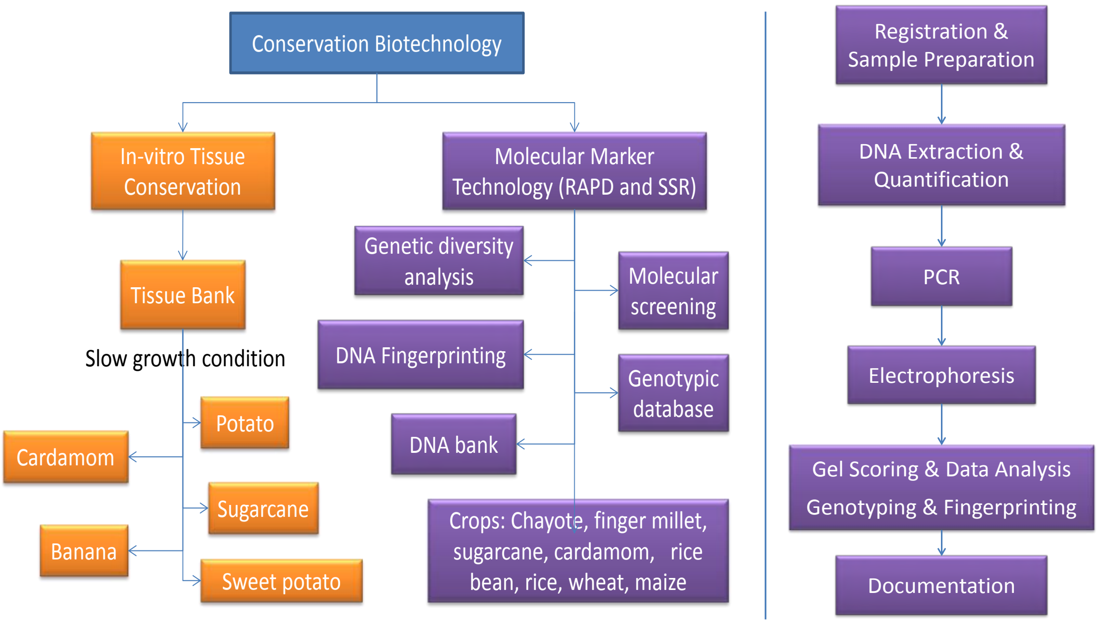

Figure 2.Current scenario of application of biotechnology for management of APGRs in NAGRC (Left), general steps in molecular lab for DNA works (Right).
Source: Joshi 2017a.

Tissue Culture

Current Status

In-vitro technique is very effective for conserving those crop species, which either produce recalcitrant seeds or does not produce any seeds (Dale 1980). Plantlets can be kept in test tubes on nutrient medium for indefinite periods of time by transferring at regular interval. It requires little space for preservation of a large number of crop landraces. Plantlets are maintained in an environment free of pests or pathogens. It also protects against dangers of natural environmental hazards. It minimizes the obstacles generally imposed by quarantine systems on the movement of live plants. Because of such advantages, in-vitro tissue culture has been initiated in NAGRC with the following objectives: Development of Tissue Bank and Cryobank, Conservation of plantlets of vegetatively propagated crop species and species with recalcitrant seeds, through in-vitro (shoot tip) culture in cold storage (medium term conservation), Cryopreservation through shoot tip culture (Long term conservation) and Multiplication and distribution of in-vitro cultured plantlets.

Tissue bank of 5 crops (potato, banana, cardamom, sweet potato and sugarcane) has been developed and steps followed are given in **Figure** 4. Explants were shoot tip. The growth of tissue in in-vitro culture can be slowed down during storage through one or a combination of several technologies (Engelmann 1997). Slow growth procedures allow clonal plant material to be held for 1-15 years under tissue culture conditions with periodic sub-culturing, depending on species. In most cases, a low temperature often in combination with low light intensity or even darkness is used to limit growth.

Regeneration and successful propagation of genetically stable seedlings from cultures are prerequisites for any in-vitro conservation effort (Withers and Engelmann 1997). Protocols for clonal multiplication are well established for several species. Generally, organized cultures such as shoots are used for slow growth storage since undifferentiated tissues such as callus are more vulnerable to somaclonal variation.

Potential Application

Cryopreservation: NAGRC has only medium term storage for recalcitrant seed crops and vegetatively propagated crops, ie Tissue bank in slow growth condition. For the long term storage of these crops, cryobank is necessary to establish in the future. Cryopreservation involves storage of plant material at ultra-low temperatures in liquid nitrogen (-196°C). At this temperature, cell division and metabolic activities remain suspended and the material can be stored without changes for long periods of time. This technique can also contribute on saving the plants from extinction and reintroduction.

In-vitro collection: During collections, when seeds are unavailable or non-viable due to damage of plants by grazing or diseases; large and fleshy seeds that are difficult to transport; or where samples are not likely to remain viable during transportation due to remoteness of the collecting site from the genebank, in-vitro collecting provides solutions for collecting such problem species (Pence et al 2002, Withers 1995).

Pathogen free plants production: The ability to store and exchange healthy germplasm is fundamental to effective conservation and use of plant genetic resources. In-vitro tissue culture technique has potential to produce pathogen free plants especially through meristem culture.

Germplasm exchange and use: Exchange of germplasm as in-vitro tissue cultures offers considerable advantages eg reduced volume and weight as well as pathogens free plantlets. Rao et al (1993) reported the use of shoot tips encapsulated in alginate beads in banana. These techniques, besides reducing the weight and volume of the material, retain the sterile conditions and simplify the process of regeneration upon receipt of the material.

Molecular Marker Technology

Current status

Molecular marker technology has been applied for generating DNA finger printings, analyzing genetic diversity, characterizing germplasms, establishing DNA bank using RAPD and SSR markers in NAGRC. These activities have also been carried out in collaboration with different breeding institutes and universities.

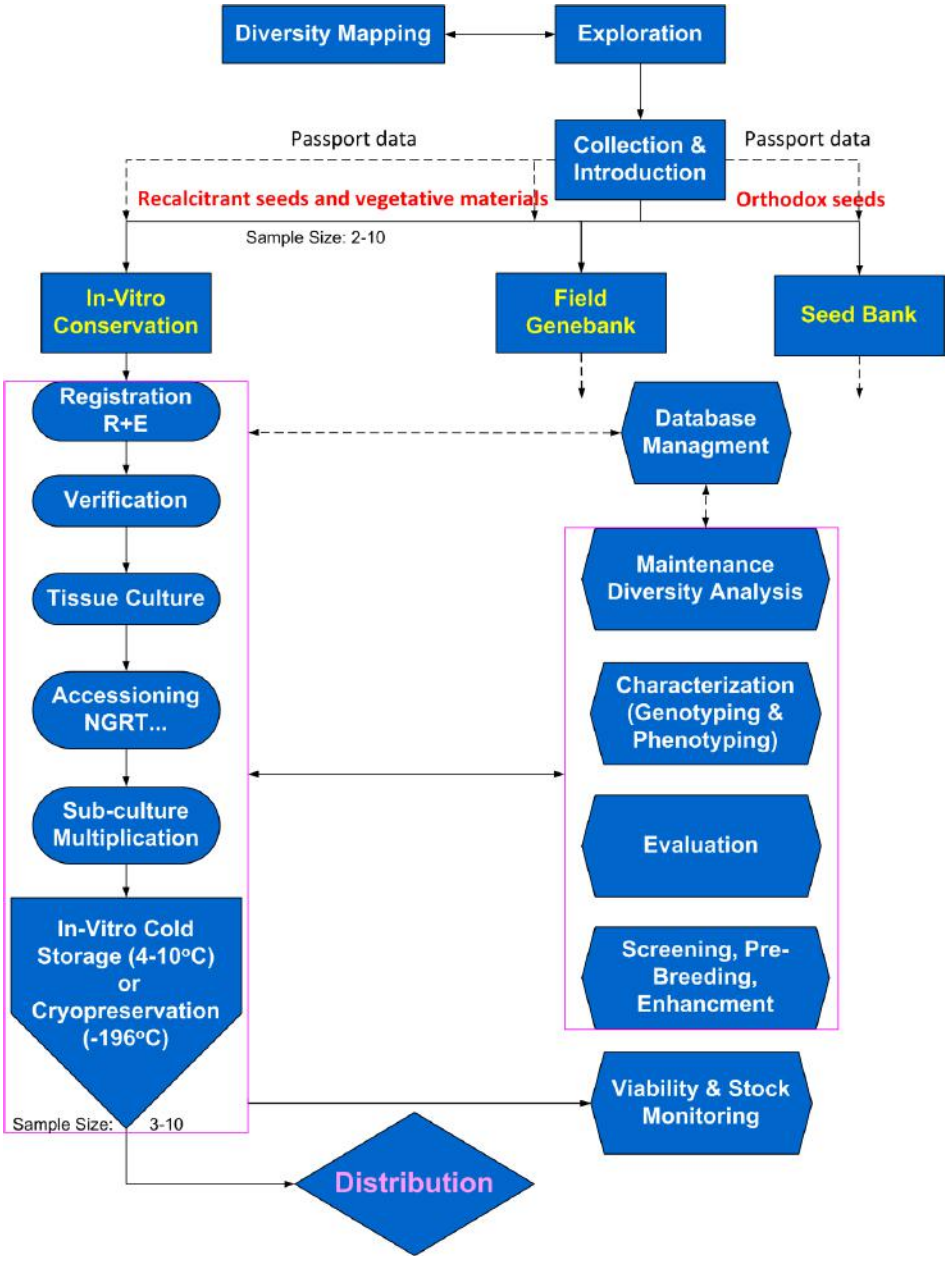

Figure 3. Stepwise activities for management of non-orthodox crop species in Tissue Bank (Left part).

DNA finger printing: DNA finger printing of landraces is being considered important ownership document. Currently RAPD and SSR profiles (Figure 5) of chayote, rice (Joshi 2017b) finger millet, sugarcane, maize, wheat and cardamom have been developed. Molecular markers have been employed for fingerprinting, verification of accession identity and genetic contamination in many genebanks around the globe.

Genetic diversity analysis: The ability to identify genetic variation is indispensable to effective management and use of genetic resources. The major advantage is that they analyse the variation at the DNA level itself, excluding all environmental influences. The analysis can be performed at any growth stage using any plant part and it requires only small amounts of material. After developing DNA profile of germplasms, genetic diversities mainly using multivariate technique were analyzed in chayote, finger millet, cardamom and wheat. This diversity information will be useful for selecting parental lines during hybridization, for managing accessions, for designing sampling strategies, for identification of gaps in the collections, identification of redundancies, identification of genetic contamination, etc.

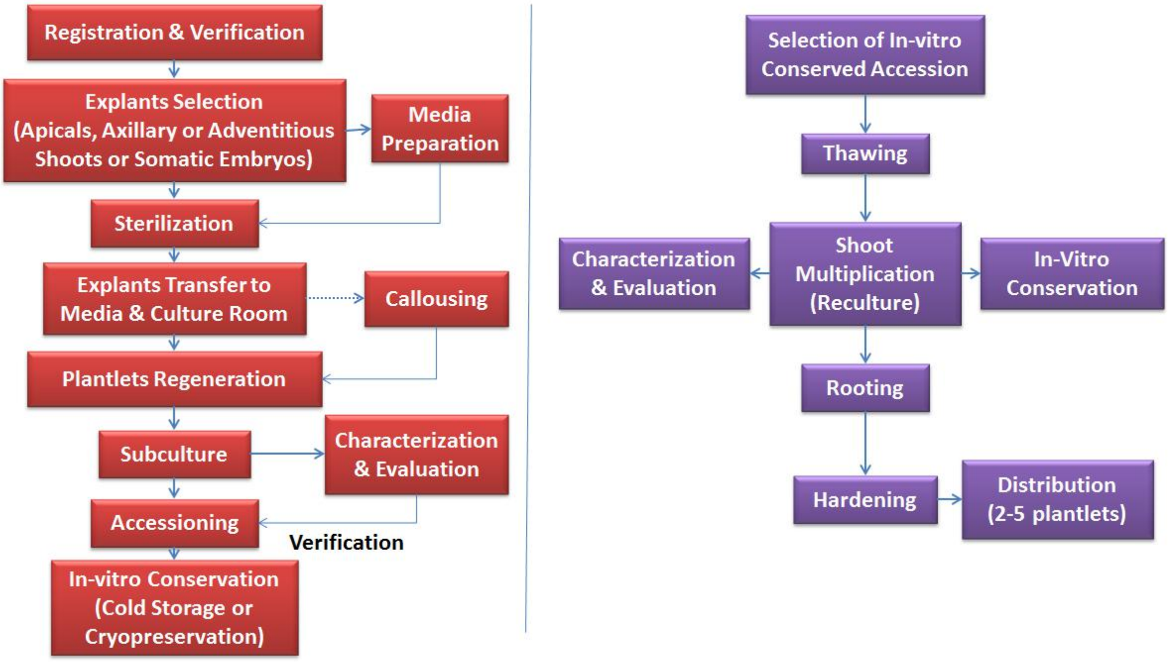

Figure 4. General steps in tissue culture: In-vitro conservation process (Left), multiplication and distribution process of plantlets (Right).

Screening for a particular traits: Under the pre-breeding program, NAGRC has focused on screening the collections using linked DNA markers with economic traits eg drought tolerance in rice and maize (**Figure** 5), submergence tolerance in rice, blast resistance in rice, quality protein in maize, rust resistance in wheat, etc.

DNA Bank: DNA Bank, as a part of the Genebank is a repository of DNA, usually for research. The DNA Bank is conserving the different kinds of DNA extracted from the genetic resources in tubes at -40^{o}C. DNA conserved in DNA Bank is used for studies and research at molecular levels. DNA banking is the secure, long term storage of an individual's genetic material (de Vicente 2006). Molecular Research Lab in NAGRC, focuses on identification, genetic diversity analysis and genes and QTLs (quantitative trait loci) tagging and mapping. During molecular research, DNA is generally extracted from young growing leaves. After genotyping, remaining DNA is quantified and conserved ex-situ at Deep Fridge. DNA Bank was started from 2013 by conserving the DNA of 12 accessions of chayote in NAGRC, Khumaltar (**Figure** 6). Another potential area of DNA bank is exchange of genetic resources. It is easier to exchange genetic resources as DNA samples, rather than seed or vegetative propagules.

Genotypic database: Database of each accession conserved in the Genebank is being maintained. Currently NAGRC has genotypic database of chayote, wheat, maize, finger millet and sugarcane.

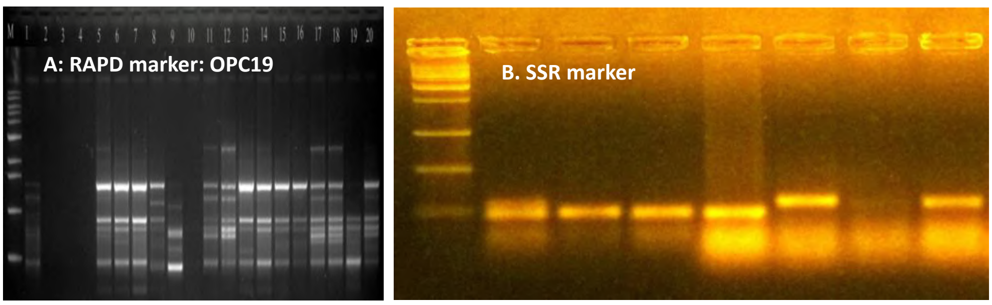

Figure 5. DNA fingerprint of finger millet (Left) and maize landraces (Right).

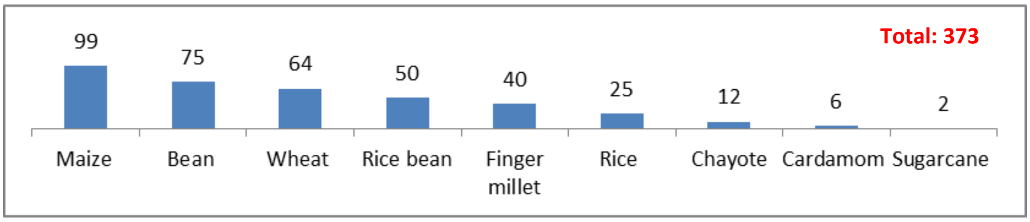

Figure 6. Number of crop accessions in DNA Bank.

Potential Application

Currently NAGRC has limited application of biotechnology for APGRs conservation and utilization. This is due to limited man power and financial support. New methods and tools have been rapidly developing in molecular marker technology. This offers wide range of application for effectively and efficiently managing the agricultural biodiversity (Spooner et al 2005) (**Figure** 7).

Duplicates management: It is very common to have duplicates in the collections. This increases the cost of maintenance and may not be able to capture other diversity. Phenotypically it is not possible to manage the duplicates (Dean et al 1999). Therefore, many genebanks around the globe have applied molecular marker technology for identifying the duplicates.

Use for sampling strategies (collection sites, populations or in-situ sites): Information at genetic levels is very useful for designing sampling strategies (Ghislainet al 1999). Genetic diversity if one could relate to geography, can be used to determine the collection sites, sample sizes as well as for in-situ or on-farm conservation. Diversity at intra or inter landraces is useful for sampling strategies.

Genetic integrity and monitoring: After the conservation over the years, it is important to study its genetic integrity and needs regular monitoring. DNA markers offer a great advantage for such kind of study.

Seed health testing (disease diagnosis): During germplams exchange as well as collections, there is increasing the risk of introduction or collection of pathogens. Diseases in crops, caused by viruses, bacteria, fungi and nematodes threaten food security in resource-poor countries and cause significant damage and economic losses every year (Vurro et al 2010). Biotechnological diagnostic tools, such as ELISA and PCR-based methods for pathogen identification can bypass many shortcomings related to culture-based morphological approaches. The pathogen problems are more severe for crops propagated by vegetative means, as viruses and viroids are transmitted very efficiently through vegetative propagules.

Accelerating the utilization of germplasms: NAGRC has more than 11,000 accessions of different crops conserved in Seed Bank, Tissue Bank, Field Genebank and DNA Bank. Most of them could not be used directly either for breeding or production. Therefore, molecular marker technology should be extensively applied to identify the accessions with important traits. High throughput genotyping of germplasms allows for the examination of genetic relationships that will be useful for selecting parental lines during crossing and for developing conservation strategy.

GEOGRAPHICAL INFORMATION SYSTEM

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map which enables people to more easily see, analyze, and understand patterns and relationships (Guarino et al 2002). GIS is increasingly used in managing and utilizing APGRs (Greene et al 1999a, 1999b). GIS is a technique for analyzing collections based on the geo-information. Coordinates of each collection are necessary to apply GIS in Genebank collections. Old collections have missing data on coordinates and they need to update. DIVA-GIS (http://www.diva-gis.org/) is the common and freely available software for APGRs management (conservation and utilization).

Collection Map

NAGRC has developed distribution of crop landraces and collection maps for a number of crop species. Based on the geo-location, collection map is generated for any crops that are useful for observing collection rich areas, for collection patterns over the years and for organizing further collection missions. Wild rice collection map is presented in **Figure** 8 generated from NAGRC collections. Collection sites of Nepalese rice accessions that are conserved in different foreign countries are given in **Figure** 9. Rice was collected from most of the rice growing areas and numbers of collections were higher from five sites.

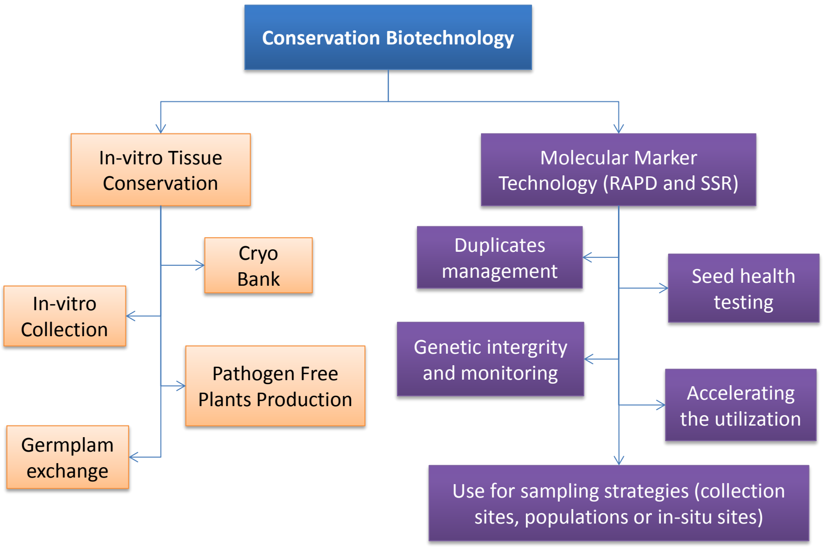

Figure 7. Potential application of biotechnology tools for management of APGRs.

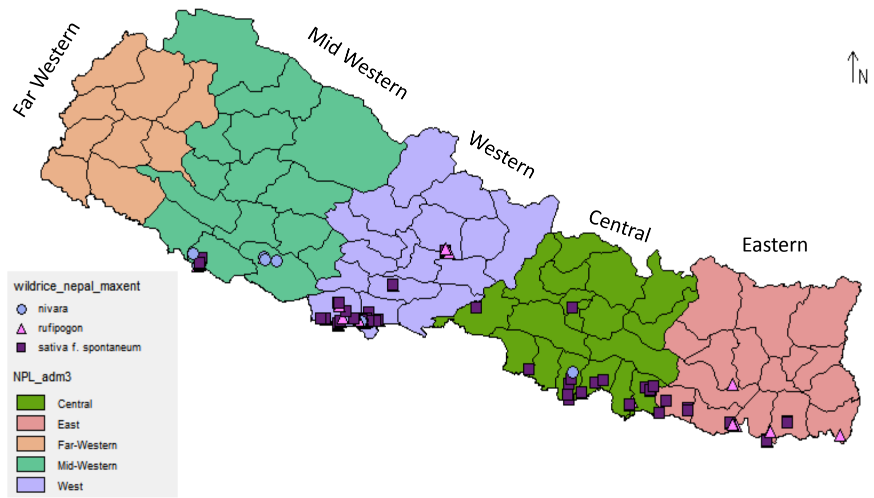

Figure 8. Wild rice collection sites in Nepal.

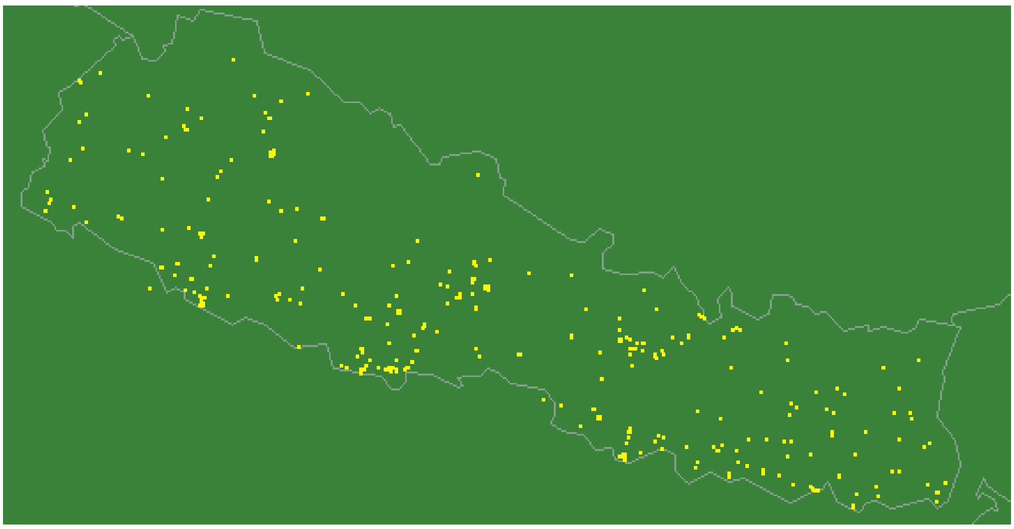

Figure 9. Collection map of Nepalese rice accessions that available at GENESYS database.

Diversity and Collection Analysis

Large number of collections in genebank needs to analyze for better management and utilization. GIS helps for locating diversity rich areas (Ravikanth et al 2002) based on different traits, for generating diversity and unique collection maps (Joshi et al 2008b). Wild rice richness based on Genebank collection are presented in **Figure** 10. Collections can further be analyzed in terms of climatic adaptation, altitude, longitude, rainfall (**Figure** 11) etc. Extreme points of collections can be graphically presented including unique landraces. Such classifications of collections are useful for making core collections and use in research and conservation.

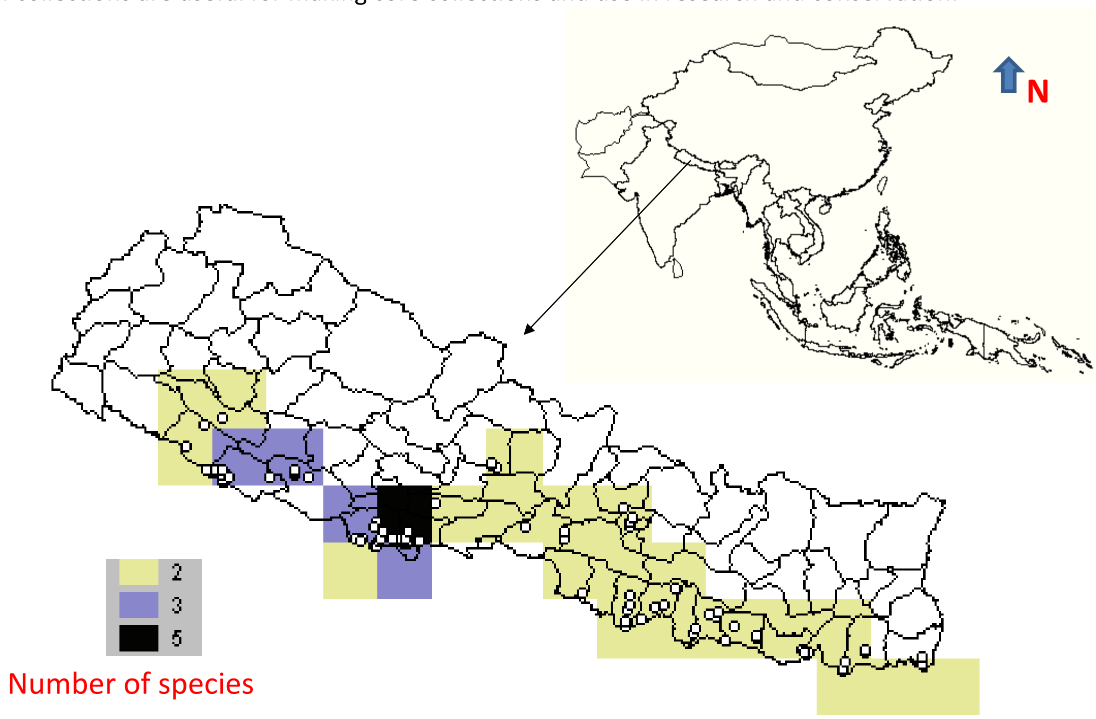

Figure 10. Collection sites and mapping species richness area of wild rice in Nepal.

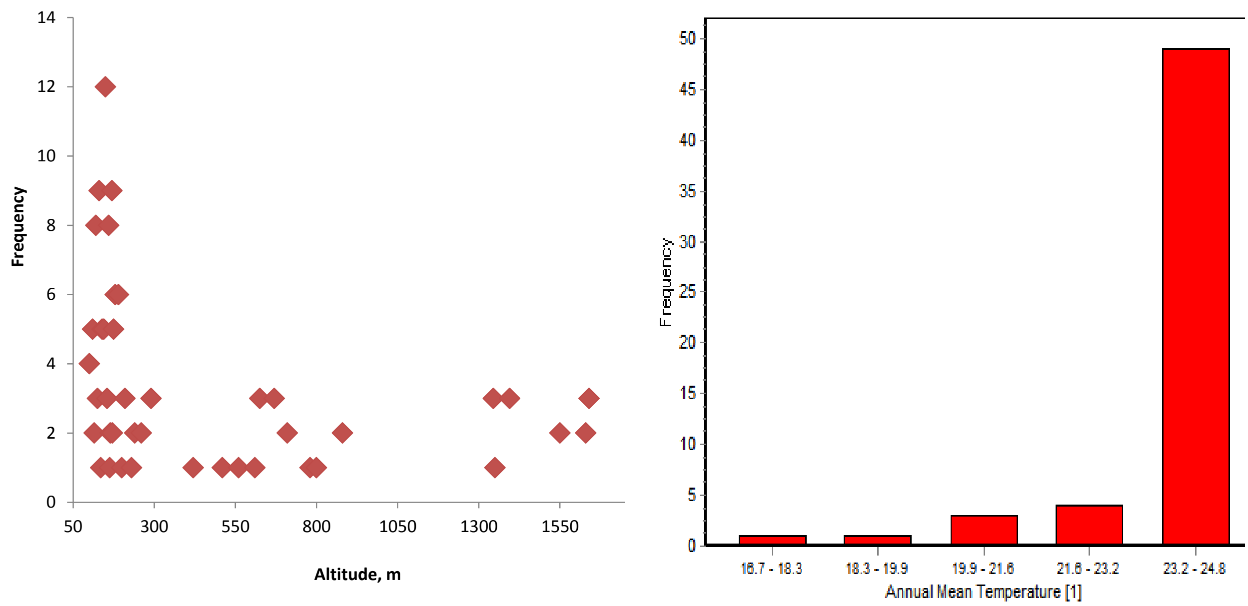

Figure 11. Frequency of wild rice collections based on altitude (Left) and annual mean temperature (Right).

Gap Analysis

GIS ease to identify the collection gaps. After generating collection maps, one can locate collection gap in relation to growing areas, analog sites, diversity rich areas, etc (Shrestha et al 2010). Collection mission is generally organized targeting to minimize the collection gaps, any geo location (eg region, district, altitude, drought area, heavy rainfall area, etc) gaps, any specific trait gaps, etc. Gap analysis helps to identify priorities for further collection. As an example, collection gap of wild rice (*Oryza rufipogon* Griff.) was identified (**Figure** 12).

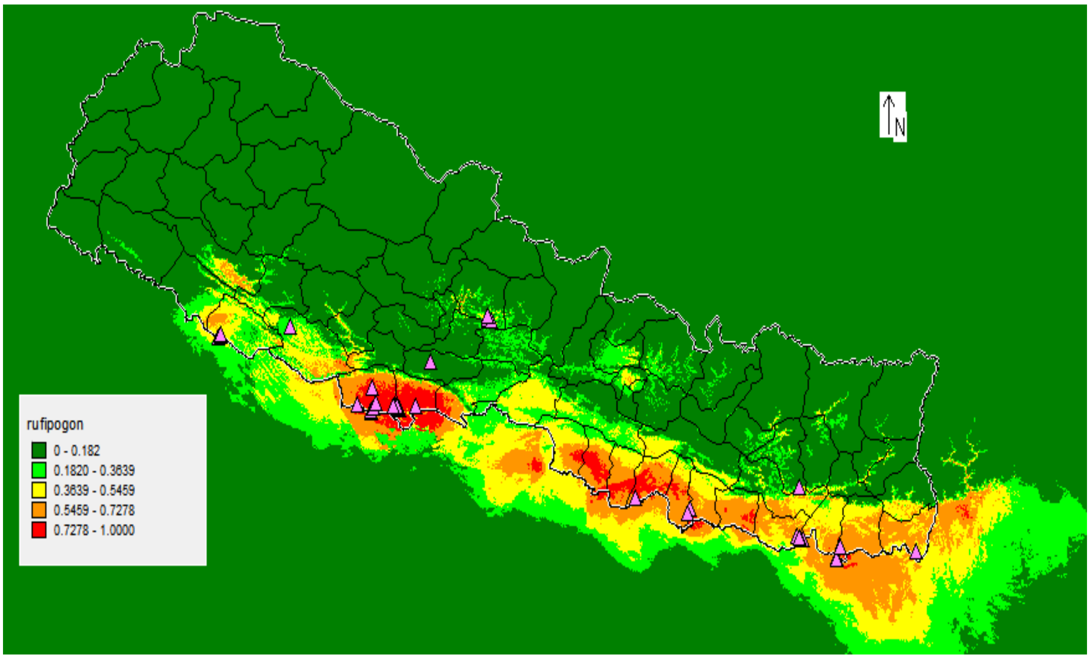

Figure 12. Collection gap analysis for *Oryza rufipogon* Griff.

Extracting Missing Information and Climate Data

Passport data is generally lack many information mainly geo-coordinates and location name. This information can be updated through GIS eg Diva-GIS. Alternatively NAGRC is extracting such information from Maps and Literature; Gazetteers (www.diva-gis.org); Google Earth and BioGeoMancer (www.biogeomancer.org). Climatic data can also be extracted of any geo-point which can be used for comparative study and pattern analysis. Collections can be related to climatic conditions.

CLIMATE ANALOG TOOL

Climate analog tool (CAT) is a planning tool for finding tomorrow's agriculture today (Ramirez-Villegas et al 2011). It accelerates the exchange of germplasm, increase effectiveness of adaptation trials (Pollak and Corbett 1993) and identify probable distribution/ introduction sites of species through locating analog sites. It may be equally applicable to other technologies to exchange among analog sites (climate smart technology). It has scope for identifying future and current analogue sites based on 19 bioclimatic indices.

Methods and Requirements

CAT is online analysis tool available at http://www.ccafs-analogues.org/tool/. Major four steps are i. Select location (need coordinate at DD format), ii. Select a direction and global climate models (Where can I find my site in the future? (FORWARD), Where can I find a place that currently looks like how my site would be in the future? (BACKWARD) and Where can I find similar areas to my site currently or in the future? (NO-DIRECTION)), iii. Select climate variables and define analysis settings, and iv. Run analysis. Geo-coordinates are most for CAT.

Analog Site

Major target of CAT is to identify analogue sites of any location at current and future, so that climately related technologies including germplasm can be exchanged, introduced (Joshi et al 2016b). For example, based on the analog site of genotypes testing trial, recommendation areas can be proposed. Joshi et al (2008a) has studied using GIS tool for finding environmentally analogous areas to recommend wheat varieties (**Figure** 13). Approximately 50% of Mid Hill areas are environmentally analogous to these five research stations. Highly matched sites are suitable for genotypes doing well across research stations. In same principal, new research stations including appropriate farmers' field trials can be identified. Climatic parameters are the main determinants for crop production. Following equation explains one of the factors for having big yield gap between research station and farmer's field.

Yield gap (Research station – Farmer's field) = Climatic differences (Research station – Farmer's field)

Through CAT, yield gap can be minimized by recommending suitable growing sites for newly developed varieties (testing sites similar to production sites). Use of GIS datasets by breeders and crop specialists may permit more precise matching of crop species and cultivars to suitable locations thereby increasing testing efficiency (Vernooy et al 2015). Identification of germplasm accessions from genebank is possible to accelerate the adaptation trials based on the analog sites. Rice germplasm were identified for Kachorwa, Bara based analog sites from Genesys and NAGRC (**Figure** 14, Chaudhary et al 2016).

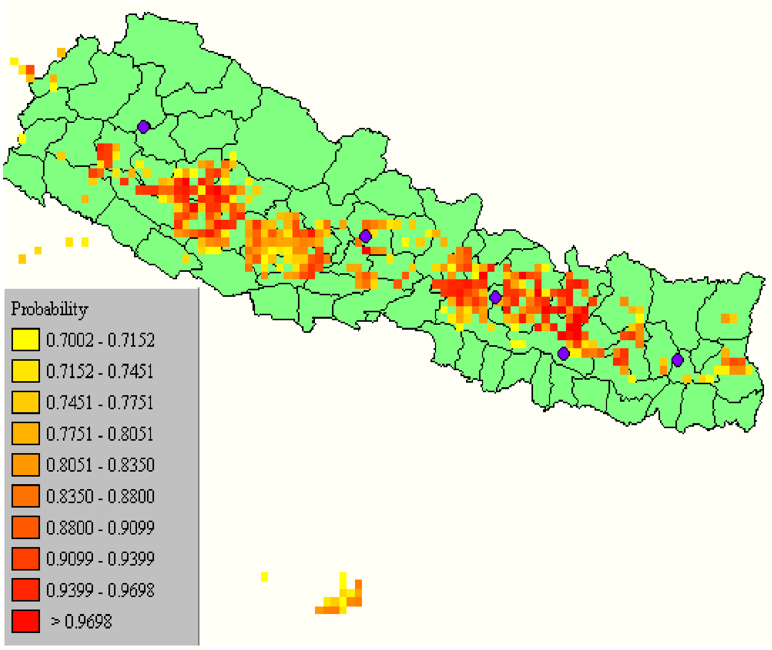

Figure 13. Analogous areas to that of five coordinated varietal trial sites indicating probability of matching sites and suitable for variety recommendation.

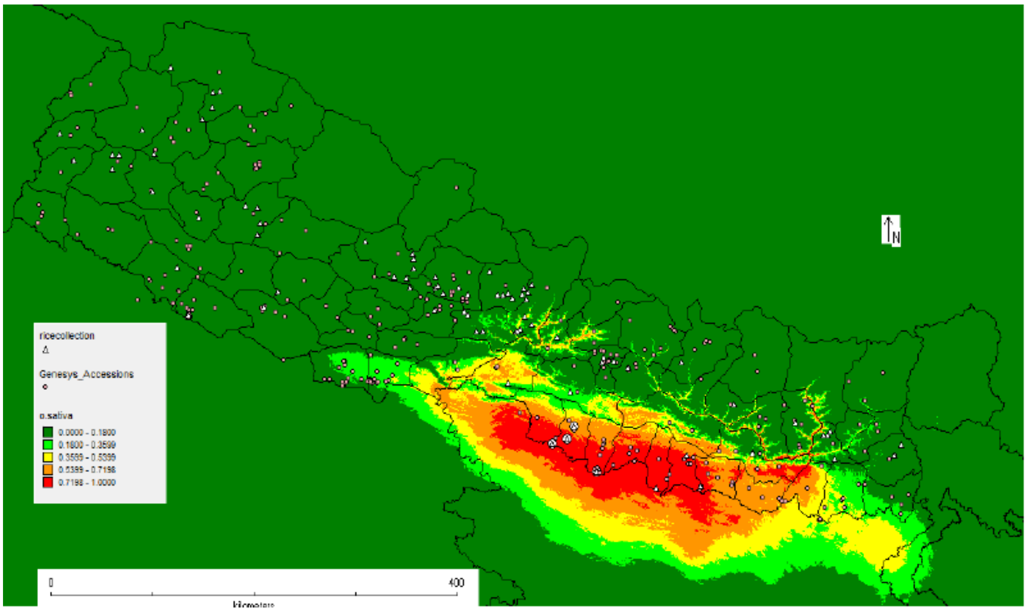

Figure 14. Identification of analog sites based on Kachorwa, Bara and potential rice germplasm from GENESYS and Nepal Genebank for matching areas.

Repatriation

Collections conserved in Genebank can be repatriated to their original site from where, these were collected. Analog sites need to identify based on the climate of collection site and then collections can successfully be repatriated to analog areas. Any accessions that were extinct or are endangered, can be returned to its original collection site or other climately similar areas.

Maxent, FloraMap and CAT

Probability of species distribution as well as potential sites for introduction can be estimated using computer software and all these are based on climate model. Commonly used software are Maxent, FloraMap and CAT. The Maxent software is based on the maximum-entropy approach for modeling species niches and distributions. From a set of environmental (eg climatic) grids and georeferenced occurrence localities, the model expresses a probability distribution where each grid cell has a predicted suitability of conditions for the species. Under particular assumptions about the input data and biological sampling efforts that led to occurrence records, the output can be interpreted as predicted probability of presence or as predicted local abundance (http://biodiversityinformatics.amnh.org/open_source/maxent/).

FloraMap is a computer tool for predicting the distribution of plants and other organisms in the wild. It is a system for producing the predicted distribution or the areas of possible adaptation, for natural organisms when little or nothing is known of the detailed physiology of the organism. It is assumed that the climate at the point of collection of a set of individuals is representative of the environmental range of the organism. In the case of plants, these are usually germplasm collection accessions or herbarium specimens. The climate at these collection points is used as a calibration set to compute a climate probability model. The system has been used to guide plant collecting, to investigate taxonomic and genetic variation, and to map crop pests and their potential predators (http://dapa.ciat.cgiar.org/floramap/). CAT is online tool and user-friendly and readily accessible platform that will facilitate quick identification of likely analogue sites (http://www.ccafs-analogues.org/. CAT can identify areas that experience statistically similar climatic conditions, but which may be separated temporally and/or spatially. In essence, the approach allows you to glimpse into the future by locating areas whose climate today is similar to the projected future climate of a place of interest (ie where can we find today the future climate of Lamjung, Nepal?), or vice-versa.

Climate Smart Conservation

Seed bank with cooler can be established anywhere for long term conservation of orthodox seeds. GIS and CAT could be very useful for establishing Field Genebank, community genebank, household genebank and on-farm as well as in-situ conservation so called climate smart conservation (CSC). For example, analog sites of Kachorwa Community seed bank were identified from where seeds can be exchanged for use and conservation (**Figure** 15). It suggests that further community seed bank within analog sites may not be necessary to establish. Collections from the analog sites of CSB location should be based on the study at current, past and future climate scenario. Similarly command areas of field genebank can be identified using CAT to collect and exchange germplasm.

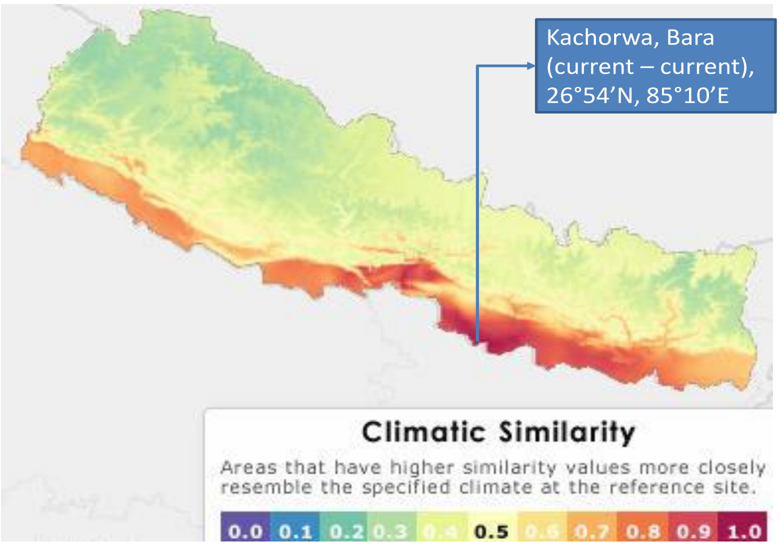

Figure 15. Potential analog sites for germplam exchange with climate smart community seed bank.

Climate Smart Germplasm

Collections in the Genebank are from wide range of geography. The analog sites of collection points can be identified in term of current and/ or future scenario. Considering climate of collection site during year of collection, CAT helps to identify matching sites where these collections can be tested and germplasm identified in this way is called climate smart germplasm (Joshi et al 2016a). This strategy is good for accelerating use of genebank collections.

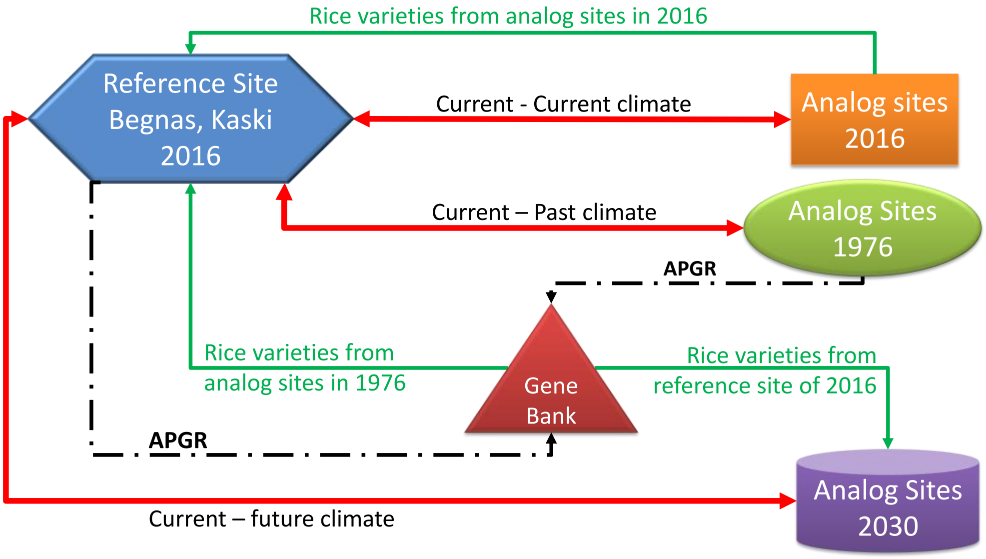

Figure 16. General steps for identification and deployment of climate smart rice germplasm.

Climate Smart Plant Breeding

Adaptation trial in plant breeding is the major part on determining the genotypes selection. Climate smart plant breeding (CSPB) may be the good strategy and it is described in **Figure** 17. It is proposed to use at least one parent from analog site of target environment, which is possible through selecting materials either from Genebank or directly from the fields. Other features of CSPB are testing genotypes including FFT in analog sites, using georeference of ancestors based recommendation of modern variety, considering geo-reference of research sites to find out the analogue sites for recommendation.

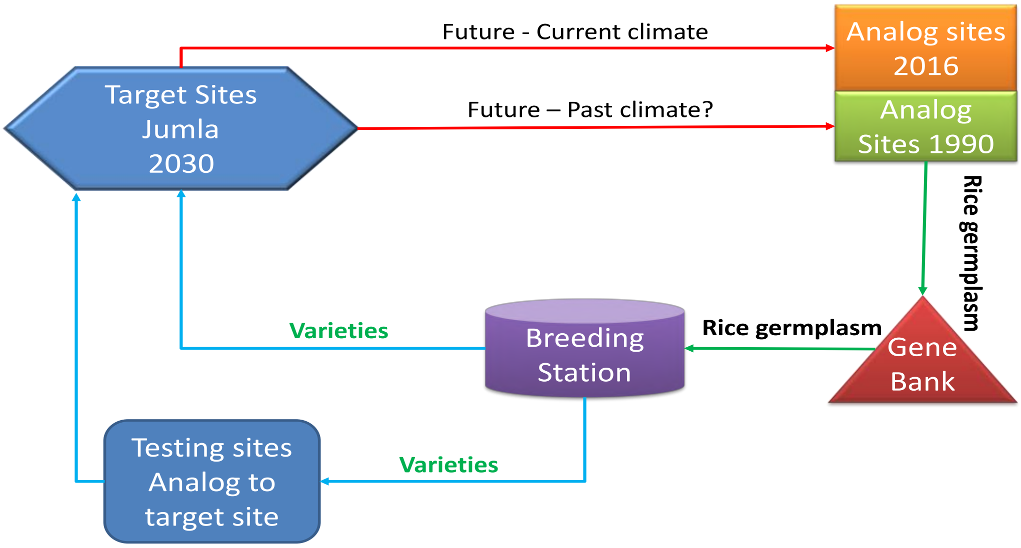

Figure 17. Conceptual step of climate smart plant breeding based on the climate analog sites.

ISSUES AND GAPS

Biotech tools are considered expensive and appropriate DNA markers for a number of crops are not available. DNA sequences are publicly available however; their use is almost zero in Nepal. GIS and CAT consider just climate data, but there are other factors that pay important role on crop adaptation and performance. CAT identify analog site based on single geo-point, multiple points based study may have more appropriate for finding analogue sites. Altitude is also determinant factor for crop selection, but it is not considered by GIS and CAT. CAT can reduce the varietal testing period and number of sites, but need to verify. Germplasm exchange through multilateral system may also be considered based on analog sites.

WAY FORWARD

Large scale screening is necessary using DNA markers in local crop diversity for accelerating uses of APGRs in breeding and research. Advanced biotechnological tools eg RT-PCR, sequencing system, etc should be introduced and needs to initiate QTL mapping and duplicates management using DNA markers. Tissue bank of very important and unique landraces should be established in different tissue culture labs. GIS and CAT are considered good tools for managing APGRs and adaptation study. Some of the future agendas are updating geo-referencing of all collections; analyzing collection gaps and diversity; matching sites identification for collections; using GIS and CAT tools for exchanging local landraces among community seed banks; studying landrace adaptability, generating information for potential exchange of germplam in future within Nepal; for selecting sites to establish Field Genebank and Farmer Field Trial. Climate smart breeding should also be extended widely.

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Agrobiodiversity Index to Measure Agricultural Biodiversity for Effectively Managing It

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ABSTRACT

Agricultural biodiversity is a source of nutritious foods, which are culturally acceptable and often adapted to local and low input agricultural systems. It is also a source of important traits for breeding climate-resilient, nutritious crops and animal breeds. Agrobiodiversity is increasingly identified as key indicator to sustainability of food systems, without which a food system cannot be sustainable. Agricultural biodiversity is shrinking fast and humanity is losing cost effective options to deal with global challenges. To sustainably manage agrobiodiversity, we need to measure it and devise appropriate conservation strategies. Scientists have developed diverse metrics to measure genetic diversity at molecular, variety, species and ecosystem levels. However, a universal and holistic way of measuring agrobiodiversity per se for sustainable food system is limited. Agrobiodiversity index has been developed as a consistent, long term monitoring tool to measure and manage agrobiodiversity across four dimensions: diets, production, seed systems and conservation. Based on desk research, key informant consultations and review of recent outcomes of relevant work of Bioversity International, this paper aims to introduce the evolving concept of agrobiodiversity index and highlights the benefits and merits of the index. The paper argues three scientific foundations to measure agrobiodiversity index for each food sub system are: i) contributing to safe and healthy diets, ii) contributing to sustainable production, and iii) contributing to healthy seed systems and conservation options for ensuring sustainable food systems globally. Some examples of potential indicators for each of the food sub system are outlined. The paper also discusses how the index can help governments make their food systems sustainable and contribute to multiple Sustainable Development Goals (SDG) and Aichi Biodiversity Targets. The index is expected to provide planners, policy makers and private investors 'easy-to-digest' metric that allow them to link decisions across human nutrition, agricultural production, biodiversity conservation and economic development. This will provide key data for private companies, investors, farmer organizations and government for allocation of financial resources to sustainable and development goals and environmental protection.

Keywords: Agrobiodiversity Index, genetic diversity, genetic erosion, sustainable development goals, sustainable food systems

INTRODUCTION

Agricultural biodiversity (in short agrobiodiversity) is diversity of crops and their wild relatives, fruits, trees, livestock, fish, pollinators, microbes and the landscapes that contribute to agricultural production. This diversity exits at the ecosystem, species and genetic levels and is the result of interactions between people and the environment. The Convention on Biological Diversity (CBD) defines agricultural biodiversity as, "A broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes."

Agrobiodiversity is, therefore, a key component of sustainable food systems, particularly in the wake of climate change (Galluzzi et al 2011, Woods et al 2015). Agro-ecological practices, such as optimizing use of crop genetic diversity (Hajjar et al 2008), can sustainably intensify agricultural production while simultaneously increasing ecosystem resilience and reducing gas emissions per unit of production (Hughes et al 2008). Crop diversity in the field can also contribute to diversity on the plate, which is known to link to better nutrition and human health (Shimbo et al 1994, Foote et al 2004). As a result agrobiodiversity is critical to the attainment of the Sustainable Development Goals (SDG)[1]: thriving lives and livelihoods, sustainable food security, sustainable

[1]The United Nations Rio+20 summit in Brazil in 2012 committed governments to create a set of sustainable development goals (SDGs) that would be integrated into the follow-up to the Millennium Development Goals (MDGs) after their 2015 deadline. Griggs (2013) argued that the protection of Earth's life-support system and poverty reduction must be the twin priorities for SDGs. It is not enough simply to extend MDGs, as some are suggesting, because humans are transforming the planet in ways that could undermine development gains. Global

water security, universal clean energy, healthy and productive ecosystems, and governance for sustainable societies. The SDGs can guide "green competition" for novel ideas and technologies at the macro scale and stimulate new business practices. Agrobiodiversity is also vital to meeting the Aichi Biodiversity Targets[2] of the Convention on Biological Diversity which promote the sustainable management of agriculture for biodiversity conservation and the conservation of genetic diversity of cultivated plants, farmed and domesticated animals and crop wild relatives[3].

Global biodiversity is in crisis, as evidenced by dramatic global declines in species distributions and populations, together with loss of large areas of natural habitat (eg Butchart et al 2010) and many of them irreversibly. Agrobiodiversity is continuing to decline and the extinction rate is gradually accelerating. This crisis of agrobiodiversity loss has been recognized by the Convention on Biological Diversity (CBD), whose members have set ambitious targets to avert ongoing declines in the state of biodiversity by 2020. In response, the Convention on Biological Diversity (CBD) has set out the 'Strategic Plan for Biodiversity 2011–2020', whose vision is to restore, value and conserve biodiversity for the benefit of all people by 2050 (CBD Secretariat 2010). Embedded within this plan are 20 so called 'Aichi Biodiversity Targets' (ABTs), adopted at the CBD meeting in Nagoya in 2010 and organized under five strategic goals: 1) Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society, 2) Reduce the direct pressures on biodiversity and promote sustainable use, 3) Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity, 4) Enhance the benefits to all from biodiversity and ecosystem services, and 5) Enhance implementation through participatory planning, knowledge management and capacity building. On current trajectories, results suggest that despite accelerating policy and management responses to the biodiversity crisis, the impacts of these efforts are unlikely to be reflected in improved trends in the state of biodiversity by 2020. For appropriate policy and management responses, compilation and analysis of quality data and information at genetic, species and ecosystem levels is essential.

The scientific community has developed a wide range of methods of measuring various dimensions of agrobiodiversity, each with different levels of certainty, accuracy and complexity (Jarvis et al 2008, Jarvis et al 2016, Brown 1999). These methods are designed for meeting specific purposes and mostly at genetic and species level. The question now is how to measure and monitor agrobiodiversity to guide investments in green bonds and food and agricultural sectors of stock markets towards more ecologically viable and socially sustainable food systems. This question is important for local and national governments and international organizations for sourcing resources whereas it is essential to realize by community and local government why agrobiodiversity index is important for them and why should invest their time to measure and contribute to national and global database. Scientists have developed diverse metrics to measure diversity at different levels, however, a universal and holistic way of measuring agrobiodiversity per se for sustainable food system is limited and may not be useful for Government and Corporate sectors. Agrobiodiversity index aims to be developed as a consistent, long term monitoring tool to measure and manage agrobiodiversity across four dimensions: diets, production, seed systems and conservation. Therefore, the aim of this paper is to introduce evolving concept and context of agrobiodiversity index and highlights its importance to measure, monitor and pilot for the management of agrobiodiversity for attaining sustainable food system. This paper derives most of the information from the desk research, key informant consultations and review of recent outcomes of relevant on-going global work of Bioversity International, Rome.

NEED OF AGROBIODIVERSITY INDEX

Agricultural biodiversity is shrinking fast and humanity is losing cost effective options to deal with global challenges. Food diversity is declining rapidly in recent years. Although more than 3,000 plant species have been identified as edible, only 10 species of cereal grains, legumes and oilseeds dominate 80% of the world's cropland (Glover et al 2007). Wheat, rice and maize provide over 50% of the world's food energy intake and accounts for two-thirds of the world's arable lands. This shrinking diversity is starkly reflected in the diets we consume as 90% of our plant-based calories come from about 30 crops (FAO 2009) and about 12 commodities (7 crops and 5 animal species) provide about 75% of the world's food today.

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scientific communities combined these concerns with the MDG targets, updated and extended for 2030, to produce SDGs: zero hunger, healthy lives and well-being for all, sustainable consumption and production patterns, combating climate change and halting biodiversity loss. Sustainable Development Goals has a set of 17 goals and 169 targets [UNO 2014].

[2]*https://www.cbd.int/sp/targets/.*

[3]*https://www.cbd.int/sp/targets/rationale/*

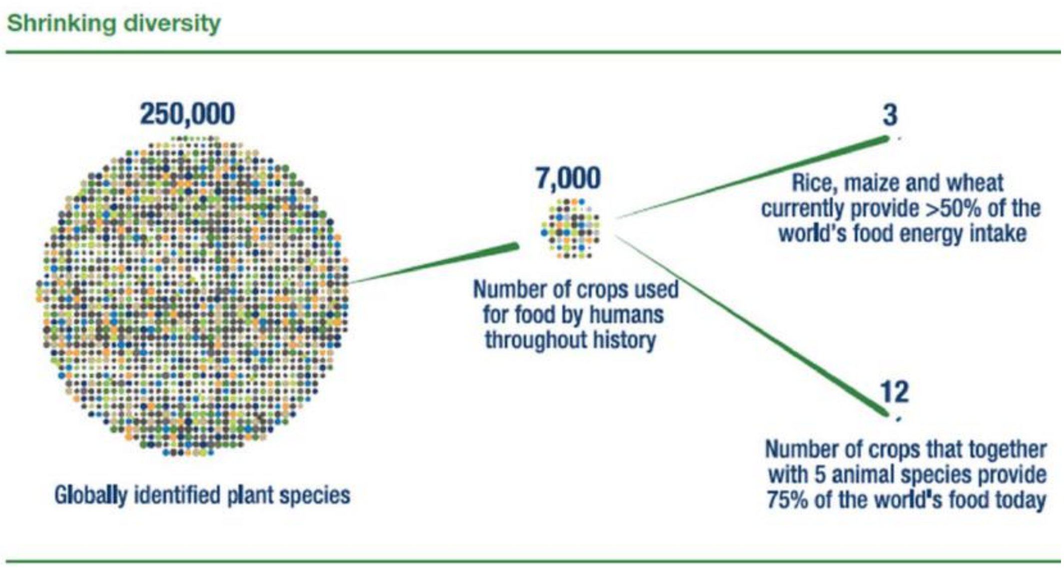

Figure 1. Shrinking diversity and number of crops meeting household food needs.
Source: FAO 1997.

Loss of agricultural biodiversity threatens food security, family nutrition and income as well loss of industrial raw materials, medical drugs and ecosystem services. Loss of biodiversity also reduces the potential genepool available for breeding new or improved crops, trees and livestock consequently reducing future innovation in agriculture. Consequently, about 60% of the world's population is malnourished, either due to the lack of enough calories or due to too much of the wrong kind of calories (Pimental 2012). In the context of changing climate, over reliance on a handful of crops also puts our food security at great risk and there is an urgent need to manage, measure and promote agrobiodiversity to enhance dietary diversity.

SCIENTIFIC FOUNDATIONS FOR AGROBIODIVERSITY INDEX

We propose an 'Agrobiodiversity Index' to help policymakers assess dimensions of agricultural biodiversity to guide interventions and investments for sustainable and nutritious food systems. Agrobiodiversity has potential to contribute to multiple Sustainable Development Goals (SDG) and Aichi Biodiversity Targets and sits at the nexus of several dimensions of sustainable food systems. Agrobiodiversity Index will allow the side-by-side visualization and assessment of important dimensions of a sustainable food system to identify leverage points for action (Bailey 2016). There are three scientific foundations to measure agrobiodiversity index for each food sub system (**Figure** 2). They are: i) contributing to safe and healthy diets, ii) contributing to sustainable production, and iii) contributing to plant breeding and healthy seed systems and conservation options for ensuring sustainable food systems globally. The three key dimensions /components of sustainable food systems are outlined below.

1. Agrobiodiversity in **consumption and market systems** includes diversity in diets and diversity in the markets contributing to healthy diets.
2. Agrobiodiversity in **production systems** includes diverse species, cultivars and functional traits in the production at farm, landscape and ecosystem, which contribute to sustainable agriculture.
3. Agrobiodiversity in **genetic resource management systems** includes diversity in conservation in genebanks and in-situ/ on-farm contributing to current and future options of biological diversity available for conservation.

The key agrobiodiversity (ABD) index related indicators are outlined for each of the food subsystems. For market and consumption, the key indicators are food group diversity available in the market and used in diet. Species and varietal diversity are key indicators for ABD in production system. Similarly, access to species and varietal diversity in seed system and % area under specific crop varieties on-farm are potential indicators for genetic resource management systems. They can be applied across number of food system components as mentioned above in providing novel insights on measuring and monitoring on each of the food system components and interactions among components. These indicators in each dimension will help to measure how diversity is changing over time. The key indicators of each of food system components are outlined in the box (**Figure** 2).

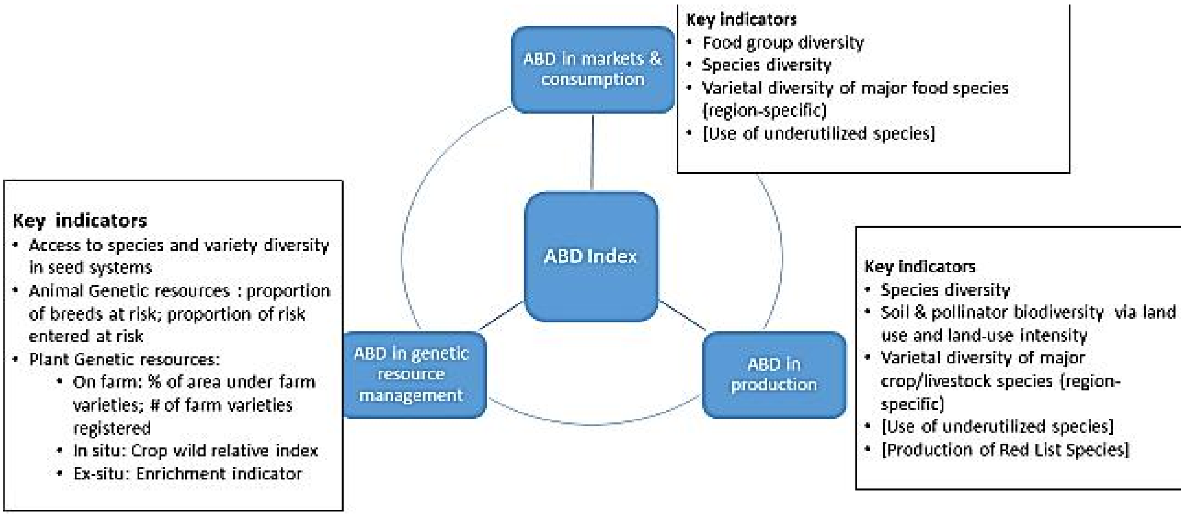

Figure 2. Scientific foundations for ABD for sustainable food systems.

DATA FOR ABD INDEX INDICATORS

Different types of indices can be identified based on type of data sources and based on main target group. Country and company level indicators are derived from using existing national databases and data from index-specific questionnaires with stakeholders. Company level indicators can be derived using publicly available information from companies and company tools and indices mainly for internal management. Indices are specifically developed for informing sustainable finance and there is a growing demand for and supply of indexes that summarize the increasing amounts of data to make those data usable in decision-making (Bioversity International 2017). The data on crop, livestock and fish can be combined with farming systems modeling and remote sensing, providing novel insights on spatial distribution, threats and trajectories of change. The data sources and mining options for the ABD index comprises Remote sensing; Company databases eg Carbon Delta; Google; Big data applications eg CGIAR big data platform; Crowd sourcing eg PREDICTS project, Seeds for needs, Agrobiodiversity 4-cell assessment; Others such as seed index.

COMMITMENT AND ACTIONS ON ABD INDEX

The commitment and actions to be undertaken by the national government and the private sectors for agrobiodiversity index and resulting status is presented in **Figure** 3. Commitment is important for the government and the private sectors for diverse diets and nutrition security, development of strategies to manage agrobiodiversity in supply/value chains/market portfolios for more diverse diets and the strategies that aim to avoid potential negative effects of market functioning on diet diversity.

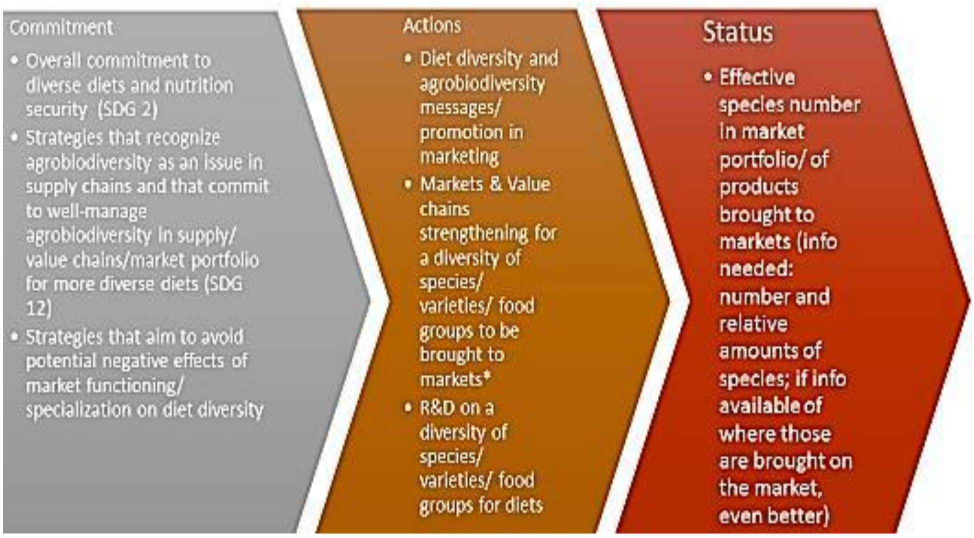

Figure 3. Commitment, actions and status of agrobiodiversity index.

Accordingly actions can be designed to undertake activities to meet dietary diversity, market value chains and R&D on a diversity of species and varieties. These will result in achieving effective species and cultivar number in market portfolio of products brought to markets, enhance consumption as well as production diversity.

CONCLUSION AND WAY FORWARD

Agrobiodiversity index has been developed as a consistent, long term monitoring tool to measure and manage agrobiodiversity. There are three scientific foundations to measure agrobiodiversity index for each of the food subsystem such as production, consumption and market, and conservation subsystem. There is a huge, and growing, number of existing datasets related to agricultural biodiversity, collected at different scales across different dimensions that can be used and made analysis for the measurement. There is a need to measure and understand biodiversity in rapid, cost-efficient ways, to connect also with policy decisions by countries and companies on best practices to foster diversity. ABD Index is an option which can help governments make their food systems sustainable and contribute to multiple Sustainable Development Goals (SDG) and Aichi Biodiversity Targets. The essence of the ABD Index is translation and packaging of scientific research and insights into actionable strategies that can be utilized by governments, corporates and investors. It helps these actors plan for and manages, for example, their exposure to extreme climate events (eg drought or new pest occurrences) that could trigger a harvest crisis and affect production for several agriculture seasons / cycles. Information about agrobiodiversity-related risks and opportunities for corporate operations can support more strategic internal capital allocation decisions, including to R&D and procurement strategies, and make new opportunities visible, both in terms of revenues and acquisitions (Bioversity International 2017). The ABD Index should also be considered as an operational risk management tool for governments. At the same time, understanding the role of agrobiodiversity and diversification strategies can help in stabilizing the national and local economic base and create new, more resilient, revenue and financing pathways. Governments are also greatly concerned with food and nutritional security (and associated healthcare costs) and these may be exacerbated in agrobiodiversity-poor landscapes. Therefore, the index will assist government to use 'easy to use' metrics that stimulate private companies, investors, farmer organizations and government for allocation of financial resources to sustainable development goals and environmental protection. It is also expected to provide planners, policy makers and private investors 'easy-to-digest' metric that allow them to link decisions across: human nutrition and agricultural production, biodiversity conservation and economic development. Therefore, future work on mainstreaming of ABD index is essential for sustainable development of agriculture and food system in Nepal.

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National and International Policies and Incentives for Agrobiodiversity Conservation and Use in Nepal

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ABSTRACT

Agricultural Plant Genetic Resource (APGR) constitutes an important part of the biological diversity and is the basis for sustainable agriculture and livelihood of two-third of the population in Nepal. The objectives of this paper were to review status of national and international policy and incentive mechanisms and assess their likely impact on conservation and sustainable of use agricultural biodiversity in Nepal. Nepal has become party to Convention of Biological Diversity in 1993 and International Treaty on Plant Genetic Resources for Food and Agriculture in 2009, formulated some relevant policies (Agrobiodiversity Policy 2007 (2014); National Biodiversity Strategy and Action Plan 2014) and Agricultural Development Strategy (2015) including National Seed Vision (2013) and drafted some legislations (Access and Benefit Sharing, Plant Variety Protection and Farmers' Rights) that are in the process for revision and approval. In the last two decades, the country has also initiated some novel programs and projects in conservation of agricultural biodiversity and established national genebank and provided environment for the initiation of community seed banks at the local level. However efforts and policy initiatives made so far are inadequate to provide incentives for conservation and sustainable use of agrobiodiversity and creating enabling environment for access and benefit sharing. Agriculture and economic development policies in Nepal currently have emphasized on production of a few major crops and modern varieties in favorable pockets without their potential effect on crop genetic diversity and sustainability of production system. Seed, inputs and credit subsidies, research and extension support programs are mainly directed to major food crops and few uniform modern varieties resulting in disincentives for production and promotion of diverse native crops and landraces. Legislation on plant variety protection, farmers' rights and access and benefit sharing mechanisms are not formally in place that provides incentives for farmers, plant breeders and other actors in conservation and sustainable use of diverse APGRs. The major gaps and challenges faced are the formulation and implementation of biodiversity friendly legislative framework, action plans and incentive mechanisms (royalty, subsidy, value addition, property rights, benefit sharing, rewards, recognition, etc) supporting conservation, sustainable use and their integration in national development programs. The key issues and mechanism for wide consultation, debate and public participation in the development and implementation of relevant strategies, legislations, incentive structure and action plans have been still very much limited and therefore, needs to be strengthened and mainstreamed in the country.

Keywords: APGRs mainstreaming, gaps and issues, incentives, likely impact on agrobiodiversity, policy status

INTRODUCTION

Agricultural Plant Genetic Resources (APGRs) are the raw materials for the genetic improvement of crop plants and directly support the livelihoods of two-third of the population who depend on agriculture in Nepal. APGRs are valuable to human beings not only to meeting the current needs of food security and livelihood of present generation but also to providing options for future crop improvement, innovations in agriculture and to respond to changing climatic conditions and market needs. However, the rich diversity of APGRs conserved and managed by farmers in Nepal over generation is being eroding with the advent of modernization, commercialization and globalization including changing climatic conditions. Along with these valuable APGRs, the traditional knowledge of cultivation, management and use associated with them are also in serious threat of extinction (FAO 1998). This loss of diversity of APGRs and associated knowledge has been identified as a serious potential cost of economic development (Oldfield and Acorn 1987, Brush et al 1992). Decreased diversity may imperil food supplies by limiting the availability of genes that confer resistance to pests, pathogen and environmental change (Jarvis et al 2016). The history of agriculture has repeatedly shown the social and economic consequences of relying on a narrow genetic base for any crop, such as the incidences of potato famine in Ireland in 1840s and corn blight in USA in 1970s. Developing countries including Nepal have limited ability to hedge against the increasing risks of such genetic vulnerability due to her poor capacity, lack of resources and poverty.

Policy environment and incentives play critical role in the conservation and sustainable use of the genetic resources by farmers, plant breeders and other stakeholders. In the changing context of economic liberalisation and globalisation, conservation and sustainable use of APGRs will depend on the availability of incentives for farmers and plant breeders to continue selecting, maintaining and making availability of these resources (Hawtin and Hodgkin 1997, UNEP 2000, Gauchan et al 2005b). There are some studies on the various socio-economic, agroecological and institutional factors that influence farm households' and stakeholders' decision to maintain and promote APGRs in Nepal (Gauchan et al 2005a, Bragdon et al 2009). However, little is known about the effects of national and international policies and incentives mechanisms on the conservation and sustainable use of APGRs. Therefore, this paper aims to assess state and influence of relevant national and international policies and incentive mechanisms in the conservation and sustainable use of APGRs in Nepal. It also explores options for integration of APGRs in the national development programs.

INTERNATIONAL POLICIES RELEVANT TO AGRICULTURAL PLANT GENETIC RESOURCES

There are various international conventions, treaties and agreements that are important and relevant to biodiversity and agricultural genetic resource conservation, access, exchange and use in crop improvement in Nepal. These include CBD (1992), WTO/TRIPs (1995), UPOV (1978, 1991), GPA (1997), ITPGRFA (2001), Nagoya Protocol (2010) and Biosafety Protocol (2000). Among them, the Convention on Biological Diversity (CBD) which was signed in Earth Summit, Rio de Janeiro in June 1992 is most important convention for biodiversity conservation, sustainable use and equitable sharing of benefits arising from the use of genetic resources (CBD, 2001). It is a llegally binding agreement ratified by Nepal in 1993 which recognizes biodiversity as a "common heritage" to "national sovereignty**".** Nepal became the member of The World Trade Organization (WTO) in April 2004. It influences the agricultural sector mainly through provisions such as an agreement in agriculture (AoA), Sanitary and Phytosanitary Measures (SPS) and the Trade Related Aspects of Intellectual Property Rights (TRIPS). Among these three provisions, TRIPS has direct relevance to crop improvement, conservation, exchange and ownership through the Article 27.3(b). This article has a provision for requirement of Plant Variety Protection (PVP) that can be met either through Patents, effective *Sui generis* system or combination thereof. The other most important convention relevant to provisions for developing incentives to crop improvement is International Union of New Plant Varieties (UPOV) model, which is a voluntary Convention established in Geneva, in 1961 under World Intellectual Property Organization (WIPO). UPOV offers governments specifically two models of protecting plant varieties: 1978 and 1991 through Patents and Plant Breeders' Rights**.** However**,** the option of signing on to the 1978 convention is now no more available and Nepal is not yet a member of UPOV (1991). This Convention does not recognise the indigenous knowledge and innovations of farmers and local communities to genetic resources.

Nepal was a party to Global Plan of Action (GPA) in 1997, developed under the auspices of FAO at an international technical conference on Plant Genetic Resources (PGRs) held at Leipzig, Germany in 1996 (**Table** 1). Nepal officially became party to FAO-International Treaty for Plant Genetic Resources for Food and Agriculture (IT-PGRFA) in 2009 which is a legally binding international agreement approved by the FAO conference in November 3, 2001. This treaty highlights the unique future and public good nature of crop genetic resources and recognizes the present and past contribution of farmers in developing and making availability of crop genetic resources (Gauchan and Upadhyay 2006). Article 7 of the ITPGRFA suggests for national commitments and international cooperation for conservation and sustainable use of PGRFA. It provides mechanisms of access and exchange of genetic resources that are pooled under Multilateral Systems (35 food crops and 29 forage PGRFA-Annex-1 Materials) and also recognizes Farmers' Rights (Article 9) to genetic resources and the traditional knowledge that are conserved and owned by farming communities. However, Nepal is yet to officially ratify Nagoya Protocol (2010) that provides framework for access and benefit sharing of genetic resources as per the provision of the Conventional of Biological Diversity (1992). An international framework called as Cartagena Protocol on Biosafety Protocol that deals with the regulations related to the safety of the genetically modified (GM) technologies and GM foods on human health, biodiversity and environment has been developed in 2000. It is the product of initiative made under the framework of CBD and initiated on 29 Jan 2000, which entered into force on Sept 11, 2003 and bind the members to implement precautionary principle in handling and trade of GMOs. Nepal has signed the Cartagena Protocol on Biosafety on March 2, 2001, but it has yet to ratify this.

Table 1. Relevant international policies and their specific features, Nepal

International policies	Specific features
Convention of Biological Diversity (1992): Nepal signed it	• Sovereign rights to nations

in 1992 and ratified in 1993.	• Conservation and utilisation • Access and equitable sharing of benefits
WTO (1995): Nepal got full membership in April 2004.	• Plant Variety Protection • Agreement on Agriculture • Sanitary and Phytosanitary (SPS) Measures
International Treaty for Plant Genetic Resources for Food and Agriculture (2001): Nepal acceded to this Treaty on October 2009.	• Conservation, sustainable use, benefit sharing • Multilateral Systems of Access • Farmers' Rights
Global Plan of Action (1997): Nepal was a party to Global Technical Conference.	• Conservation through use • Technical support for the countries
UPOV (1991): Nepal is not a member of it.	• Plant breeder's Rights and Patents
Nagoya Protocol (2010): Nepal has yet to ratify it.	• Provides framework for access to genetic resources and the fair and equitable sharing of benefit arising from their utilization
Biosafety Protocol (2000): Nepal has yet to ratify it.	• Regulations for the safety of GM technologies, genetic materials and foods.

Adapted from Gauchan et al 2005a.

Nepal has implemented provision of CBD (1992) by allocating nearly one-fifth of the national area in protected area, forest and wild life reserves with the overall aim of biodiversity conservation. The country has established National Genebank in 2010 to implement conservation and sustainable use of agrobiodiversity as per the provision of ITPGRFA (2001) and Global Plan of Action (1997).

NATIONAL POLICIES, ACTION PLAN AND IMPLEMENTATION STRATEGIES

Recently the increased awareness and realization about the importance of agricultural biodiversity for food security made some efforts to conserve and use APGRs in the country and led to the formulation of policies and legislations (**Table** 2). Agrobiodiversity conservation was officially first included in the text of the Tenth Plan (2002-2007) which recognized that biodiversity is closely linked to livelihood and economic development (Gauchan et al 2005a). Subsequently, agrobiodiversity Policy was formulated and officially approved in 2007 and also revised in 2014 with the provisions of multilateral systems of ITPGRFA and broadened coverage of animal genetic resources (MoAD 2014). Government of Nepal has also formulated National Biodiversity Strategy and Action Plan (NBSAP) for 2014-2020 to provide overall strategies and action plans for biodiversity conservation encompassing five components of biodiversity; forest, rangeland, wetland, mountain and agrobiodiversity. Conservation of APGRs within protected area, crop wild relatives and in-situ conservation are included in both agrobiodiversity policy and NBSAP. Conservation of agrobiodiversity is also mentioned in the recently formulated Nepal's umbrella strategy “Strategic Framework on Nature Conservation for Sustainable Development (2015-2030). The newly formulated “Constitution of Nepal” emphasizes conservation of biodiversity by minimizing negative effect of industrialization and physical development. Similarly the country formulated National Seed Vision (2013-2025), amended old Seed Act of 1988 in 2008 and revised Seed Regulation in 2013. Most recently Government of Nepal has approved National Intellectual Property Policy (2017) which has provision of property rights on new creations including plant variety, traditional knowledge, and products of geographic origins. But legislation to implement it has yet to be approved. Most recently the Government of Nepal formed National Farmer's Commission to ensure and protect rights of farmers in agriculture, agrobiodiversity, land, food, natural resources and social security. The country has drafted Plant Variety Protection and Farmers' Right to meet obligations of TRIPs of the WTO as well as to provide incentives to breeders, innovators and farmers. This is a form of own *sui generis* legislation. However, it is yet to be reviewed, finalized and approved. Recently the Government of Nepal has revised Access to Genetic Resources and Benefit Sharing Legislation to meet obligations of CBD and Nagoya Protocol in the context of Nepal. The country has also formulated biosafety framework to regulate safe introduction and use of GM products and genetic resources in compatible with the Cartagena Protocol (2000), though formulation of legal framework for biosafety rules is yet to take place.

Table 2. Relevant national policies and legislations and their specific features, Nepal

Relevant national policies	Specific features
Constitution of Nepal	Biodiversity conservation by minimizing the negative impacts of industrialization and physical development
Biodiversity Policies: Agrobiodiversity Policy (2007) revised 2014; National Biodiversity Strategy and Action Plan (2014-2020)	Focus on holistic agrobiodiversity: in-situ and ex-situ conservation approach with protection, ownership and conservation of crop and animal GRs. Agrobiodiversity is one of the five components of

Relevant national policies	Specific features
	the biodiversity indicated in NBSAP
Agrobiodiversity/Biodiversity Legislations: Access to Genetic Resources and Benefit Sharing Draft Bill (2016); Plant Variety Protection and Farmers Rights Bill; Agrobiodiversity Draft Bill (2015)	Focus on Access and benefit sharing arising from the use of Genetic Resources, property rights on genetic resources (farmers' rights and plant breeders' rights), Check bio piracy and facilitated exchange of agricultural genetic resources under Multilateral System as per ITPGRFA provisions
Agri-development policy: Agricultural Development Strategy (2015); National Agricultural Policy (2004); Agribusiness policy (2006)	Sustainability is the focus with some indication of agrobiodiversity related activities. But major focus on increased productivity; commercialization and livelihood focusing on major food and cash crops and MVs with limited focus on conservation
Seed sector Policy and Legislations: National Seed Vision (2013); Seed Policy (1999); Seed Act (1988) revised 2008; Seed Regulation (2013)	Conservation and use of farmers' varieties is spelled out in National Seed Vision, while Seed Policy and Seed Act are silent on this. Seed Act and Regulation mentions the provision of rights to plant breeders but not that of farmers rights
National Strategic Framework on Nature Conservation for Sustainable Development (2015-2030)	Umbrella strategy for conservation of nature covering biodiversity, forest, water, air, land, cultural heritage. It recognizes agrobiodiversity/biodiversity as the important component of nature conservation
National Intellectual Property Policy (2017)	Provision of property rights on new creations including plant variety, traditional knowledge, products of geographic origins
National Farmer's Commission (2017)	The main objective is to ensure and protect rights of farmers' in agriculture, food, land, social security and agrobiodiversity
Other relevant policies: Climate Change Policy (2011)	Local crops and varieties and use of diversity are useful for climate change adaptation, ecosystem services and nature conservation for sustainable development.

INCENTIVES AND THEIR LIKELY INFLUENCE

Incentive measures have long been used by governments to manipulate the ways in which macro and sectoral economies work. It is however only relatively recently that they have started to be applied to biodiversity conservation specifically after the historic summit of CBD in 1992. The article 11 of the CBD (CBD 2001) stipulates that each contracting party as far as possible and as appropriate, adopt economically and socially sound measure that act as incentive for the conservation and sustainable components of biological diversity. The basic aim of setting in place economic incentives for biodiversity conservation is to influence people's behavior by making it more desirable for them to conserve, rather than to degrade or deplete, biodiversity in the course of their economic activities. Incentives relevant to APGRs are mainly of three types: direct, indirect, and perverse incentives (**Figure** 1).

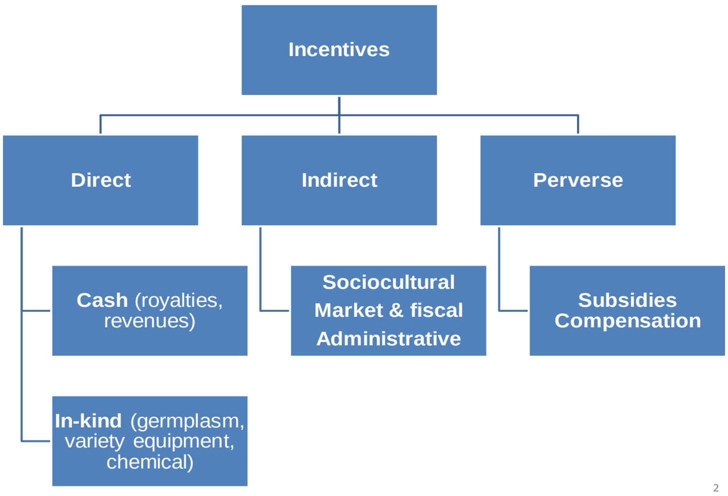

Figure 1. Types of incentives for including genetic resources in the multilateral system.

Market plays important role in creating incentives and disincentives and it is one of the least cost options for conservation of agrobiodiversity on-farm (Gauchan et al 2005b) Direct incentives include cash and in-kind inducements provided by the state, whereas indirect incentives are socio-cultural, market, fiscal, and administrative factors influencing farmers' and stakeholders' choices (Gauchan et al 2016). Perverse incentives are subsidies and compensation for cultivation and commercialization of high-yielding modern seed varieties that negatively affect the conservation, use, and inclusion of indigenous APGRs. Incentives modify the structure and effects of household utility function and give people the opportunity to choose the best option for them. Incentives such as payment for ecosystem services or certification schemes aim to correct market failures by 'rewarding' farmers for the adoption of environmental/ biodiversity or socially friendly practices (Hunter et al 2017).

RECENT INITIATIVES AND EFFORTS IN CONSERVATION AND USE OF APGRs

Nepal has made some initiatives recently to address conservation and utilization of agrobiodiversity such as establishment of National Genebank in 2010 and initiation and operation of over 100 numbers of Community Seed Banks at the local level by different organizations. On-farm conservation programs formally initiated from 1997 with the implementation of global project 'Strengthening the scientific basis of in-situ conservation of agrobiodiversity on-farm" in Nepal. This project was successfully completed in 2005 in Nepal by developing good practices and approaches for on-farm conservation, which are globally adopted and popular (Gauchan et al 2003). These included important participatory on-farm /community based biodiversity management tools such as participatory 4-cell analysis, community biodiversity register, community seed banks, Diversity Blocks, Diversity Fairs, participatory plant breeding including value addition and marketing approach (Sthapit and Jarvis 2005). The project also played important contribution in creating awareness, build capacity and integrate some of the activities of agrobiodiversity conservation in agricultural R&D programs. Other subsequent past projects that played important role in agrobiodiversity management were "Home Gardens (2002-2016)", "Neglected and Underutilized Species (NUS)", "Genetic Resource Policy Initiative (GRPI), Phase I and II"; and "Diversifying Availability of Diverse Seeds (DADS)" implemented in Nepal since early 2002.

Currently GEF UNEP Local Crop Project (2014-2019) is being implemented for traditional mountain crops in the mountains of Nepal in active collaboration with Bioversity International, Nepal Agricultural Research Council, Department of Agriculture and LI-BIRD. The project is making good progress in linking local community with national genebank for the deployment and evaluation of diverse locally adapted crop varieties and mobilizing communities for the establishment of community seed banks to strengthen local seed security in the remote mountains.

The policy research analysis and advocacy carried out through the past initiatives of multi-stakeholder partnership have played significant role in agrobiodiversity policy development and facilitating policy change (Upadhyay et al 2005, Bragdon et al 2009, Gauchan et al 2012). One of the major contributions of the projects and initiatives is formulation of Agrobiodiversity Policy (2007) and its successive revision in 2014 in Nepal to include provisions of ITPGRFA multilateral system and broadening the provisions of animal genetic resources. The other important contribution was Nepal's accession to ITPGRFA in 2009 and developing program for field implementation of the ITPGRFA. The initiatives made in Nepal in the last two decades also helped in relaxation of seed policy and legislation for release and registrations of local varieties and those developed from participatory research with local communities.

LIKELY IMPACT OF POLICIES AND INCENTIVES ON CONSERVATION AND USE OF APGRs

Incentives and policies influence the exchange, flow, use, and inclusion of APGRs at the international, national, and local levels. International policies, agreements and legal frameworks to which the country is a party, guide the development and enforcement of national policies and laws at the national level (**Figure** 2). National policies (environment, forestry, agriculture, education, property rights, trade, investment, fiscal, monetary, etc) and legislations can facilitate or impose restrictions on the access, use, and exchange of APGRs in communities, regions, and beyond national boundaries (Gauchan et al 2003, 2005a). National policies and laws mainly have direct impact on conservation of genetic resources through related product and input markets, prices, information and regulations. The regulations of national laws (eg Seed Act, Plant Protection Act) can impose restrictions on the access, use and exchange of genetic resources in the communities, regions and beyond the national boundary. The local policies and informal institutions at the community level directly influence on-farm conservation through affecting farmers' choice, selection, saving, exchange and management of local genetic resources in the community.

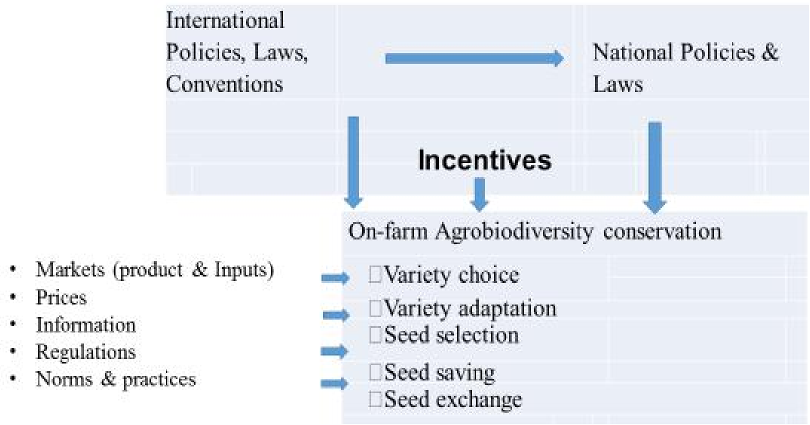

Figure 2. Influence of national and international policy and incentives on APGRs conservation.

Present agricultural policies of government of Nepal are guided by the Agriculture Development Strategy (ADS) (2015-2035) and in the past by the Agricultural Perspective Plan (APP) and the Periodic Economic Development Plans including sectoral policies and directives. These policies have fundamentally focused on production of a few major crops and well researched uniform modern varieties of crops in favorable pockets with intensive input use and package approach. The 'pocket package' approach of APP in the past and presently Prime Minister Agriculture Modernization Project (PMAMP) in pockets, blocks, zones and super zones approach have given no attention on analyzing their consequences on on-farm crop genetic diversity and conservation of APGRs. Presently, area covered by improved varieties and short term profitability of agricultural production are major indicators of the current development programs without analyzing their consequences on sustainability, equity and diversity. Agricultural development (eg research and extension) and related economic policies, such as for credit, input supply, markets and education, were directly or indirectly found to influence conservation of agrobiodiversity on-farm (Gauchan et al 2006).

GAPS, CHALLENGES AND ISSUES

The major gaps and challenges faced are the formulation and implementation of biodiversity friendly legislative framework, action plans and incentive mechanisms (royalty, subsidy, value addition, property rights, benefit sharing, rewards, recognition, etc) supporting conservation, sustainable use and their integration in national development programs. Legislation on plant variety protection, farmers' rights and access and benefit sharing mechanisms are not formally in place that can provide incentives for farmers, plant breeders and other actors in conservation and sustainable use of diverse APGRs. As a party to WTO TRIPS and CBD, Nepal has drafted Plant Variety Protection and Farmers' Rights Bill and Access and Benefit Sharing Bill respectively, which have been revised but still in draft form. They need improvement and official government approval before they are put in place for field implementation. A limited awareness exists among stakeholders on the recent international, national policy and incentive mechanisms for protecting and promoting APGRs conservation and use. The key issues and mechanism for wide consultation, debate and public participation in the development and implementation of relevant strategies, legislations, incentive structure and action plans have been still very much limited.

At present policies formulated and implemented are mainly directed to promotion of major food and cash crops with the promotion of modern varieties without analyzing their consequences on on-farm genetic diversity. The notion that "economic benefits can be derived only from the promotion of modern varieties/technologies" is still the guiding philosophy in the policy formulation (Gauchan et al 2005a). Therefore, policies to multiply, certify, quality control and seed distribution of underutilized but important indigenous food security crops are lacking. Crop-specific seed and input policies directed for major crops and modern varieties often result in disincentives for farmers to cultivate crops and farmers varieties that make important contributions to nutritious diets, such as underutilized crops and local varieties. In addition, informal seed supply systems do not receive any form of policy and institutional support from the government despite its large coverage (80-90%) and contribution in overall crop production and food security of small-scale farmers (SQCC 2016). The existing regulatory framework also provides insufficient incentives to the rapid promotion and utilization of rich landraces diversity found in the farmers' fields. Despite some good initiatives made in agrobiodiversity policy development and project implementation presently agrobiodiversity programs are not fully integrated and mainstreamed in national development programs. Biodiversity policy and program is still focused on forest and wildlife than conservation and sustainable use of agricultural genetic resources for ensuring food security and poverty reduction. Nepal is still far behind in developing relevant policy, program and legal needs to address the changing needs of the country in the context of membership to WTO and changing climate scenarios. The government is constrained by the relevant expertise, resources and institutional arrangements in the development of policy.

CONCLUSION AND WAY FORWARD

The Convention on Biological Diversity (CBD) and International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) are two important international instruments guiding conservation and use of agricultural biodiversity in Nepal. Nepal has made some progress in the development of policies and programs in line with the international treaties and conventions. However, current international attention to biodiversity focuses mainly on conservation of "globally-important" forest and wildlife biodiversity including rare, endemic and endangered species and ecosystems. Less widely recognized is the centrality of agrobiodiversity to food security and livelihoods of the poor, and the vulnerable communities. Some initiatives such as on-farm conservation of agrobiodiversity and policy related projects were implemented in Nepal that made some contribution in influencing policies and bringing agrobiodiversity conservation agenda through community empowerment, policy research and advocacy. Despite some good initiatives made in agrobiodiversity policy development and project implementation presently agrobiodiversity programs are not fully integrated and mainstreamed in national development programs.

Favorable policies on sustainable agricultural development and formal education will provide incentives to local communities and stakeholders for sustainable harnessing, utilization and conservation. These include specific targeted policies such as appropriate technology, price, and institutions (market, credit, regulatory framework) for their production, value addition and marketing. Policies and programs for value addition and marketing support to local crops and landraces will provide incentives to farmers for the production, promotion and integration in agricultural development programs. Raising awareness on the value of agricultural biodiversity at different levels, building capacity of 'custodian' farmers and researchers to assess diversity, characterize and use are basic steps required for integrating on-farm conservation of agricultural biodiversity in national development programs. In addition, appropriate policy on effective *sui generis* systems and farmers' rights need to be created to recognize and reward farmers for their knowledge and innovation including safeguarding valuable genepools from potential threat of erosion or outside use. Designing appropriate curricula and courses in formal education systems and training extension workers for the dissemination of landraces through extension packages will be needed. This would effectively enhance seed supply network as local varieties could be made available to farmers along with modern varieties.

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Agrobiodiversity in Education Systems of Nepal

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ABSTRACT

It is crucial to develop qualified and competent human resources in agriculture and agrobiodiversity management in Nepal. Different universities and campuses (both public and private) have developed the courses on agriculture and agrobiodiversity in particular. It is certainly important to provide practical knowledge on different aspects of agrobiodiversity conservation and management, related policies and international treaties. This paper has reviewed the course curricula of undergraduate and graduate programs particularly on agrobiodiversity in selected universities/campuses with the aim to analyze the contents and provide recommendations for the improvement. It is found that different universities/campuses offered it in different names such as “agrobiodiversity conservation and climate change” in Agriculture and Forestry University; “agrobiodiversity management” in Institute of Agriculture and Animal Science of Tribhuvan University; “plant genetic resources management” in the Mahendra Ratna Multiple Campus (Ilam) of Tribhuvan University and “plant genetic resources and biodiversity conservation” in Himalayan College of Agricultural Science and Technology of Purbanchal University. It is also found that only “agrobiodiversity management” course has included the content of International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). With this analysis, we would like to recommend that it is necessary to 1) review the courses to integrate ITPGRFA and 2) build capacity of institutions and faculties to deliver the courses effectively. Furthermore, we recommend to 3) establish fund to encourage faculties and students on agrobiodiversity research and generate new in-depth knowledge, 4) organize regular seminars/training workshops and 5) build networks among individuals and organizations for effective collaboration on agrobiodiversity education at the national and international levels.

Keywords: Agriculture, agrobiodiversity, conservation, plant genetic resources, universities

INTRODUCTION

Nepal stands in a 25th position in terms of the global ranking of biodiversity (NBS 2002). It is well-known for diverse ecosystems, rich biodiversity (both floral and faunal diversity) including agricultural diversity within 0.09% of land area occupied by the country in the global scale. There are 118 different types of ecosystems identified in Nepal. It is estimated that 687 species of algae, 1822 species of fungi, 2000 species of lichens, 853 species of bryophytes, 380 species of pteridophytes, 27 species of gymnosperms and 5856 species of angiosperms are existed in Nepal (NBS 2002). Due to high degree of ecological and species diversity, the country is rich in agricultural diversity that has significant roles on food security and livelihood. It is recorded that a total of 200 species out of 500 edible plants are cultivated in Nepal and additionally 120 wild relative species of cultivated plants are reported. Joshi (2017) reported 790 plant species with food values in Nepal. The farmers in Nepal grow more than 95 local aromatic and fine rice landraces (NBS 2002). All these resources are the main basis of Nepalese agriculture, food security, poverty alleviation and sustainable development.

Agrobiodiversity or agricultural biodiversity is defined as all components of biodiversity related to food and agriculture including the agroecosystems, variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels (Bioversity International 2009, Rudebjer et al 2011). Agricultural plant genetic resources (APGRs) including cultivated crops, wild edible plants and crop wild relatives are part of agrobiodiversity (Joshi 2017). Regmi and Paudyal (2009) emphasized on the important roles of the agrobiodiversity and livestock on the livelihood of the rural communities. This agrobiodiversity fulfills the immediate needs and the long-term sustenance of the rural poor (NBS 2002). However, this rich agrobiodiversity has been gradually disappearing over the time and space (www.farmersrights.org). Bioversity International (2009) reports that modern varieties of rice varieties have replaced the landraces in 3 quarters of the rice fields in the period of 40 years from 1960 to 2000. These varieties and species of landraces are conserved and maintained by farmers and farmers’ managed community seed banks. There are many additional impacts on agrobiodiversity losses such as changes in land use, land degradation, deforestation and habitat loss. One of the major issues of such deteriorating is the lack of competent human resources, more accurately the successors, in this sector as most of the youngsters have been out-migrated from this sector due to general mentality of considering it as the low class jobs, lack of strong government policies for its promotion, lack of linkages between education and research in agrobiodiversity and the huge gaps on agrobiodiversity in practices ie, field work vis-a-vis text books.

Since agriculture is the backbone of the country's economy, it is crucial to develop the human resources on agriculture and agrobiodiversity in particular. The biological and cultural diversity of the country are also quite important in terms of teaching and learning agriculture and agrobiodiversity. Chaudhary and Pasa (2015) emphasized on the importance of agriculture education in agricultural and rural development in Nepal ultimately supporting in poverty reduction and socio-economic development. Agriculture education has a long history in Nepal with the establishment of school of agriculture under the Ministry of Agriculture in 1957, which was later upgraded to the Institute of Agriculture and Animal Science (IAAS) for higher education in agriculture in 1972 under the umbrella of Tribhuvan University (TU). However, the education on agrobiodiversity is very recent in Nepalese context. Due to high demand of the qualified and competent human resources, many private and government colleges including the Himalayan College of Agriculture Sciences and Technology (HICAST) of Purbanchal University (PU), and Agriculture and Forestry University (AFU) are established in 2000 and 2010 respectively (Paudel et al 2013, Chaudhary and Pasa 2015). But very few departments have concentrated the agrobiodiversity course specifically as most of them have concentrated on the conventional courses. There are only 3 universities –TU, AFU and PU among 12 universities offer the higher degrees on agriculture and related fields in its various institutes, campuses and programs (Paudel et al 2013). Each of these three universities have offered course curriculum on agrobiodiversity, recently.

The Government of Nepal (GoN) is committed on conservation and securing access to agrobiodiversity and plant genetic resources for food and agriculture in line with international treaties such as Convention on Biological Diversity (CBD) and International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). There are number of studies conducted focusing on effect of education on the performance of agriculture in last two decades (Dhakal et al 1987). No study focusing on the course curriculum on agriculture particularly on agrobiodiversity in Nepal. Bioversity International (2009) recently reviewed the role of academic institutions on agrobiodiversity in Africa, Latin America and Asia Pacific and found the common problems of mainstreaming agrobiodiversity education in the universities. This opens the scope of research on introduction of curricula on agrobiodiversity education in Nepal. This paper attempts to survey the existing course curriculum of agrobiodiversity in higher education in Nepal.

RECENT ADVANCES ON AGROBIODIVERSITY CONSERVATION, RESEARCH AND EDUCATION

There are many new advancements in agrobiodiversity discourse globally and also in Nepalese context to some extent. In this regards, government organizations, especially, National Agriculture Research Council (NARC) and non-governmental organizations (NGOs) are advancing the conservation and development of agrobiodiversity since 1937 (Joshi et al 2016). Basically, some of the NGOs such as Local Initiatives for Biodiversity Research and Development (LIBIRD), Forum for Rural Welfare and Agricultural Reform for Development (FORWARD-Nepal) among others have been consecutively conducting research and development in agrobiodiversity and contributing in developing qualified and competent human resources jointly with the government and research organizations within Nepal and also in abroad. One of the milestone works LIBIRD has conducted in agrobiodiversity is the on-farm management of agrobiodiversity in Nepal jointly with NARC and Bioversity International (used to be International Plant Genetic Resource Institute – IPGRI) since 1997. With this joint effort, numbers of milestone advancements have been achieved in the field of research, conservation, management, development and education in agrobiodiversity in Nepal. LIBIRD also has direct collaboration with universities within Nepal and in abroad such as TU, AFU, Wageningen International for training and education in the agrobiodiversity. The academic institutions are rather progressing very slow in terms of agrobiodiversity education and human resources generations based on formal course curricula in Nepal. Some of these advancements are highlighted hereunder (**Box** 1) though these advancements are not reflected in any text books of any schools, colleges and universities:

Box 1. Advancements on agrobiodiversity research, conservation, development and education in Nepal

- Household gene bank (household seed bank, household field genebank)
- School field genebank
- Village level field genebank
- Community gene bank (community seed bank and community field genebank)
- Seed herbaria
- Rescue collection mission
- Crop Specific Park, Home gardens, Rooftop Gardens
- Aqua pond genebank
- Livestock farm genebank
- Safety duplication/ back up
- Red listing APGRs
- DNA bank/ Tissue bank; Conservation ladder
- Landrace as geo indicator, GIS + CAT, MLS
- Nepal Annex-1 Crops
- Landrace enhancement and conservation (LEC) – Participatory Plant Breeding, Farmer Breeders
- Accessioning
- Landraces catalog
- Write shop; Edit shop; Sharing shop
- Virtual workshop
- Image bank
- Diversity kits; Diversity blocks
- Diversity fair; Food fairs, Diversity field school
- Pre breeding
- Cultivar mixture (varietal blend)
- Diversity rich solution
- Community Biodiversity Register (CBR)
- Farmers' Field Schools
- Travelling Seminars
- Participatory Seed Exchange, Seed Networks

Source: Joshi et al 2016 modified by authors.

CURRENT EDUCATION SYSTEM

The current teaching-learning system and education system, at least in Nepal, is more concentrated on text books. Especially in the government universities, the course curricula are out of date that means not thoroughly updated based on the recent advancements in the respective fields (Paudel et al 2013). One of the examples is the reluctance of introduction and enrollment of agrobiodiversity management course in these universities. Agriculture education has been started in 1957, but the courses on agrobiodiversity are recently started only after 4-5 decades. However, the situations in private universities and schools are comparatively flexible and somehow consider as the updated than the government universities. Being an applied science, the textbooks and course curricula in agriculture in general and agrobiodiversity in particular need to be practical based on the real issues and problems based on the field contexts, which is somehow lacking or limited in the courses in Nepalese context. There are lots of potentialities on advancing the agrobiodiversity courses in the curriculum. In fact, there are many advancements on the research and education including the assessment and analysis tools and methods in diversity that should be included in the courses (**Box** 2). The government and academic institutions need to develop and regularly update the agriculture and agrobiodiversity courses for the rapid advancements of agriculture sector in Nepal.

Box 2. Methods and tools for diversity assessment and analysis

- Richness, Shannon-Weaver Index, Cluster and Principal Component Analysis
- Genetic and Population Parameters (Nei's, Wright's Index)
- GGE Biplot, Augmented Design, Alpha Lattice
- Rod Row Design (solid seeded lines), Multi-locations/ years trials, Un-replicated trial
- Software: GGE Biplot, Agrobase, R, SAS, Minitab, MSTAT-C, NTSYS, Diva-GIS IRRIStat, GenStat, and Alphagen, MapMaker, WinQTLCartographer, PopGene, PHYLIP, KIN, Genestat, GDA, PowerMarker and GenAlex, etc

AGROBIODIVERSITY COURSES ON SCHOOL EDUCATION

It's unfortunate that there are very few schools that have given emphasized on agriculture and agrobiodiversity similar to other compulsory courses like English, Science, Mathematics at the school levels in Nepal. The first school was established in 1853 in Nepal, however, it was not open for the public. Almost after a century, the agriculture education was started as the 'School of Agriculture' to generate the low level technical manpower 'Junior Technical Assistants (JTAs)' in 1957 under the Ministry of Agriculture. Later, the school was upgraded to College of Agriculture and the courses on agriculture was moved to the Council for Technical Education and Vocational Training (CTEVT) as equivalent to higher education in 1989 under the Technical and Vocational Education and Training (TVET). The TVET is committed to develop skillful and competent technical human resources including through diploma, technical SLC and short-term vocational training in different sectors including agriculture (Paudel et al 2013).

Agricultural education should be constantly changing in Nepal based on the rapid advancements in agricultural technologies and the emerged issues and challenges including insects, pests, diseases and also climate change. However, it is realized that more emphasis given on the higher agricultural education than that of school level education. There are some technical schools and polytechnics that offer the short and long term training courses on agriculture and related fields. But so far no specific focus or course on agrobiodiversity is found at the school level. However, it is being prioritized in schools recently. The government has given emphasis recently on agriculture curriculum as compulsory course in grade 9 and 10, which used to be optional course in the past (Paudel et al 2013). They further reported that the curriculum in schools have given more priorities on practical (60%) that theory (40%). Some of the schools have established the field genebank and diversity blocks and demonstration plots. Furthermore, the students also directly participated in agrobiodiversity conservation and management such as biodiversity fair, community biodiversity register (CBR) among others.

COURSES ON AGROBIODIVERSITY IN HIGHER EDUCATION

Many universities in developed countries have specialized courses on agrobiodiversity. Most of these universities have focused on agrobiodiversity conservation and management in developing world. But, very few universities in developing countries have specifically concentrated on agrobiodiversity conservation and management. The universities in Nepal also have recently realized the importance of agrobiodiversity in the curriculum, despite the long history of curriculum on agriculture since 1957. Currently 3 universities in Nepal have started the course on agrobiodiversity. But there is no any standards and quality control mechanism and proper mechanism for periodic review and improvement of the course curriculum. It is appreciative and encouraging that these universities have started the course on agrobiodiversity, but it is very crucial to maintain the standard of the courses to meet the current needs of the country in line with international treaties and policies such as ITPGRFA and CBD. So far, it is realized that the course on 'Agrobiodiversity Management' being taught in IAAS has followed the ITPGRFA (Dangol 2008).

Table 1 has presented the courses on biodiversity or agrobiodiversity or plant genetic resources offered in undergraduate and postgraduate levels in the universities and campuses of Nepal. IAAS of TU has already introduced courses on agrobiodiversity (course title: Agrobiodiversity Management) for undergraduate program with 30 lectures (1+1) including theory and practical. AFU has also offered "Agrobiodiversity conservation and climate change" course for undergraduate level and has 10 lectures for agrobiodiversity course (AFU 2072). Only IAAS and AFU have offered specific course on agrobiodiversity, but other universities and campuses have introduced biodiversity in general (IOF 2000, KU 2000). However, Central Department of Botany (CDB) has also offered a two lecture on agrobiodiversity under the course title "Biodiversity and Biogeography" for the Master degree on Biodiversity and Environmental Management. Mahendra Ratna Multiple Campus (MRMC) of Ilam and Himalayan College of Applied Sciences and Technology (HICAST) have offered "Plant Genetic Resources Management" and "Plant Genetic Resources and Biodiversity Conservation" for undergraduate students, respectively.

Agrobiodiversity is an emerging area of learning. The universities and campuses play crucial roles in developing human resources in agriculture and agrobiodiversity to conserve, manage and use agrobiodiversity, to develop new knowledge and technology through research and outreach activities. Some universities have started the courses already as in the case of Nepal, whereas others are in the process of developing new courses (Rudebjer et al 2011). They further emphasized that the higher education in agriculture is crucial for strengthening human skills and capacities and knowledge generation for the societal development, which has led to achieving the United Nations Millennium Development Goals of poverty alleviation, food security and improved health, nutrition and environmental sustainability. It is found the number of universities in Africa, Latin America and Asia-Pacific have offered the courses on agrobiodiversity, however, it is not offered as the full program at any level in Africa. Likewise, there is no any dedicated course on agrobiodiversity in Latin America. In case of Asia, very few universities have specific courses on agrobiodiversity though many of agricultural universities offered 1-2 courses on plant genetic resources. Most of these courses are enrolled by the students of plant breeding, seed technology, botany and natural sciences. However, number of students enrolling is generally declining over the years (Bioversity International 2009). In addition, many institutions of higher agricultural education have crucial roles in implementing and expanding the agrobiodiversity agenda through capacity development and knowledge generation and sharing by organizing trainings, seminars, conferences and developing knowledge platforms etc (Rudebjer et al 2011).

HISTORY OF AGROBIODIVERITY IN EDUCATION SYSTEM

Despite long history of agriculture education in Nepal, agrobiodiversity education has very short history of almost a decade in Nepalese context. IAAS under the TU first started the course on agrobiodiversity management under the elective of Conservation Ecology in BSc Ag Course in 2004. Prior to enroll the students in this course, series of discussions and consultations were made with the experts, related agencies to finalized and approved by the subject matter committee in the University. There were 12 students in the first batch studying this course. Later the HICAST of PU, AFU and Mahendra Ratna Campus of Ilam also started the courses on agrobiodiversity and related topics (**Table** 1).

Table 1. Universities, their program, course titles and credit hours and type of courses on biodiversity and agrobiodiversity

Name of university	Program	Course title	Credit hours	Course type
Tribhuvan University				
IAAS	BSc Ag	Biotechnology and Biodiversity	2(1+1)	Core
	BSc Ag	Agrobiodiversity Management	2(1+1)	Core
	MSc Ag	Biodiversity Management	3(2+1)	Core
MRMC, Ilam	BSc Horticulture	Plant Genetic Resource Management	3(2+1)	Core
IOF	BSc	Biodiversity Conservation and Ecotourism	2 (2+0)	Core
	MSc	Biodiversity Conservation and Protected Area Management	2 (2+0)	Core
IOST	BSc	Biodiversity		
CDB	MSc Botany	Plant systematics and Biodiversity		Elective
	MSc Biodiversity and Environment Management	Biodiversity and Biogeography	8 ECTS	Core
Kathmandu University				
	BSc Environment Science	Biodiversity	3	Core
Purbanchal University				
HICAST	BSc Ag (honors)	Plant Genetic Resources and Biodiversity Conservation	3(3+0)	Core
Agriculture and Forestry University				
AFU	BSc Fisheries	Introductory Biotechnology and Biodiversity	2(2+0)	Core
	BSc Fisheries	Aquatic ecology and Biodiversity	2(1+1)	Core
	BSc Ag (Conservation Ecology)	Agrobiodiversity conservation and climate change	2(2+0)	Core
	MSc Ag (Conservation Ecology)	Biodiversity Conservation and Restoration	2(2+0)	Core

AGROBIODIVERSITY COURSES ON NON-EDUCATION SYSTEM

The CTEVT is a national autonomous body for vocational education and training in Nepal. Under this, Diploma, technical SLC and other short term vocational trainings are provided in agriculture, health, engineering and others. Many students don't want to return to agricultural production jobs after their graduations. Thus, there is serious issue of paucity of agricultural graduates and competent human resources in agriculture sector. The non-formal agricultural education or vocational education has been producing human resources to meet the demand, though not adequate to fulfill the additional efforts for expansion. The CTEVT has the capacity of an average yearly enrollment of 13,000 students for Diploma and TSLC courses (Paudel et al 2013).

PROCESS OF CURRICULUM DEVELOPMENT IN TRIBHUVAN UNIVERSITY

The curriculum development process in IAAS, TU followed the seven consecutive steps started from the informal meetings and consultations with the faculties and students and ended with the approval of the course by the academic council (**Figure** 1). In the process of designing and implementing the course curriculum in agrobiodiversity management in IAAS under TU, the Subject Matter Committee (also known as curriculum development committee) was formed under the chairmanship of the Dean. However, the training and orientation to the faculties for effective implementation of the courses is still necessary. In addition, it is crucial to link up the courses to national agriculture development process such as National Agriculture Development institutions such as Ministry of Agricultural Development (MoAD), NARC and other research and development institutions.

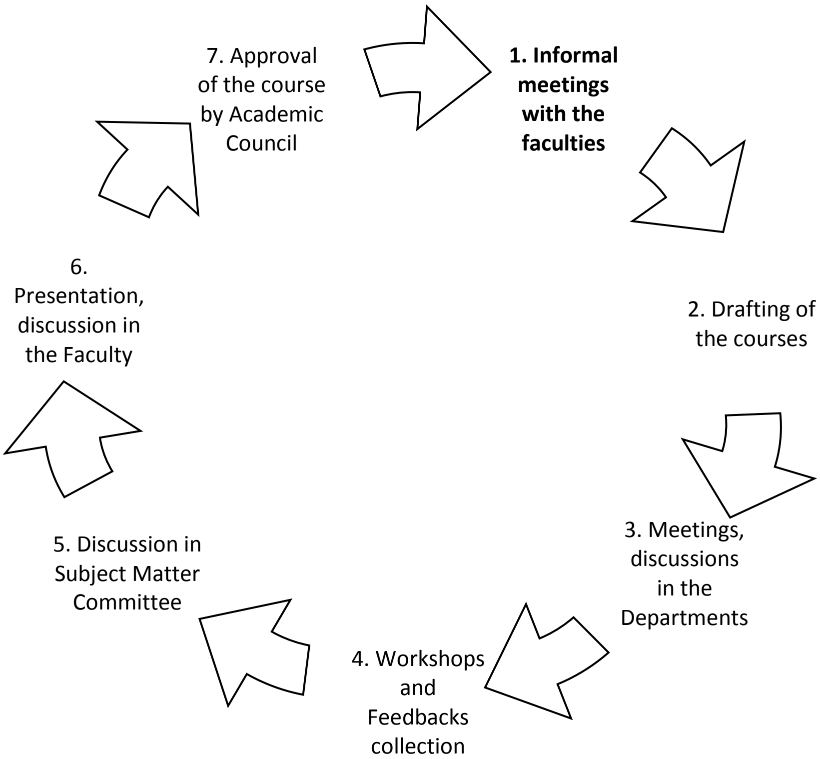

Figure 1. Flow chart of the process of curriculum development in Tribhuvan University.

1. Consultation with the Faculties, Students and other Stakeholders

The consultations for the curriculum began with the informal meetings with the faculties, students and other stakeholders to identify the need of the course on 'Agrobiodiversity' and its contents. Furthermore, the experts from NARC, government and non-government organizations were also consulted in the process.

2. Drafting the Course

The IAAS course bulletins were reviewed prior to draft the course. A course was drafted considering the IAAS course bulletin and incorporating the suggestions and feedbacks of the faculties, students, stakeholders. Additionally, the suggestions and comments of the experts were also incorporated and shared in the workshops and meetings that the author(s) had participated.

3. Discussion in the Meetings of Departments

The draft course was also discussed with the faculties and students of the Department of Environmental Science and other related departments of IAAS. Based on the suggestions and comments, the course was revised.

4. Workshop for Sharing and Feedback

A workshop was organized on 26 December 2008 for collecting feedbacks on the draft course on agrobiodiversity management. The workshop was attended by the participants from IAAS (Dean, Assistant Deans, faculties and students), executive director, coordinators and staffs of Local Initiatives for Biodiversity, Research and Development (LI-BIRD), executive director of Ecological Services Centre, Forum for Rural Welfare on Agricultural Reform and Development (FORWARD), NARC, District Agriculture Development Office (DADO), Farmers and Journalists and discussed thoroughly and recommended the course (Dangol 2008).

5. Discussion in Subject Matter Committee

The recommended course (Agrobiodiversity Management) by the workshop was discussed in the Subject Matter Committee of Agriculture Environmental Science and decided to recommend the course to the Faculty Board of TU. The course was submitted by the chairperson of the Subject Matter Committee to the secretary of the Faculty Board.

6. Presentation and Discussion in Faculty Board

The Faculty Board put this course as an agenda with other agendas to discuss on its importance in the present context of agricultural education in Nepal and the faculty board decided to submit the course to the Academic Council of TU.

7. Approval from Academic Council

The Academic Council approved the course to offer as a course of Bachelor Degree Agriculture Program of the Institute of Agriculture and Animal Science under TU. Later, the course on biodiversity management was approved for the masters with series of discussions and consultations with the experts, faculties and stakeholders. The Masters curriculum is broader as compared to the undergraduate. In fact, it should be more specific to agrobiodiversity conservation and management.

ACHIEVEMENTS

Development of Course Curriculum

A course curriculum was developed and approved by the faculty board, which is the highest body of TU. The course has theory and practical classes with 2 credit hours and 50 marks. Number of students has taken this course, especially the students under the BSc Ag Conservation Ecology. All the students who have enrolled this course were excited to learn the course which was different than the regular courses offered in the institute. Additionally, the students have got additional exposure on the concept of agrobiodiversity, component and state of agrobiodiversity management including documentation and conservation of agrobiodiversity and policies, laws and international mechanisms on agrobiodiversity. The detail of the course is given below (Table 2).

Table 2. The detail course on agrobiodiversity management in IAAS, TU

Course Code : **ACM**

Course Title : **Agrobiodiversity Management**

Credit Hours : **2 (1+1)** **Full Marks: 50** **Theory: 25** **Practical: 25**

I. SYLLABUS

Concepts, aims, scopes and research trends. Classification, diversity, and distribution of agrobiodiversity with special reference to Nepal. Understanding centers of crop and animal genetic resources, causes and consequences of loss of agrobiodiversity, traditional uses and value addition. Current national policy and international conventions and treaties on conservation and management of agrobiodiversity, Agrobiodiversity prospecting, intellectual property rights (IPRs), plant breeders' rights and farmers' rights on crop and animal genetic resources.

II. COURSE OUTLINE

A. Lectures

Unit	Topic	Lecture, n
1	**Introduction to agricultural biodiversity**	**1**
1.1	Concepts, history, importance and prospects of agricultural biodiversity	
1.2	Centers of origin of crop and animal diversity	
1.3	Research and development in agricultural biodiversity	
2	**Components of agricultural biodiversity**	**3**
2.1	Plant genetic resources: Crops and their relatives	
2.2	Animal genetic resources: Livestock and their relatives	
2.3	Aquatic genetic resources	
2.4	Soil flora and fauna diversity for soil fertility management	
2.5	Species of ecosystem services related to agricultural production, e.g. bees, silkworms and butterflies	
2.6	Pests (weeds, insect pests, fungal pathogen, bacteria, viruses and nematodes)	
2.7	Agro-forestry resources	
3.	**State of agricultural biodiversity management**	**2**
3.1	Present status of agricultural biodiversity conservation and utilization in Nepal	
3.2	Trend of agricultural biodiversity management	
4	**Documenting and assessing uses and threats of agricultural biodiversity**	**3**
4.1	Methods and advances in documentation of genetic resources, traditional knowledge and practices (Community Biodiversity Register - CBR, Biodiversity Fair)	
4.2	Assessment of genetic resources (Four cell analysis, ecological foot print etc.)	
4.3	Emerging threats to agriculture biodiversity and key measures to reduce the threats (Biotic, abiotic, climate change, socio-political, institutions)	

5	**Conserving and managing agricultural biodiversity**	**3**
5.1	Concept and theory of conservation and management of biological resources	
5.2	Strategies for conservation and utilization of agricultural biodiversity (Economical and socio-cultural value based)	
5.3	Approaches for conservation and utilization of agricultural biodiversity (In-situ, Ex-situ, On-farm methods, through CBM approach)	
5.4	Value addition of agriculture biodiversity through breeding and non-breeding: market methods, linking with tourism	
6.	**Policies, laws and institutional mechanisms**	**3**
6.1	Global Plans/Strategies, Legal Instruments and Institutions (with special reference to CBD, ITPGRFA, WTO/TRIPS, WIPO, ILO 169).	
6.2	Regional Cooperation on Agriculture Biodiversity Conservation and Development (with special reference to SAARC)	
6.3	National Policies and Laws on Agriculture Biodiversity Conservation and Development (with special reference to CBD, ITPGRFA, WTO/TRIPS, WIPO, ILO 169)	
6.4	Implementation Challenges for Intellectual Property Rights and the Rights of Local, Indigenous and Farming Communities (corporate-led vs. community-led agriculture biodiversity management)	
6.5	Institutional Framework for the Effective Implementation of Policies and Laws in Nepal (with special reference to Govt., community and other institutions, including NGOs and Media)	
	Total:	15

B. Practical

SN	Topic	Practical, n
1	Documentation of indigenous knowledge on agrobiodiversity of home gardens of a locality to know about the community biodiversity register	2
2	Assessment of the genetic resources by four cell analysis method	2
3	Study of the genetic resources displayed in Biodiversity Fair in campus periphery or Local Knowledge and Innovation Resource Centre	2
4	Seed collection and display in seed bank of Local Knowledge and Innovation Resource Centre	3
5	Study of on-farm conservation and management practices of agrobiodiversity in national research organizations near to campus	3
6	Case studies (key methods): Field Gene Bank, Community Seed Bank, Cryopreservation of plant and animal genetic resources, Eco-farm park	3
	Total	15

CHALLENGES OF AGROBIODIVERSITY EDUCATION

1. Insufficient Educational Resources and Academic Researches

The educational resources currently available in the universities and colleges are not sufficient for teaching and learning agrobiodiversity courses. Academic institutions need to collect teaching resources such as books, reports, thesis copies, scientific papers, museum specimens, computers, overheads, slide projectors, posters, TV, etc. The resources can be collected from different organizations working in agrobiodiversity in Nepal and in abroad. Rudebjer et al (2011) have also emphasized on importance of mobilizing the resources in order to support the integration of agrobiodiversity in higher education because there are issues of limited financial resources, learning resources, unclear policies on agrobiodiversity and lack of infrastructures for teaching and learning process.

2. Lack of Research Funds and Limited Academic Researches

Very few academic researches have been conducted concentrating the agrobiodiversity by the academic and research institutions. However, some of the civil society organizations have focused on the research and development activities focusing on agrobiodiversity management. The faculty and students require research fund to generate new knowledge on agrobiodiversity through research. Academic institutions have not allocated the any research fund specifically for agrobiodiversity research and development activities for the faculties and students.

3. Lack of Trained Human Resources

As this subject is new in academic institutions, there is lack of trained human resources. University teachers, who are responsible for teaching agrobiodiversity, need refresher training to update on recent advancement in the biodiversity education and research in Nepal and also in the world. They need to participate in training, seminars, workshops and conferences to update on the subject matter. Rudebjer et al (2011) also highlighted the lack of human capacity and expertise in agrobiodiversity among the teaching staff. Furthermore, the process has tendency to emphasize on teaching rather than facilitating learning.

4. Weak Networking and Partnership Development

There is a big gap in communication and networking of the academia with research and developmental organizations. This gap in networking and communication is hindering in sharing information among teaching and research organizations and enhancing network with different organizations for partnership building and cooperation to enhance participatory research on agrobiodiversity. Consequently, recent developments in biodiversity studies are unable to channelize from teachers to students.

5. Key Challenges and Issues

The courses being taught in the universities and campuses are mostly the conventional courses. It is comparatively easy to develop and offered the new courses in private universities/campuses than the public universities/campuses. Furthermore, the agricultural education is beyond the accessibility and affordability of the poor, marginalized and backward communities. Chaudhary and Pasa (2015) gave strong emphasis on enhancing the accessibility and affordability of these people in agricultural education opportunities which is very crucial to meet the national demands of agricultural production and transformation. It is also important to mobilize the agricultural graduates in the remote areas and encourage the business sectors to invest in agriculture sector and food security.

Rudebjer et al (2011) also highlighted the similar issues and challenges in mainstreaming agrobiodiversity education such as lack of capacities of the teachers, clarity on the concept, weak networking and partnerships, lack of resources for integration etc. The courses in agrobiodiversity are not visible in most of the universities and limited awareness on the subject among the faculties and students. They further added that the integration of the course on agrobiodiversity into curricula depends on the capacity of the teachers and existing situation of the universities.

CREATING OPPURTUNITIES FOR AGROBIODIVERSITY EDUCATION

Realizing the importance of agrobiodiversity, academic institutions in Nepal have initiated teaching agrobiodiversity, especially in higher agriculture education. These academic institutions need to strengthen the capacities of teachers and departments for providing quality education and research in agrobiodiversity courses offered. They need to convert challenges into opportunities by (1) strengthening capacity of institutions and faculties in teaching and research on agrobiodiversity, (2) developing national and international collaboration and cooperation for quality agrobiodiversity education and research programs, (2) guiding MSc/PhD students' thesis research, and (3) raising research fund for teachers and students to conduct research. Universities also need organize regular consultations, interactions and scientific events in collaboration and cooperation with national/international universities, governmental organizations, NGO partners and need to encourage university teachers/students to present their research finding in the meetings or seminars. Collaborative research projects can be developed jointly for seeking fund for generating research data and teaching resources, which can be directly used in classroom and field teaching. There is opportunity of partnership development for agrobiodiversity education among IAAS, LIBIRD, NARC, International Plant Genetic Resource Institute (IPGRI), Bioversity international, Wageningen University and other organizations.

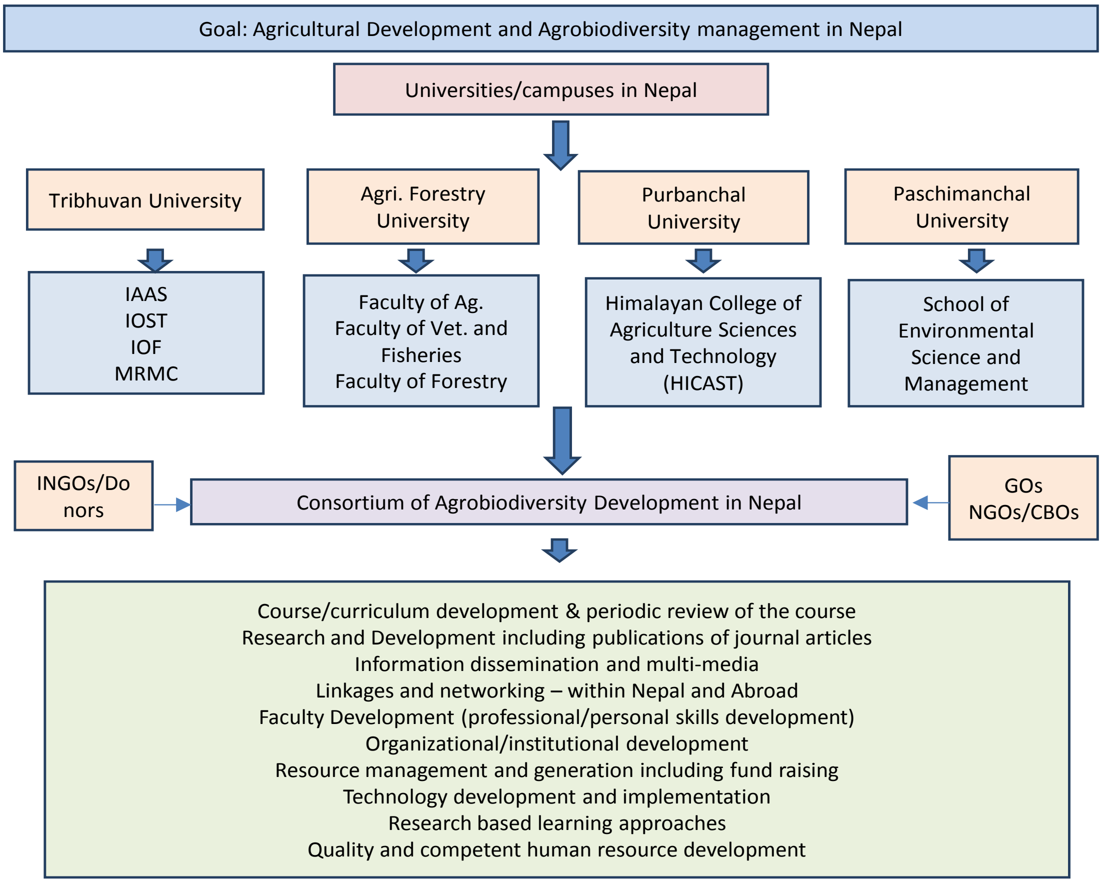

Figure 2. Proposed institutional framework for development and promotion of agrobiodiversity education in Nepal.

Agricultural development is crucial to boost up the livelihood of the farming communities in Nepal (Chaudhary and Pasa 2015). In order to effectively turn the challenges into the opportunities and teaching agrobiodiversity education and overall agricultural development in Nepal, the Institutional framework and effective collaboration among the universities, research institutions and development partners is needed. It would be basically the consortium of the academic institutions and concerned stakeholders for the development and promotion of agrobiodiversity in Nepal (Figure 2).

CONCLUSION AND WAY FORWARD

The course on agrobiodiversity has been offered in some of the universities in Nepal especially TU, AFU and HICAST of PU. However, these courses are still not visible and not given high importance like other main courses in the respective universities. Based on the current situation of the agriculture such as loss and shrinkage of agricultural diversity, change in land use, habitat loss etc, the course curriculum on agrobiodiversity is enormously important to generate the experienced and knowledgeable human resources on agriculture and agrobiodiversity in particular with practical, field based knowledge and research experiences. These courses are at different states of implementation and enrollment in these universities. It is not straight forward to offer and enroll the course on agrobiodiversity. It has many seen and unforeseen issue and challenges in terms of its implementation such as lack of trained human resources and other resources including research fund, lack of proper networking and collaboration etc. However, there are many possibilities of promotion, development and integration of this course in the universities and develop the competent human resources to fulfill the present needs and demands on agriculture sector. It is definitely required to continuous revise of the course on periodic basis and to extend the networking and collaboration with like-minded organizations including civil society organizations at national and international levels including the universities. Based on the study and analysis, the authors believe that the universities and campuses that have offered the agrobiodiversity course curriculum need to concentrate on following areas for the improvement in agrobiodiversity courses in Nepalese context.

- Review the courses in line with international treaties and agreements on agrobiodiversity and also integrating International Treaty on Plant Genetic Resources on Food and Agriculture
- Build capacity of institutions and faculties on concentrating on personal, professional, organizational

and technical capacities and competencies to deliver the courses effectively

- Establish basket research fund to encourage faculties and students on agrobiodiversity research and generate new in depth and practical field based knowledge
- Organize regular seminars/training workshops at national and international levels particularly focusing on agrobiodiversity, conservation and management in the context of changing climate and governance
- Build networks among individuals and organizations for effective collaboration on agrobiodiversity education at the national and international levels

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Diversity and Utilization Status of Cereals and Pseudo-cereals in Nepal

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ABSTRACT

Cereals and pseudo-cereals are the primary carbohydrate supplier for the world's human population. Nearly half of the annual cereal production is used for human food and also serve as the primary food for dairy animals and poultry birds. Rice, wheat and maize alone provide nearly 60 percent of the world's food energy. Cereals are members of the grass family (Gramineae) that are grown for their edible starchy seeds while pseudo-cereals are grown for the same purpose, but are not members of the grass family. Several gluten-free grains exist, such as the pseudo-cereals amaranth and buckwheat that are commonly grown in Nepal. Cereal crops, rice/paddy (*Oryza sativa* L.), maize/ corn (*Zea mays* L.), wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), naked barley (*Hordeum vulgare* var. *nudum* (L.) Hook.f.) account for about 42.5, 25.4, 22.6 and 1.2% of the total area under food grains, respectively. Similarly, their respective contribution in national food security is 44, 25.8, 25.1 and 0.2% respectively. The extent of variation in morphological and physiological features within *Oryza sativa* is greater than in any other cereal. Nepal is one of the centers of origin and diversity for Asian rice. Rice is grown up to 3050 m altitude in Chhumjul, Jumla, which is the highest elevation of rice growing areas in the world. At least 4 species of wild rice named *Oryza nivara* S.D.Sharma & Shastry, *Oryza rufipogon* Griff., *Oryza granulata* Nees & Arn. ex Watt and *Oryza officinalis* Wall. ex Watt, two wild relatives, *Hygroryza aristata* (Retz.) Nees ex Wight & Arn. and *leersia hexandra* Sw. and several types of weedy rice *Oryza sativa* f. *spontanea* Roshev. exist in the Himalayan country. Recent quest of high protein content wheat landrace "Naphal" from northern hills has shown milestone for richness in wheat diversity in Nepal. Similarly, diversity in maize is also noteworthy. The variations in grain color, husk cover, maturity, adaptative trait to intercropping etc are observed in farmers grown varieties. Barley and naked barley have also wide range of diversity in terms of maturity, grain color, adaptation into different environments. Wild relatives of naked barley have been also reported from Rasuwa district. Two cultivated common species of buckwheat in Nepal are *Fagopyrum esculetum* Moench and Tartary Buckwheat (*Fagopyrum tataricum* (L.) Gaertn.) which are the staple and life supporting crops in the remote food deficit areas of Nepal. Apart this, there exist many wild species of Buckwheat in Nepal. It possesses high nutritional and medicinal values and is used as a raw material in preparation of different health foods. However, buckwheat has been an underexploited and poor peoples' crop in Nepal. This pseudo-cereal generally receives low inputs and poor management and is grown traditionally only when some lands remain fallow after millet transplanting. Buckwheat is an important crop of mountainous regions of Nepal and plays a major role in food security. Grain amaranth is one of the food crops in Nepal. This is cultivated mainly in the western dry hills. Some species are found all over the country as wild and/ or weed. Some of the grain amaranths and many wild types are used as vegetables in Nepal are Prince's Feather (*Amaranthus hypochondriacus* L.), Blood/ Red Amaranth (*Amaranthus cruentus* L.), Green- Pigweed/ Amaranth (*Amaranthus gracilis* Desf.), Prickly amaranth (*Amaranthus spinosus* L.), Foxtail Amaranth (*Amaranthus caudatus* L.), Chinese spinach (*Amarranthus viridis* L.). There is still high scope of exploring new landraces with unique traits of cereals and pseudo cereals including their wild form in remote hills and Tarai of Nepal. Genotyping and phenotyping of all important cereals and pseudo cereals with all possible traits need urgent attention. Utilization of Nepalese AGRFA through breeding is of greater importance for future food security and addressing climate resilience.

Keywords: Cereals, conservation, food and nutrition security, pseudo cereals, use of APGRs, wild relatives

INTRODUCTION

Cereals and pseudo-cereals are the primary carbohydrate supplier for the world's human population. Nearly half of the annual cereal production is used for human food and also serve as the primary food for dairy animals and poultry birds. Rice, wheat and maize alone provide nearly 60 percent of the world's food energy (FAO 2011). Cereal crops, rice/paddy (*Oryza sativa* L.), maize/ corn (*Zea mays* L.), wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), naked barley (*Hordeum vulgare* var. *nudum* (L.) Hook.f.) account for about 42.5, 25.4, 22.6 and 1.2% of the total area under food grains, respectively. Similarly, their respective contribution in national food security is 44, 25.8, 25.1 and 0.2% respectively (MoAD 2013).

Pseudo-cereals frequently have a unique amino acid profile and can be used to supplement cereals for a more balanced amino acid diet. Starch, the primary constituent of cereal grains, breaks down in the digestive tract into simpler and more easily digested sugars to supply the body with its primary source of energy. While varying in oil percentage, the oil plays a significant role in total energy supply in the diet and some varieties have been selected with amounts adequate for processing and selling as vegetable oil.

While rich in thiamine, riboflavin, niacin, and pantothenic acid, the cereals do not meet all of the vitamin and mineral requirements for food or feed. Frequently foods and feeds that are used to supplement these needs are considered more important than the cereals themselves, but as a proportion of total food and feed consumed, none come close. The role of fiber in the diet has recently been studied extensively and has altered somewhat the thought on the value of the seed coat, which contains the highest portion. This portion is also high in vitamins and minerals and many recipes have been altered to include higher proportions of whole grain or bran to take advantage of the health benefits.

Cereals and pseudo-cereals are not often used as human food without some preparation to convert them to a more edible and digestible form. Modern processing methods utilize grains to produce everything from tortillas to macaroni, as well as breakfast food, flour, bread, and vegetable spreads. Historical milestones on conservation of Nepalese APGRs are documented by Joshi (2017a). Utilization of local landraces in breeding program is very low (Joshi 2017c), however different breeding methods and tools have been adopted by different institutes to improve cereals and pseudo cereals in Nepal (Joshi 2017c).

CEREAL CROPS

Rice, wheat, maize, barley including naked barley and their wild form fall under Monocotyledonae class and are the members of the grass family Poaceae that are grown for their edible starchy seeds and are the main energy suppliers for global population. Cereals are the most important group of agricultural crops in Nepal. Initial development of cereal plants involves seminal roots that vary from three to eight in number. They arise directly from the hypocotyl. Further plant development includes the development of a second set of roots which are permanent and arise from the point just a little below the surface of the ground. These roots are fibrous rather than tap and are noted for their ability to control soil erosion through an extensive network of root hairs. They extend outward and downward in all directions from the crown, providing the primary nutrition for the plants. The grain is produced on a spikelet that varies significantly from corn to wheat to millet in size, shape, and appearance. Most of the Nepalese people's livelihood depends on cereals. Seventeen species of cereals are found in different parts of Nepal. All months we can observe some kinds of cereals in some places. Within a species many landraces support the diverse needs of farmers and consumers. **Table** 1 shows the list of cereals and pseudo cereals commonly found in Nepal and **Table** 2 indicates the diversity of cereals and pseudo cereals into different agroecozones (physiographic regions). The contribution of cereals and pseudo cereals in Nepal's food security is given in **Table** 3 and conservation status in National Genebank is given in **Table** 4.

Table 1. Cereals and pseudo cereal species commonly grown in Nepal

SN	Common name	Nepali and other names	Scientific name	Remarks
1.	Amaranthus	लट्टे, लुडें, मार्से, रामदाना		Pseudo cereals
2.	Barley	जौ, यव (संस्कृत)	Hordeum vulgare L., 2n=2x=16	
3.	Bread wheat	गहुँ, गेहुँ, गोधुमा (संस्कृत)	Triticum aestivum L., 2n=6x=42	
4.	Common buckwheat	फापर, मिठे फापर, वोगले	Fagopyrum esculetum Moench	Pseudo cereals
5.	Dent corn	दाँते मकै	Zea mays var. *indentata* (Sturtev.) L.H.Bailey	
6.	Durum wheat	सुजि/ मेकारोनी गहुँ	Triticum turgidum L., 2n=4x= 28	
7.	Flint corn	पहेलो/सेतो मकै	Zea mays var. *indurata* (Sturtev.) L.H.Bailey	
8.	Maize/ Corn	मकै, घोगा	Zea mays L., 2n=2x=20	
9.	Naked barley	उवा, करू	Hordeum vulgare var. *nudum* (L.) Hook. f. 2n=2x=14	
10.	Pod corn	काली मकै	Zea mays var. *tunicata* A.St.Hil.	
11.	Pop corn	पप कर्न	Zea mays var. *everta* (Sturtev.) L.H.Bailey	

SN	Common name	Nepali and other names	Scientific name	Remarks
12.	Rice/Paddy	धान (बोक्रा सहित) धान्यम् (संस्कृत), चावल, चामल	Oryza sativa L., 2n=2x=24	
13.	Six rowed Barler	छ हारे जौ	Hordeum hexastichon L.	
14.	Sweet corn	गुलियो मकै	Zea mays var. *saccharata* (Sturtev.) L.H.Bailey	
15.	Tartary Buckwheat	तिते फापर	Fagopyrum tataricum (L.) Gaertn.	Pseudo cereals
16.	Two rowed Barley	दुइ हारे जौ	Hordeum distichon L.	

Table 2. Cereals and Pseudo cereals diversity in major physiographic regions of Nepal

Agroecozone	Climate	Cereals and pseudo cereals
Tarai	Hot, humid	Rice, Wheat, Maize, Barley, Amaranth, and common Buckwheat
Mid Hill	Cool, humid Cool, dry	Rice, Wheat, Maize, Amaranth, Common buckwheat and Barley
High Hill	Cool, humid Cool, dry	Tartary buckwheat, Naked barley, Amaranth and cold tolerant rice

Table 3. Contribution of cereals and pseudo cereals in country's food security (in %)

Physiographic region	Rice	Maize	Wheat	Barley	Buckwheat	Amaranth
Mountain	22.0	44.9	15.5	1.3	✓	✓
Hill	26.7	47.7	16.2	0,2	✓	✓
Tarai	59.7	7.0	33.0	-	✓	✓
Total	44.0	25.8	25.1	0.2	-	-

Source: MoAD 2011.

Table 4. Conservation status of cereals and pseudo cereals at the National Genebank

Crop	Accessions at NAGRC
Rice	2300
Maize	520
Wheat	1700
Barley including naked barley	1230
Amaranth	250
Buckwheat	230

Rice Diversity

It is here in the Nepalese Himalayas where unique high elevation traditional rice varieties (*Oryza sativa*) are grown at the world's highest elevations, at 3,050 m, containing cold tolerance traits that are recognized globally. There are 23 species of rice, out of these, 21 are wild type and two species are cultivated. Vavilov pointed out that the origin of the present rice is in the South East Himalayan Region. Many different types, variety, forms and different quality of rice plants are found in South East Asia, India, China, Indochina and Nepal. Yoshida (1978) determined that the center of variation in rice exists in Nepal, Bhutan, Laos, Veitnam, India and Yunnan province of China. Kihara (1953) found Japonica rice in High Hill, Javonica rice in Mid Hill and Indica rice in Tarai areas of Nepal. Rice samples of 500 years ago are found at Simaraungarh of Bara district of Nepal. Therefore, Nepal is one of the origin places of rice. Different forms of Nepalese rice in term of maturity and cultivation domain are early rice, late maturity rice, upland rice, deep water and floating rice, Indica type, Japonica type and Javanica type (**Figure** 1) (Joshi and Bimb 2004). Nepal is considered to be one of the countries of origin of rice in South Asia (NRRP 1997). Its description is found in the Veda and other Nepalese literature written in 1500 BC. Due to the original home of cultivated rice, a lot of diversity exists all over the rice growing areas (**Figure** 2). Different kinds of landraces and wild rice in Nepal are reported by Sherchand et al (1998), Mallick (1981), Adhikari et al (1995), Shrestha and Upadhyay (1999) and Gupta et al (2000). About 2000 different landraces are under cultivation.

A fascinating diversity of rice growing environments is prevalent in Nepalese agriculture. Five major rice growing environments are existed based to source of irrigation. These are early rice with assured irrigation, main rice with partial or full irrigation, high altitude rice with rainfed or partial irrigation, upland rice with total rainfed and submerged deep water rice. High altitude and upland rice are stress tolerant genotypes genetically structured to suit the location specific stress for water and chilling weather in mountains. Joshi (2017b) has described diversity on local rice landraces in terms of different aspects.

Figure 1. Rice landrace diversity in Nepal.

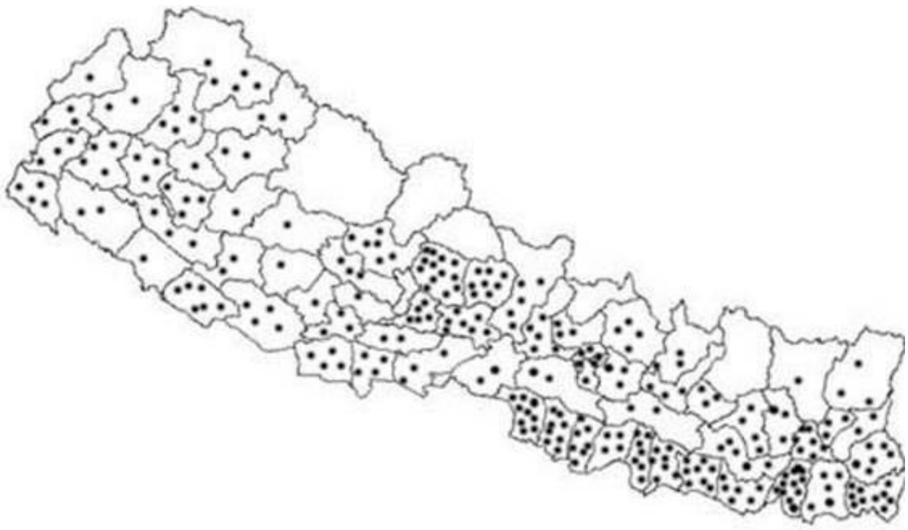

Figure 2. Rice diversity map of Nepal. Distribution of rice diversity (more the number of dots more the diversity).
Adopted from Joshi 2003.

The cultivation and diversity of rice in Nepal is unique being grown across the agro-ecosystems from Foot Hill to High Hill. The co-existence of four wild rice species (*Oryza nivara; Oryza rufipogan; Oryza granulata; Oryza officinalis*) and wild relatives (*Hygroryza aristata* (Retz.) Nees ex Wight & Arn. and *Leersia hexandra* Sw.) (**Table** 5) and cultivation of tremendous traditional varieties on-farm in the form of landraces states the existing of a high degree of genetic diversity and constitutes an important gene pool for rice research integration (Shrestha and Vaughan 1989, Upadhyay 1995). Except Manag and Mustang, rice cultivation is practiced in all 73 districts of Nepal (Joshi 2015). Kaski district is rich in rice diversity (**Table** 6) howerver, many rice landraces are either extinct or endangered (**Table** 7).

Four wild rice spices, *Oryza nivara*, *Oryza rufipogan*, *Oryza granulata* and *Oryza officinalis* are found in different areas of Nepal (Joshi 2004, 2005). Some of these areas are Ghodagodhi Tal, Ajigara Tal, Lothar, Jhapa, Illam, Sundarpur, Surkhet, Nijgada, Janakpur, Nepalgungj, Bara, Dang, Kapilbastu, Rupendehi, Birendranagar, Kaski, Palpa, Banke, Bardiya, Kancanpur etc. Weedy rice, *Oryza sativa* f. *spontanea* Roshev. is found in rice field across the country (**Figure** 3). *Hygroryza aristata* (Retz.) Nees ex Wight & Arn. and *Leersia hexandra* Sw. are other two species in related genera found in Nepal. These species are adapted to different ecological conditions in terms of height and water requirements, and distributed across the Tarai. Only weedy rice was found in the Mid and High Hills and valley. *Oryza rufipogan*, one of the natural parents of the present day cultivated rice is reported to have found in the northern most limit and the highest altitude in Nepal in the world. This extraordinary biological diversity in Nepal is due to geological and cultural factors. Nepal was considered as area of potentially new and useful genes for rice breeders. Some of them are conserved in IRRI, the Philippines and in National Genebank, Khumaltar. Diversity also exists in released rice varieties based on their ancestors used (Joshi 2006).

Figure 3. Distribution of wild rice and related species in Nepal.
Adopted from Joshi 2015.

Diverse cultural values of rice in Nepal also indicate the center of diversity for rice gene pool. Wild rice grain is also considered to have religious significance and is sold at 6 times higher price than cultivated rice grain. It is used as offering deities at Tij festival. It is also commonly sold as the purest offer for gods in Nepal. Local people use wild species as special food during religious ceremony and fodder to livestock.

Table 5. Wild rice and wild relatives of rice and their distribution in Nepal

SN	Local name	Wild /relative	Distribution
1		*Oryza nivara* S.D.Sharma & Shastry	Banke, Kapilbastu, Lumbini, Bardiya, Kailali, Kanchanpur, Kaski, Dang, Rupandehi
2	Nabo ghans, Anga	*Oryza rufipogon* Griff. (*Oryza perennis* Moench)	Banke, Kapilbastu, Kailali, Kanchanpur, Surkhet, Kaski, Palpa, Rupendehi, Dang
3	Ban dhan, Jangali dhan, Sitarani dhan	*Oryza granulata* Nees & Arn. ex Watt	Chitwan, Jhapa, Ilam, Makawanpur
4		*Oryza officinalis* Wall. ex Watt	Kancahnpur, Bara, Janakpur
5	Navo, Thima, Jara	*Oryza sativa* f. *spontanea* Roshev. (weedy rice)	Rupandehi, Kapilbastu, Banke, Bardiya, Kanchanpur, Lamjung
6		*Hygroryza aristata* (Retz.) Nees ex Wight & Arn.	Kaski, Kailali, Kathmandu
7		*Leersia hexandra* Sw.	Kaski, Lamjung

Source: Joshi 2015.

Table 6. Status of rice landraces in Seti river valley

Widely grown landraces	Landraces under threat	Landraces lost over time
Jethobudho	Pakhe jhinuwa	Thimaha
Gurdi	Basaune jhinuwa	Tauli
Aanadi	Bayarni	Darmali
Panhele	Panhele jhinuwa	Germani
Gayria	Marshi	Koili
Biramphool	Gudura	Budho thakale
Ramani	Bardani	Ghote
Mansara	Batti sara	

Widely grown landraces	Landraces under threat	Landraces lost over time
Aanpjhutte	Pokhreli jhinuwa	Jhauri
Jerneli	Pagate jhinuwa	Thapachinia
Khaltekholo	Phante silange	Bhamgera
	Salidhan	

Source: FAO 2008.

Table 7. Endangered and lost rice landraces in Tarai, Inner Tarai, Mid and High Hills of Nepal

Endangered (48)	Lost (103)
Tauli, Thapachinia, Marsi, Mansara, Siraunla, Masind, Nathani, Khalte Kolo, Biramphool, Samundaphinj, Jhinuwa, Bayarni, Ramani, Pahenle Ghaiya, Bichare, Basmati, Dudhe Marange, Pakhe Masino, Sindhuli, Pakhe Sali, Jabaka, Charinangre, Pakhe Jhinuwa, Basaune Jhinuwa, Pahenle, jhinuwa, Gudura, Bardari, Battisara, Pokhreli Jhinuwa, Pagate Jhinuwa, Phente silange, Lalka Basmati, Soka, Sarho, Satraj, Lajhi, Rango, Gajargul, Ratrani, Katuash, Latongad, Masura, Dudhisaro, Lalka Kartik, Ghuthani, Anadi, Khera, Mansari and Anga	Lahure Sahila, Gori Sahila, Makar Kandhu, Timaha, Darmali, Germani, Koili, Budho thakale, Ghote, Jhauri, Bhamger, Lalka Pharam, Lajhi, Lohasaran, Parewa Pankha, Handiphul, Karma, Golabachhi, Dudhi Kariya, Bachhi, Devsar, Dudhraj, Sikhichanda, Galphuli Dutha, Rjana, Madhukari, Habsa, Ratin, Bansbarcli, Kanakjira, Ramjamai, Ratan, Tulasiprasad, Mahajogi, Ramini Katika, Sankharika, Sokan, Baramphusi, Ghiukumari, Manshara, Satraj, Barkhabahadur, Pokhraj, Sankharika, Gondan, Maturi, Bhulani, Kuriya, Surkamiti, Satraj, Najhi, Golarato, Rajala, Megadoot, Dudhraj, Maturi, Parweapankhe, Kariyakamod, Gaddar, Kanajira, Babadudhi, Bhulani, Barkha Bahadur, Nakhi, Karma, Rati, Horinlduri, Gokulchanda, Maturi, Jhali, Gangaur, Dhudi, Katausi, Tulsi Prasad, Kanakjira, Gokulchan, Sukhichand, Pakhar, Bansnareli, Karma, Silan, Akhidudhi, Jhabri, Jajagaur, Satawa, Bangaluwa, Dudhisaro, Borch Bahadur, Mutari, Amaghaur, Barbasaru, Jhali, Mashura, Gokhul, Handa, Kudiya, Ramjamai, Kasturi, Dudha Kariya, Satariya, Changol, Golabati, Madhusar, Manshari

Source: Joshi 2015.

Uniqueness of Rice Landraces

Nepal has unique advantage from the viewpoint of the native landraces of rice. Probably, rice is thought to have originated in eastern Nepal or adjacent areas in the eastern Himalayas. These races exhibit a wide range of variability in terms of morphogenic traits and adaptation to various environments. Some of the most important traits are 1. Growth duration-two to seven months, 2. Photo period-non-sensitive to highly sensitive, 3. Plant type-completely closed at maturity to fully exerted, 4. Grain type-very fine to coarse (Mallick 1981). Nepal has early rice, main season rice, winter rice, high altitude rice, upland rice and deep-water rice. Rice has been adapted from the low tropical areas of the Tarai to the temperate high lands of Western Nepal. While most of the rice cultivation is done under lowland (wetland) conditions, many upland (dry land) types are also found throughout the country. A broad spectrum of resistance to various diseases and insects has been observed in the collections of Nepalese rice including resistance to bacterial blight, brown plant hopper and green leafhopper. Many aromatic rice are distributed from 100 to 1400 m altitude.

Gamadi, a native rice cultivar from Nepal in which the panicle remains enclosed within its flag leaf sheath up to maturity, was genetically studied (Heu and Shrestha 1986). Gamadiness is controlled by two complementary dominant genes and these genes have been proposed as *"Ga"* and *"Gb"* and found to be linked with the neck leaf gene (*nl*) of Takahashi's linkage group VI+IX. An opaque endosperm with about 10% amylose content was found in an *indica* cultivar, Pokhareli Machino from Nepal (Heu and Kim 1989). Heu et al (1987) reported that the multiple pistil originating from Double Rice is identical to those of Nepali varieties Laila Majanu and Sautenia Dhan, and is linked with the *la* (laziness) gene of linkage group VIII.

Oryza nivara from Nepal was found very distinct and considered as discrete genetic entity by Banaticla-Hilario et al (2013). *Oryza nivara* (IRGC93198) from Nepal was also found resistance to brown plant hopper (Sarao et al 2016). Some *Oryza* Nepalese rice landraces have been used in breeding globally (Joshi et al 2017a). Some of the unique landraces of rice found in Nepal are shown in **Table** 8. Released and registered varieties are listed in Joshi et al (2017c).

Table 8. Some unique landraces of rice

Landrace	Uniqueness
Gamadi	Short duration, Panicle matured within flag leaf
Mansara	Adopted to very marginalized land
Bhati	Deep water rice
Pakhe Masino, Makar Kandhu	Hiunde (winter) rice
Ekle rice	Zn deficiency tolerance

Landrace	Uniqueness
Jumli Marshi	Cold tolerant
Amaghauj	Multiple spikelets per node
Kalo nimak, Salidhan, Jetho budho, Kariya kamod, Gauria, Kasturi, Tulsi Prasad, Rajbhog, Biramphool etc	Aromatic rice

Source: Joshi et al 2013b, Joshi 2015, 2004, 2005.

Maize Diversity

Present maize is originated from a natural cross of Teosente and Tuxpano, two wild relatives of Maize abundantly found in Mexico. In Nepal maize is said to be introduced at the beginning of 15th Century during Jagat Jyoti Malla's time (Gurung 2012). Since its introduction lot of diversity among different local populations has been created. The stage of 75% silking varies in local collections from 55-70 days with an average of 61-65 days. The most common grain type is semi-flint (in 70% of the collections), followed by flint (25% of the collection) and semi dent (5% of the collection). Grain color varies from yellow to white and blue to black. Other characters such as ear size and plant height vary considerably. Different types of maize found in Nepal are given in **Table** 9. Joshi et al (2017c) has listed all released and registered varieties of maize.

Table 9. Types of maize varieties found in Nepal

Common name	Nepali name	Scientific name
Maize/Corn	मकै, घोगा	Zea mays L. 2n=2x=20
Flint corn	पहेलो/सेतो मकै	Z. mays var. *indurata* (Sturtev.) L.H.Bailey
Dent corn	दाँते मकै	Z. mays var. *indentata* (Sturtev.) L.H.Bailey
Sweet corn	गुलियो मकै	Zea mays var. *saccharata* (Sturtev.) L.H.Bailey
Pop corn	पप कर्न	Zea mays var. *everta* (Sturtev.) L.H.Bailey
Pod Corn	काली मकै	Z. mays var. *tunicata* A.St.Hil

Maize Landrace Diversity

Major features found within maize are white grain type, yellow grain type, tall plant/short plant type, husk cover, cob placement, maturity (short/late type), semi flint type to flint type some dent type, black grain type (कालो मकै) kande makai (काँडे मकै (मुस्तांग), pani makai (पानी मकै), etc.

Wheat Diversity

Wheat is believed to have originated in southwestern Asia called Fertile Crescent. Some of the earliest remains of the crop have been found in Syria, Jordan, and Turkey. Cultivation of wheat began to spread beyond the Fertile Crescent after about 8000 BC. Primitive relatives of present day wheat have been discovered in some of the oldest excavations of the world in eastern Iraq, which date back 9,000 years. Other archeological findings show that bread wheat was grown in the Nile Valley about 5,000 BC as well as in India, China, and even England at about the same time. Man has depended upon the wheat plant for himself and his beasts for thousands of years (Gibson and Benson 2002). The natural evolution of hexaploid wheat has been considered about 10,000 to 12,000 years ago (Bhatta 2012). The modern semi-dwarf wheat plant was possible with the introduction and interrogation of Noren 10 (Rht 1 and Rht 2) dwarfing genes from Japan which was derived from a Japanese dwarf wheat called Daruma. The maximum diversity of hexaploid wheat and its ancestors are present in Turkey, Tunisia, and eastern Iraq. However, China, India, Russia, USA, Canada, Australia, Argentina and EU are the major centers of domestication. Wheat diversity has been extensively studied and utilized in modern wheat plant. In Nepal following two species are under cultivation.

Common name	Nepali name	Scientific name
Bread Wheat	गहुँ, गौं, गेहु, गोधुमा (संस्कृत)	Triticum aestivum L. (Hexaploid) 2n=6x=42
Durum wheat	सुजि/ मेकारोनी गहुँ	Triticum turgidum L. (Tetraploid) 2n=4x=28

Bread wheat cultivation in Nepal prior to 1900 was confined to far and Mid Western Hills of Nepal. The exact date of the entry of these tall wheat varieties in that area is not known, however, wheat is said to be introduced somewhere during sixteen to seventh century in Far Western Nepal from India. Many of these landraces are still grown by farmers of the area. These wheat landraces have wide range of natural adaptation to withstand varied abiotic and biotic stresses. In addition, these landraces have high tillering ability, withstand severe drought stress, high protein content such as in Naphal (**Figure** 4) and longer seed dormancy. These are purely spring bread wheat. Some landraces with winter growth type have been reported in the northern high mountain area bordering to Tibet China. Since these landraces are adapted to a small confined area and wheat was considered a minor cereal until the middle of 20th century, there was no any attempt to improve these landraces and also the production practices. These landraces are generally grown under marginal lands under rainfed and low fertility conditions. At present we estimate about 5% of Nepal's total wheat area is covered by these local landraces. **Figure** 5 showed the distribution of wheat landraces in Nepal. National Genbank has maintained 1700 of such landraces and improved version of wheat germplasm collected during 1950s. Morphological variation exists in Nepalese wheat landraces and ancestors from different countries were used to develop modern wheat varieties in Nepal (Joshi et al 2001).

Major Traits of Nepalese Wheat Landraces

Major traits of local landraces are tall types, long coleoptile, awned, awnless, white grain type, red grain type, longer dormancy, drought tolerant, good chapatti taste (softness), high protein content (eg Naphal) and susceptible to rusts diseases.

Figure 4. Naphal, a Nepalese winter wheat landrace, rich in protein content recently collected and maintained at NAGRC.

Figure 5. Distribution of Nepalese wheat landraces (number of red dots directly proportional to the diversity of wheat). *Adopted from Joshi et al 2013a.*

Nepal has also many landraces of wheat which are mainly being cultivated and maintained in western Nepal (Joshi et al 2006). Cultivated landraces of spring and winter type, wild relatives of wheat with diploid species have been reported in Nepal (Mudwari 1999). Most of the improved wheat varieties were developed CIMMYT germplasm and originated in Mexico and India. Almost all improved wheat varieties developed in Nepal contain CIMMYT/Mexican and Indian blood in their pedigree. List of released varieties of wheat are available at http://agrobiodiversityplatform.org/cropbiodiversity/files/2017/03/Variety-Catalogue-Ebook.pdf. Some of the uniqueness landraces are given below.

Some unique wheat landraces

Naphal	High protein content and drought tolerant
Mudule	Sweet and soft chapatti, drought tolerant
Dabde local	Drought tolerant
Lumle local	Black chaff, drought and shattering tolerant

Wild Relatives of Wheat

Wild relatives of wheat in Nepal (Mudwari 1999) are *Aegilops exaltata* L., *Agropyron canaliculatum* Nevski, *Agropyron flexuosissimum* Nevski, *Agropyron longiaristatum* (Boiss.) Boiss., *Agropyron microlepis* Melderis, *Agropyron nepalense* Melderis, *Agropyron schrenkianum* (Fisch. & C.A. Mey.) Drobow, *Agropyron semicostatum* Nees ex Steud., *Agropyron sikkimense* Melderis and *Agropyron thomsonii* Hook.f.

Barley Diversity

Barley (*Hordeum vulgare* L.) is a winter cereal grown from Tarai, up to an elevation of 4000 m in Nepal. In Mid and High Hills of Nepal, it is the staple food crop grown in different cropping patterns in both Khet (irrigated) and Bari (non-irrigated) lands. Barley grows in the harsh environment of low soil fertility, low input and varied agro-ecological conditions in High Hills of Nepal, and where exclusively the endemic landraces dominate its cultivation (**Figure** 6). The area devoted to barley crop is decling compared to previous years. During 1995/96, barley was grown in about 39000 ha but in 2010 it occupied only 26600 ha (MoAC 2010). Nacked barley (*Hordeum vulgare* var. nudum) occupies about 12557 ha (47% of the total barley area) with the production of 13021 mt (47.2% of the total barley production) in mountain agroecosystem contributing significantly in livelihood of the people living there (**Figure** 6). Barley is valued by the farmers in these areas because it can be grown as a winter crop, maturing approximately one month earlier than wheat, thus allowing time to plant a summer crop such as maize, rice or buckwheat after barley. The crop is important in highest elevations, where experience an alpine climate, barley is grown as spring planted crop, taking up to ten months to mature. Diversity at species level are:

Common name	Nepali name	Scientific name
Barley	जौ, यव (संस्कृत)	Hordeum vulgare L. diploid, 2n=2x=16
Naked Barley	उवा, करू	Hordeum vulgare var. *nudum* (L.) Hook.f. 2n=2x=14
Six Rowed Barley	छ लाइन जौ	Hordeum hexastichon (L.) Asch.
Two Rowed Barley	दुइ लाइन जौ	Hordeum distichon L.

The historic literature shows cultivated barley (*Hordeum vulgare* L.) was domesticated from its wild relative, *Hordeum spontaneum* K.Koch, in around 1000 BC in Himalayas where a good diversified domesticated barley landraces could be found (Azhaguvel and Komatsuda 2007, Hadado et al 2009). However, the centre of origin and location of domestication of cultivated barley has still been the subject of vigorous scientific disputes (Yang et al 1987, von Bothmer et al 2003). Globally it is an important model crop and many studies on its genetic and phylogeny has been undertaken.

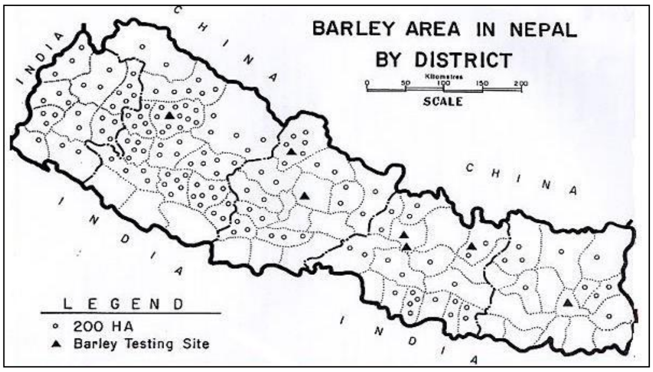

Figure 6. Distribution and testing sites of barley landraces based to field survey carried in different agro-ecosystems and districts.

Intra Specific Diversity

A large number of barley plant accessions from all over the world have been saved in genebanks for future use. These collections have been reported predominantly comprised of landrace forms. Barley being an inbreeding plant, the landrace accessions of these collections were reported genetically heterogenous comprised of inbreeding lines and hybrid segregates generated by a low level of outcrossing (Nevo 1992). Nepal is considered as a center of diversity for barley (Witcombe 1975), and many studies (Takahashi et al 1968, Witcombe and Gilani 1979, and Konishi 1986) have described and classified this variation. Earlier studies on agro-morphological characteristic, traditional seed system, isozyme and SSR marker diversity on barley landraces and their explorations in the High Hills have revealed the existence of considerable diversity in barley germplasm of Nepal (Witcombe 1975, Witcombe and Gilani 1979, Bajracharya et al 2003, Gupta et al 2003, Baniya et al 2003, Joshi et al 2010, Bajracharya et al 2012).

Dynamic of local crop diversity is determined by how the interdisciplinary elements integrate. The population genetic, surrounding environments, social and indigenous knowledge and local seed system are the key elements that play on shaping diversity (Weltzein et al 1998, Brown 2000). A Similar observation on barley diversity with effect of surrounding agro-ecosystem and seed system (Ethiopia and Nepal respectively) has been reported (Hadado et al 2009, Joshi et al 2010, Bajracharya et al 2011). The total genetic diversity in these barley landrace accessions was majorly due to within the landrace variations (intra populations) and only few resided on difference between landraces (Brown and Munday 1982, Parzies et al 2000).

Chawali, Bhuwali, Lekali and *Pawai* are four farmers' varieties that are grown in a range of agroecological environments in Jumla, Nepal (2240-3000 m) (Paudel et al 1998). These landraces vary in their morphological traits, in traditional farming system, and for preferred traits and uses (Rana et al 2000). Chawali and Lekali are two common six rowed barley landraces with small to bold grains, grain color (**Figure** 7 and 8) and wide adaptation from low land to High Hills. SSR marker studies on these landrace populations detected a level of heterogeneity at intra and inter population variation among the landraces populations of individual farmer irrespective of how many barley landraces have maintained. Moreover the study also indicated that the common landrace growing in large area is always less subject to homogenising gene flow between populations than the landrace with wide adaptation (Bajracharya et al 2012).

Figure 7. Diversity in grain shape, size and color of nacked barley landraces collected from Mid and High Hills of Nepal.

Figure 8. Different traits of barley and naked barley observed in local landraces. 1230 such barley and naked barley landrace are conserved in NAGRC.

Besides, there is traditional cultivation of nacked barley (hullless barley) in high mountain regions of the country. These have been reported in historic explorations carried in high elevations. Riley and Singh (1989) observed that farmers in the mountains of both Eastern and North Western Nepal generally grow only one landrace of hullless barley commonly colled as (Uwa) and one of hulled barley (Jau) which they regard as two separate crops. Hulless barley in Eastern Nepal is generally hooded, or has reduce awns and is very early, but less frost tolerant, and more susceptible to powdery mildew and covered smut than is the hulled landrace from the same area (Riley and Singh 1989). In highest elevation areas (4000 m) a long maturing blue or black seeded hulled landrace with good winter hardiness, known as "Pawe" is grown. Genetic variation within landraces has been found to increase with altitude (Konishi 1986) with greatest within landrace variation from areas where barley is most important. Barley is an important food crop in the High Hills of Nepal. Naked barley (*Hordeum vulgare* var. *nudum* (L.) Hook.f.) Local varieties of barley are mainly distinguished by spike characters. All the collections of barley show a spring growth habit. One of the notable characteristics of High Hill varieties is the presence of non- adhering glume or huskless trait. Most of the varieties are six-rowed but there are also the intermediate types in which the lateral kernels are markedly smaller than the central one. Variation for days to 50% heading is observed when varieties are exposed to different environments. Height generally ranges from 70-115 cm. The local collections are early in maturity. Released varieties are available at http://agrobiodiversityplatform.org/cropbiodiversity/files/2017/03/Variety-Catalogue-Ebook.pdf.

Wild Relatives of Barley

The wild relatives of barley in Nepal (Baniya 1999) are 1. *Hordeum spontaneum* K.Koch, 2. *Hordeum agriocrithon* Aberg, 3. *Hordeum lagunculiforme* Bacht., 4. *Hordeum murinum* subsp. *glaucum* (steude.) Tzvelev, 5. *Hordeum murinum* subsp. Leporinum (Link) Arcang. and 6. *Hordeum bogdanii* Wilensky.

Uses

One of the common use of barley is "Sattu" in the Mid Hill and or "Tsampa" in the High Hill, where roasted grains are milled to flour and consumed by mixing with other liquid foods. In Western Hills and Mountains, barley flour is used in making chapatti (roti) and or porridge. Small quantity of barley is used for religious occassions. In some areas, barley is used as animal feed and its straw is used for animal fodder, roofing and fuel.

PSEUDO CEREALS

Buckwheat and amaranth are two of the most widely used pseudo cereals, but their production is dwarfed by the true cereals. Pseudo cereals such as buckwheat (Polygonaceae), *Amaranthus spp.* (Amaranthaceae) and quinoa (*Chenopodium* sp.) are grown for the same purpose as cereals, but are not members of the grass family. In fact these species falls under Dicotyledonae. Several gluten-free grains exist, such as the pseudo cereals amaranth and buckwheat that are commonly grown in Nepal. Neither has been the primary energy source for large regions, but both have played significant roles in food use. They both have a tap root rather than a fibrous root system and have two cotyledons rather than one as is true for the grasses. The root system consists of a tap root (central or primary root) that extends downward to a considerable distance. This root is thicker and stouter than the lateral roots that arise from it. The lateral roots may be divided several times. Under ordinary conditions buckwheat attains a height similar to wheat. Amaranth is typically twice the height of wheat, but there are some dwarf varieties that seldom grow taller than four feet. Both plants adjust themselves very efficiently to surroundings, such as fertility of soil and rate of seeding, by sending out branches from the main stem. The buckwheat kernel is in the form of an achene, being a single seed enclosed in an indehiscent pericarp that fits tightly around the seed. The achene is three angled, the angles being acute, and has the form of a pyramid with the base rounded. The hull or pericarp varies from silver gray to brown or black in color and is hard and thick, with the surface polished and shining. It separates readily from the mealy endosperm. The relatively large embryo is central, dividing the soft, white endosperm into two parts, the cotyledons being broad. The surrounding testa is membranous and light yellowish-green in color.

Buckwheat Genetic Resources

Buckwheat (*Fagopyrum esculentum* Moench and *Fagopyrum tataricum* (L.) Gaertn.) reach their highest elevations in the world here in Nepal, grown at mountain slopes at elevations reaching 3800 m and 4700 m, respectively. In the rain shadow areas, where the monsoon rain is attenuated to a three month rainy season only, farmers continue to manage a portfolio of short duration varieties to tolerate drought, including, buckwheat (*Fagopyrum esculentum* and *Fagopyrum tataricum* with *Fagopyrum cymosum* (Trevir.) Meisn. and

Fagopyrum megacarpum H.Hara as wild species) and amaranths (*Amaranthus caudatus* L. and *Amaranthus leucocarpus* S.Watson).

Buckwheat is one of the minor food crops in the temperate and hilly countries of Europe, East Asia and the Himalayan region. Two cultivated species (*Fagopyrum esculentum and Fagopyrum tataricum*) are the staple and life supporting crops in the remote food deficit areas of Nepal. Buckwheat is an important crop in terms of its adaptation to diverse climatic conditions, moisture stress regime, nutrient limitation and cool temperature and it fits well to different cropping patterns due to its short growing period. It possesses high nutritional and medicinal values and is used as a raw material in preparation of different health foods. However, buckwheat has been an underexploited and poor peoples' crop in Nepal. This pseudo cereal generally receives low inputs and poor management and is grown traditionally only when some lands remain fallow after millet transplanting. It is equally important as staple and livelihood supporting crop and valuable in terms of wide adaptation, resistant to moisture stress, nutrition limitations and cool temperature in remote hilly regions of Nepal. some traits of two species of buckwheat are given below.

English name	Nepali name	Genus/spp/subspp	Major traits
Common Buckwheat (Sweet buckwheat)	फापर, मिठे फापर (Mithe Phaper), वोगले	Fagopyrum esculentum Moench, (Syn. Fagopyrum emarginatum Moench) 2n = 2x = 16	Wide adaptation, more diversity in spp. and in food culture
Tartary buckwheat (Bitter buckwheat)	तिते फापर (Tite Phaper), भाते फापर, लेकाली फापर (Mountain Buckwheat)	Fagopyrum tataricum (L.) Gaertn., (Syn. Fagopyrum suffruticosum F.Schmidt) 2n = 2x = 16	Mostly abundant in mountains, high diversity, more nutritious, higher medicinal properties and better yield than common buckwheat

Figure 9. Distribution and cultivation of buckwheat species based on field survey.
Source: Joshi 2008, Joshi et al 2014.

Common buckwheat (*Fagopyrum esculantum* Moench), Tartary buckwheat (*Fagopyrum tataricum* (L.) Gaertn.), and their wild types *Fagopyrum cymosum* (Trevir.) Meisn., *Fagopyrum megacarpum* H.Hara and *Fagopyrum tataricum* ssp. *potanini* have been reported growing as cultivated and natural populations in Mid and High Hills in Western and Far-Western regions of the country. *Fagopyrum cymosum* (Trevir.) Meisn. is the most common wild buckwheat and believed to be the ancestor of Tartary buckwheat (Onishi and Matsuoka 1996). A good collection of these landrace and wild populations have been made during field surveys in mountainous districts: Dolakha, Kaski, Mustang, Dolpa, Jumla and Kathmandu (**Figure** 9). The diversity of buckwheat, its geographical distribution (**Figure** 10), population sizes and growing habitats have long been explored and reported, however the systematic research on collection, characterization, evaluation, documentation started only with the establishment of National Hill Crops Research Programme (NHCRP) in Nepal (Baniya 2001).

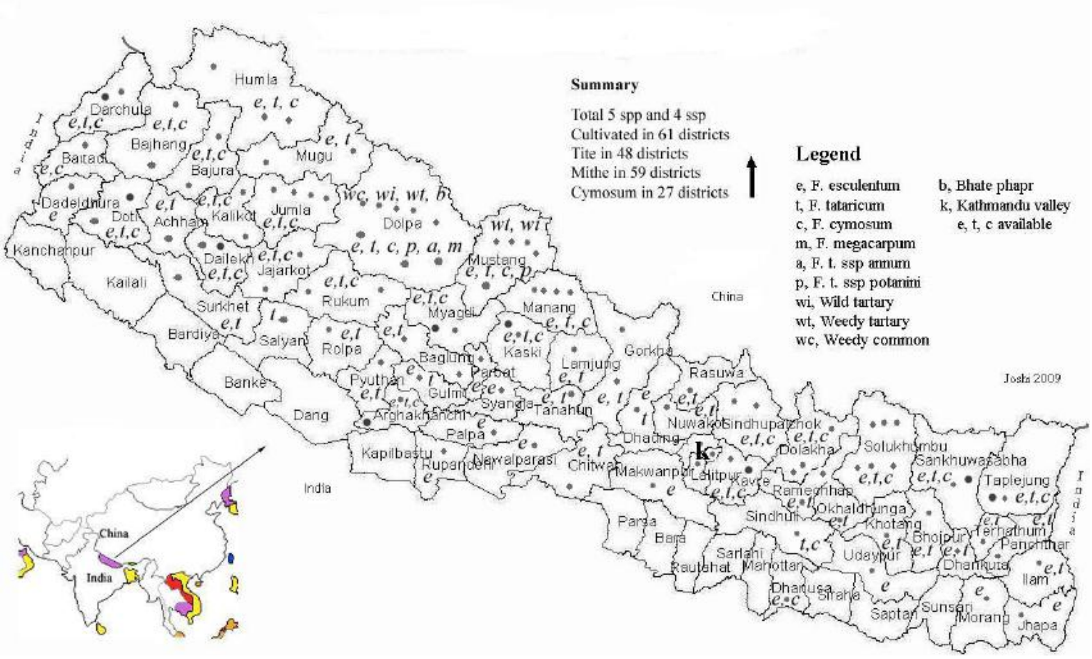

Figure 10. Distribution of buckwheat genetic resources in Nepal. District with more dots means more diversity at species, varietals and genetics levels.
Source: Joshi 2008

The available information indicates that all Nepalese common buckwheat are of autumn types, sensitive to day length, mostly with intermediate growth habit, mainly with pink or purple flowers, and red pigmented stem. The area of buckwheat stands the second position after millet but its area and production are not recorded regularly. Based on available information, buckwheat is grown in about 43000 hectares and with a total production of 23100 t (Sherchand et al 1986). The leding buckwheat growing mountain districts of Nepal are jumla (871 ha), Dolpa (594 ha), Mustang (558 ha), and Humla (450 ha). Some reports state that Chitwan disttrict alone has about 4000 ha of buckwheat area (Regmi et al 1990). In 25 districts (out of 75) of Mid and High Hills of Nepal, 4620 ha of buckwheat were found with an average yield of 772 kg/ha (Adhikary et al 1994). The buckwheat productivity in Nepal is 2 to 4 times lower as compared to other major buckwheat growing countries, ie Canada, Japan, and Russia. The realized buckwheat grain yield level goes up to 3000 kg/ha (Rajbhandari and Mishra 1990).

Table 10. Wild species of buckwheat found in Nepal

Species /subspecies	Genome	Mode of pollination	Distribution	Local name	Growth habit
Fagopyrum cymosum (Trevir.) Meisn (Syn. Fagopyrum dibotrys (D.Don) H.Hara	2n=2x, 4x=16, 32	SI + SC	Mid and High Hills	Banbhade, Dhukupa, Bhande,	Perennial
Urophyllum spp group					
Fagopyrum gracilipes (Hemsl.) Dammer	2n=4x=32	SC	East Nepal, Dolpa		Annual
Fagopyrum esculentum Moench ssp esculentum	2n=2x=16	SI	Mid and High Hills		Annual
Fagopyrum tataricum (L.) Gaertn. ssp tataricum	2n=2x=16	SC	Himalayan region		Annual
Fagopyrum tataricum ssp annum	2n=2x=16	SI	Western-North Nepal		Annual
Fagopyrum tataricum ssp potanini Batalin	2n=2x=16	SI	Western-North Nepal		Annual
Wild and weedy type					

Weedy Tartary buckwheat	SC	Western- North	Jhura	Annual
Wild Tartary buckwheat	SC	Western-North		Annual
Weedy common buckwheat	SI	Western North		Annual

Source: Joshi 2008.

Intra Specific Diversity

Many studies have been carried on diversity of cultivated and wild species (**Table** 10) of buckwheat from different parts of world. Diversity studies of buckwheat populations using phenotypes, biochemical (isozymes) and molecular (RAPD) markers show that diversity exists in Nepalese landrace populations. These variations have been reported in terms of growing seasons, cultural practices, adaptability to different growing habitats, morphological types, mode of pollination and socio-economic use values on-farm. Ujihara (1985, 1989), Ohnishi (1985, 1989), Tulachan (1989), Baniya et al (1992), Rajbhandari and Hatlay (1993), Rana and Sharma (2000), Pandey et al (2003), Joshi and Baniya (2008) evaluated the common and Tartary buckwheat landrace populations for agro-morphological variations. In their studies, a significant variation within and among species and landraces was found for most qualitative traits. Inflorescence and grain types and their color were important morphological traits useful in quantifying diversity in buckwheat (Joshi and Baniya 2006). The study also revealed that common buckwheat landraces were mostly of autumn types (Ujihara 1989) while Tartary populations were comparatively of wide adaptation and they occur in different weedy forms.

Likewise in an allozyme study on diversity of cultivated Tartary buckwheat in Jumla (3000 m) under the global project In-situ conservation of Agricultural Biodiversity, a high intra population divergence (Gst 0.227) was recorded. It indicates that the farmer's seed populations were highly diverse and the total genetic diversity was due to within population variations (77.3%) (Bajracharya et al 2001). Similarly in a study on RAPD on eight Tartary buckwheat populations from mountainous districts: Dolpa (Mid Western Nepal), Mustang (Western Nepal) and Dolkha (Central Nepal), the landrace populations from Dolpa in route to Tibet province showed the highest genetic diversity and the least in populations from Mustang (Bimb et al 2001a) and diversity was due to intra population variation. However, there was not observed the geographical groupings among the samples.

Level of genetic variation and its change over time and space; and genetic relationships among population are important information for management of APGRs in terms of conservation and utilization in crop improvement. A similar RAPD study on wild populations of *Fagopyrum cymosum* from Nepal, India and China (Yunana and Sichuan) was carried for genetic diversity, relationships among populations of different origin and monitoring of change in diversity structure of these wild populations over time. The Chinese populations exhibited a high level of divergence and distinctly grouped the Sichuan and Yunan separately. Level of genetic diversity among the Nepalese and Indian populations were found similar and grouped together. The study found the populations under study were genetically distinct from each other and grouped distantly exhibiting the geographical distribution (Bimb et al 2001a). The change in diversity structure in wild *Fagopyrum cymosum* populations over the consecutive years was noticed in the study with decrease in diversity. It could be due to the disturbances of habitats through continuous grazing, genetic erosion or growing of crops other than buckwheat (Bimb et al 2001b).

Unique Landraces and Uses

Unique landraces of buckwheat are Bhate Phaper with loose husk, Kagpani and Tatopani with the highest ruting content (Joshi 2008, 2014). Buckwheat poseesses high nutritional and medicinal values, and is used as a raw material in different health food preparations. It is one of the major food crops in High Hill of Nepal (more than 1800 m elevations) for grains and green vegetables. Unlike the other cereals, buckwheat has an excellent protein quality of 18-20 essential amino acids with biological values including lysine and tryptophan (Joshi and Paroda 1991, Dongol et al 2001). It is also used as a green manure and serves as an important ecosystem servicer as apple pollinators and in honey making (Baniya 1999). Buckwheat flour is used for chapatti preparation and other food products and consumed by diabetic patients. Buckwheat tender leaves and shoots are used as green vegetables and the straw is used for animal feed and bedding. Tartary buckwheat is used for medicinal purposes.

Amaranth Species

The earliest dating of amaranth as a domesticated grain crop comes from archaeological digs at a cave in Tehaucan, Puebla, Mexico, where seeds of *Amaranthus cruentus* L. were dated as 6,000 years old, although Sauer (1993) notes that initial domestication could have occurred much earlier and in different locations. The oldest known seeds of *Amaranthus hypochondriacus* L. appeared in the same caves about 1500 years BP, although domestication may have occurred earlier. Grain amaranth is one of the food crops in Nepal. This is cultivated mainly in the Western dry and remote High Hill areas. Some species are found all over the country as wild and/ or weed. Some of the grain amaranths and many wild types are used as vegetables in Nepal. Grain amaranth (*Amaranthus* spp.) is one of the pseudocereal like buckwheat and chenopod. Three species in the genus *Amaranthus* are cultivated and they are called as 'grain amaranths' (*Amaranthus caudatus* L.; *Amaranthus cruentus* L. and *Amaranthus hypochondriacus* L.) and one wild vegetable crop (*Amaranthus hybridus* L.) (**Table** 11). These species are respectively associated with parental wild types: *Amaranthus quitensis* Kunth and *Amaranthus powellii* S.Watson (Popa et al 2010). All these species have a large terminal inflorescence producing numerous edible seeds. *Amaranthus hypochondriacus* and *Amaranthus cruentus* were domesticated in Central America and *Amaranthus caudatus* L. was in South America.

Table 11. Species of amaranths available in Nepal

SN	Common name	Nepali names (रामदाना, लट्टे, मार्से, लुडें, बेथु)	Scientific name	Image
1	Prince's Feather	दाना लट्टे	Amaranthus hypochondriacus L. (Grain amaranth)	
2	Blood/ Red-Amaranth	रातो लट्टे	Amaranthus cruentus L.	
3	Green-Pigweed/ Amaranth	हरियो लट्टे	Amaranthus gracilis Desf.	
4	Foxtail Amaranth	झुले लट्ट	Amaranthus caudatus L.	
5	Prickly amaranth	बन लुडें	Amaranthus spinosus L.	
6	Chinese spinach	लुडें	Amarranthus viridis L.	

Source: Joshi et al 2017b.

Wild Relatives of Amaranths

Wild species reported in Nepal (Baniya 1999) are *Amaranthus lividus* L.; *Amaranthus quitensis* Kunth; *Amaranthus oleraceus* L.; *Amaranthus polygamus* L.; *Amaranthus viridis* L.; *Amaranthus retroflexus* L.; *Amaranthus hybridus* L.; *Amaranthus spinosus* L.; *Amaranthus hybridus* subsp. *cruentus* (L.) Thell; *Amaranthus hybridus* subsp. hypochondriacus (L.) Thell.

Grain amaranths in these days are cultivated sporadically in Asia espicially in the countries on the southern slope of the Himalayas where there is diversity in topography, climate and agro-ecology (Nemato et al 1998). There are many landraces under cultivation in these regions. Nepal being located in the centre of the Himalayas all these three species *Amaranthus hypochondriacus* L., *Amaranthus caudatus* L. and *Amaranthus cruentus* L. are found under wide cultivation as pseudo cereal and edible vegetables in mountainous areas (Nemato et al 1998). However, it is one of the minor food crops grown intensively in remote Western High Hilly areas of Nepal where experiences a chronic food shortages. Few scattered fields of amaranthus are also found in upland condition in other parts of Nepal. A limited information are available on genetic studies on grain amaranths but a pioneering work on grain amaranths has been undertaken in NHCRP, Kabre, Dolakha (Baniya et al 1992). A good collection, evaluation, documentation and utilization of grain amaraths germplasm have carried out by NHCRP in 1984 and 1986 and these collections represents the altitude ranges from 500 m to 3000 m across the regions from East to Far West of Nepal (Nemato et al 1998). The **Figure** 11 shows the field surveys carried out by NHCRP in collaboration with IBPGR, Rome (at present it is Bioversity International); IBPGR/USDA; Shinchu university, Japan. The area and production figures of grain amaranth are not available, but Sherchand et al 1986 had estimated about 8250 ha of area with 7000 tons of production.

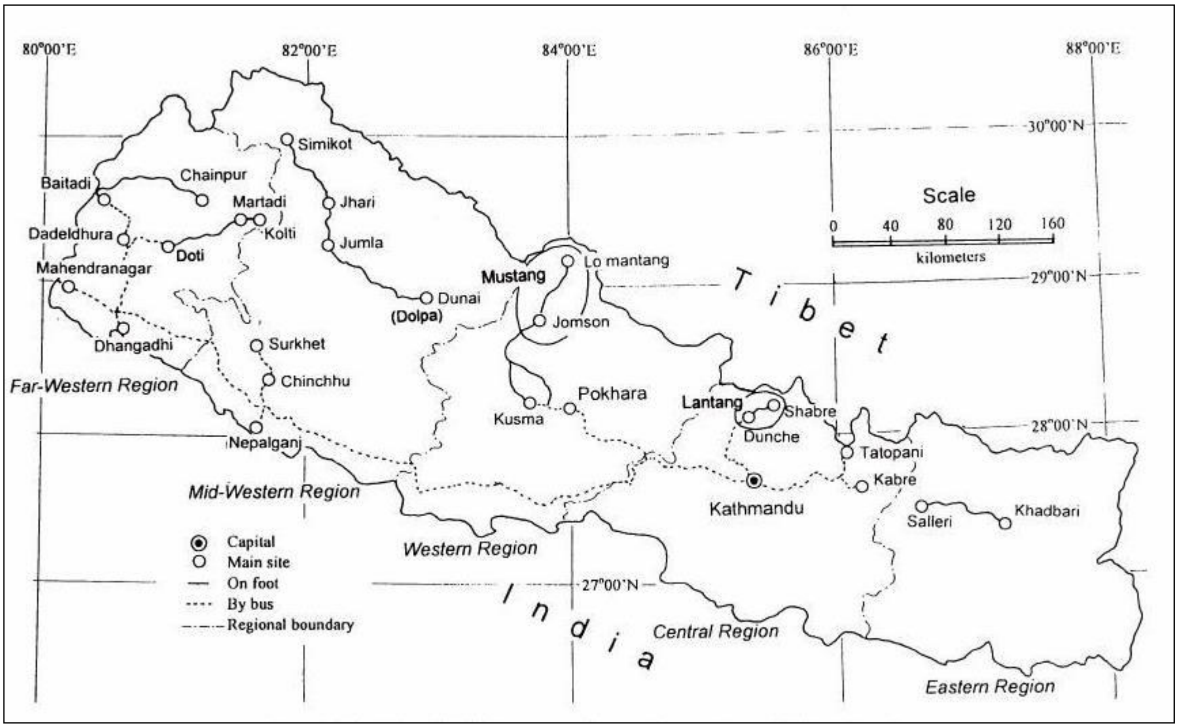

Figure 11. Distribution of grain amaranths and field surveys carried across the Mid and High Hills of Nepal.
Source: Nemato et al 1998.

Genetic Diversity

Information on cultivation, phylogeny and genetic studies in grain amaranths are very limited. However, the earlier studies and field surveys, respective collections and evaluation of amaranth germplasm has shown the existence of wide variations within and between the species under cultivation in Nepal. These variations were observed in days to heading, flowering, plant height, size, shape and colour of inflorescence and seed characters (**Figure** 12). Highland varieties (2500 m from Mustang, western district) were observed early in heading than the varieties from lowland (105 m in Tarai zone) (Nemato et al 1998). Similarly a variously colored inflorescence were reported in *Amaranthus hypochondriacus* and purple red dominated other colour ranges. While only the red and white colored inflorescence were reported in *Amaranthus caudatus.* In seed characters, the former species found widely varied in seed coat colour and starch types where as the latter exhibited variation only on seed coat color and they were of non waxy starch type (**Table** 12). A wide variation for these seed traits in *Amaranthus hypochondriacus* were reported in the collections of germplasm from Langtang valley (Sainju 1989, Sakamoto 1982). The Nepalese germplasm along with germplasms from India, Pakistan, Srilanka, Bhutan, Myanmar, Thialand, China and New World have been used in the academic studies in Shinshu the university and they have been analysed in detail for the geographical distribution and relationships among these genotypes using the RAPD data (Nemato et al 1997).

Table 12. Variation and distribution of seed coat color and seed storage starch in grain amaranths collected during field survey across the developmental regions of Nepal.

Region	Sample No.	*Amaranthus hypochondriacus* L.				Sample No.	*Amaranthus caudatus* L.		
		White		Dark brown			Red	White	Dark brown
		Waxy	Non waxy	Waxy	Non waxy		Non waxy	Non waxy	Non waxy
Far Western	56	70.5	0.3	29.1	0.1				
Mid Western	41	58.8	0.3	19.5	6.2	13	15.2	2.0	2.0
Western	12	72.9	0.1	19.8		1	7.2		
Central	22	68.1	1.8	0.6		5	29.5		
Eastern	10	64.0	5.0	31.0					

Source: Nemato et al 1998.

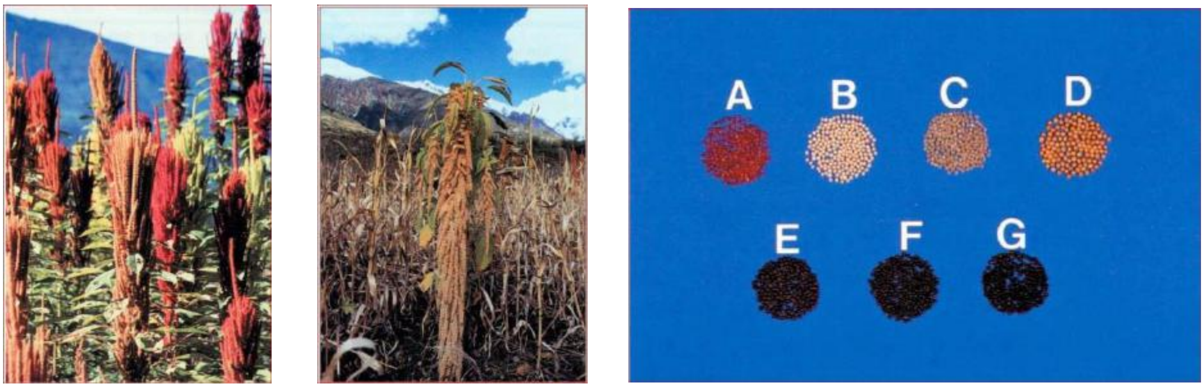

Figure 12. Variations in color, type and size of inflorescences and in seed coat and texture of grain amaranths from left to right: *Amaranthus hypochondriacus* (erect and red); *Amaranthus caudatus* (dropping and creamy white); seed coat color variations for these two species.
Source: Nemato et al 1998.

Uses

Various preparations are made locally using grains and leafy parts of the amaranths. The white grains are popped and utilized in various forms as mixed with tea or with milk and sugar called kheer, in the form of sweet pudding locally called *haluwa*. Even the flour of the grains is used in preparation of breads called *chapatties*, mixed with sugar the flour to make the sweet balla called *laddoo*. Some of these preparations are used as the religious foods being used during fasting days with nutritive values. The tender parts of this crop is also used as green vegetable. A favourite preparation of white grain amaranth with commercial value in local market is the *latteppa* which is made with popped grain mixed with liquid sweeten to form small balls (**Figure** 13).

Figure 13. Preparation of snacks using the white grain amaranths mixed with sugar syrup called as 'Laddoo or latteppa' and green shoots are used as leafy vegetables.
Source: Nemato et al 1998.

WAY FORWARD

- Finger print preparation of conserved APGRs is of utmost importance
- Globally demanded, highly nutritious, medicinal and climate resilience "Buckwheat" so called (Kuanna) must get national priority in research and development (FSF)
- Need to revisit endangered and lost list of APGRs
- Landrace enhancement activities in all APGRs
- Except rice, there is poor utilization of landraces in plant breeding. Pre-breeding initiatives need to be started soon

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Diversity and Utilization Status of Millets Genetic Resources in Nepal

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ABSTRACT
Millet is the group of small seeded cereal crops. Major millets grown in Nepal are finger millet [*Eleusine coracana* (L.) Gaertn.], proso millet [*Panicum miliaceum* L.] and foxtail millet [*Setaria italica* (L.) P.Beauv.]. Besides, barn yard millet [*Echinochloa frumentacea* Link], sorghum [*Sorghum bicolor* (L.) Moench], pearl millet [*Pennisetum typhoides* (Burm.f.) Stapf & C.E.Hubb.Hubb.] etc are also grown. *Eleusine indica* (L.) Gaertn. and *Eleusine africana* Kenn.-O'Byrne are the two wild forms that have been reported their existence in Nepal. Millets are under-utilized but important food crops for rural poor farming communities living under subsistence and marginal environments in the Hills of Nepal. They are also known as Himalayan Super-foods due to their nutrient-dense nature. Five varieties of finger millets namely Okhle-1, Dalle-1, Kabre kodo-1, Kabre kodo-2 and Sailung kodo-1 have been released so far from Hill Crops Research Program (HCRP) but no varieties of other millet species have been released in the country. Finger millet is the 4th most important crop of Nepal after rice, maize and wheat in terms of area and production and it occupies an average of 7.9% (268,050 ha) of the total area covered by cereal crops and accounts for 3.3% (308,488 mt) of total cereal production. Major finger millet producing districts of the country are Khotang, Sindhupalchok, Baglung, Syangja, Kaski, Gorkha and Sindhuli. National Agriculture Genetic Resources Centre (NAGRC) holds more than 850 finger millet genetic resources in medium and long-term conservation. Less utilization of local genetic resources conserved in genebank for crop improvement program is evident due to lack of information about the desirable accessions in the genebank resulting from the poor characterization and evaluation data. Great intra-specific diversity has been observed in finger millet. Proso millet has two popular types of landraces: Dudhe and Hade. Nepali genebank holds 51 accessions of proso millet, 55 accessions of foxtail millet, 15 accessions of sorghum, 2 accessions of barn yard millet, 1 accession of pearl millet and 3 accessions of kodo millet. Foxtail millet has higher intra-specific diversity than proso millet as studied by national genebank. Proso millet is grown mainly in Karnali region but cultivation of foxtail millet is found across High Hill of the country. However, sorghum, barn yard millet and pearl millet are grown in small areas and have less economic contribution to the country. In the context of climate change, millets are the crops of the future with great potentiality to cope with food insecurity not only within the country but also for the hungry world. Priority should be given on research and promotion of other millet species such as foxtail millet and proso millet for food and nutrition security of mountain region.

Keywords: Conservation, diversity, genetic resources, landraces, millets

INTRODUCTION
Millet is an important group of small seeded cereal crops. Millets are the member of grass family and native of Africa and Asia. Millets are well known for their wide adaptability to diverse but adverse agro-ecological environments in the world. This group of crops do well in low fertile and low input management condition and possess good nutritional values. Therefore, millets are the important plant genetic resources available at field level as source of food for the rural poor farming communities residing in arid, infertile and marginal lands and as the units to address and cope the unpredictable climate conditions, desertification process and socio-economic marginalisation. It is a unique component of agricultural biodiversity and comprises a group of important crop species (Upadhyay and Joshi 2003). In the context of climate change, millets are the crops of the future with great potentiality to cope with food insecurity not only within the country but also for the hungry world.

MILLET SPECIES DIVERSITY
Finger millet is the first important crop among the millets in Nepal in terms of area and production followed by proso millet and foxtail millet. Sorghum, barn yard millet, pearl millet, little millet and kodo millet are the other crops that have been reported to be grown in parts and parcels of the country (**Table** 1). Besides the cultivated species, few wild species related to cultivated millets also found in Nepal (**Table** 2).

Table 1. Cultivated species of millets grown in Nepal

SN	Crop	Nepali name	Scientific name	Distribution
1.	Finger millet/African millet/Bird's foot millet	कोदो (Kodo)	Eleusine coracana (L.) Gaertn.	Across the country. Mainly: Khotang, Baglung, Sindhupalchok, Sindhuli, Kaski, Gorkha, Syangja
2.	Foxtail/Italian/Hungarian/ Siberian/German millet	कागुनो/काउनो (Kaguno)	Setaria italica (L.) P.Beauv.	Mugu, Kalikot, Humla, Jumla, Bajhang, Bajura, Dolpa, Lamjung, Gorkha, Ramechhap, Kavre
3.	Proso/Broom corn/ Common/Hug/Russian/ Indian/Hershey millet	चिनो/चिनु (Chino)	Panicum miliaceum L.	Mugu, Dolpa, Humla, Jumla, Kalikot, Bajura, Jajarkot
4.	Sorghum/Great millet	जुनेलो/ज्वार/जुनेली मकै (Junelo)	Sorghum bicolor (L.) Moench	Across Mid Hill and across Tarai, small area
5.	Barn yard/Japanese/ Sanwa millet	सामा/साँवा (Sama)	Echinochloa frumentacea Link	Gorkha, Lamjung, Far Western Region
6.	Pearl millet/Bajra	बाजरा/घोगे (Bajra)	Pennisetum typhoides (Burm.f.) Stapf & C.E.Hubb.	Rerely found in Nuwakot and Far Western Tarai
7.	Little millet	कुट्की सामा (Kutki sama)	Panicum miliare Lam.	Rarely found in Far Western Region
8.	Kodo millet	धान कोदो/कोदी (Kodi)	Paspalum scrobiculatum L.	Gorkha, Lamjung, Tanahun, Dhading

Table 2. Wild species of millets found in Nepal

SN	Crop	Nepali name	Scientific name	Distribution
1.	Finger millet/Crab's grass	दांदे/कोदे झार (Kode/dande)	Eleusine indica (L.) Gaertn.	Across the country
2.	Finger millet		Eleusine africana Kenn.-O'Byrne	
3.	Pearl millet		Panicum orientale (Rich.) Willd	
4.	Foxtail millet	कुकुर बन्सो (Kukur banso)	Setaria sp.	Across the Hills

Finger Millet

Finger millet [*Eleusine coracana* (L.) Gaertn.] is a tetraploid (2n=4x=36 AABB) species evolved from the natural crossing of *Eleusine indica* (AA) x *Eleusine floccifolia* or *Eleusine tristachya* (BB). It was originated about 5000 years ago in east Africa (possibly Ethiopia) and was introduced into India, 3000 years ago (Upadhyaya et al 2006). It is cultivated for human consumption in East Africa and South Asia. It is an important food crop in the lives of some of the poorest inhabitants. Major countries growing finger millet in Asia are India, Myanmar, Nepal, Sri Lanka, China and Japan whereas in Africa are Uganda, Tanzania, Kenya, Ethiopia, Rwanda, Zaire, Eritrea and Somalia (Upadhyaya et al 2010). Precise data of area and production under finger millet in many countries is not known because the production statistics of this crop had often been clubbed with other millets. The Consultative Group on International Agricultural Research (CGIAR) has estimated that 10% of the area under millets is with finger millet. Nutritionally, its importance is well recognized because of its high content of calcium (0.38%), dietary fiber (3.6%) and phenolic compounds (0.3–3%) (Devi et al 2014). The crop offers several health benefits such as anti-diabetic, anti-tumerogenic, atherosclerogenic effects, antioxidant and antimicrobial properties (Kumar et al 2016). It is a staple food crop in the drought prone areas in the world, and is considered globally as an important component of food security.

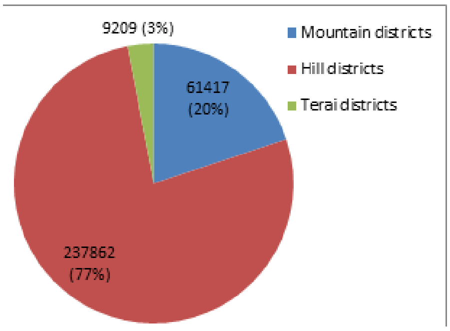

Figure 1. Production (t) of finger millet in Nepal by agro-ecology.

Finger millet (*kodo*) is the 4th most important crop of Nepal after rice, maize and wheat in terms of area and production. It occupies an average of 7.9% (268,050 ha) of the total area covered by cereal crops and accounts for 3.3% (308,488 mt) of total cereal production (MoAD 2015). It has been cultivated from Tarai; Kachorwa (85 masl) of Bara district (Amgain et al 2004) to High Hill: Burounse (3150 masl) of Humla district (Baniya et al 1992) in Nepal with cultivation records in all 75 districts. The major production districts of Nepal for this crop are Khotang, Sindhupalchok, Baglung, Syangja, Kaski, Gorkha and Sindhuli. It is considered very important in terms of food and nutrition security in both Mid Hill and mountains. A total of 237,862 tonnes (77%) of finger millet produced was from hill districts followed by 61,417 tonnes (20%) from mountain districts (**Figure** 1). Area and production of finger millet has slightly increased over last 25 years but the productivity is static or even decreased (**Figure** 2). Besides, in Mid Hill agro-ecosystem, the crop is important for different traditional food use values and is strongly associated with maize-based cropping system (Sherchan 1989).

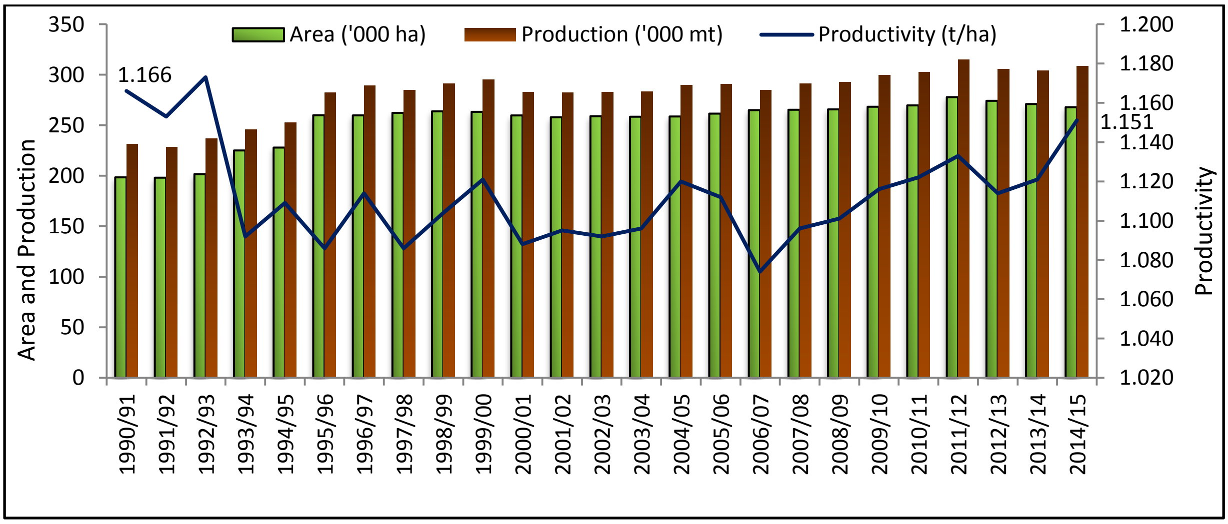

Figure 2. Area, production and productivity of finger millet in Nepal over the last 25 years.

Finger millet is important for human food and animal feed and is included in various cropping patterns. Moreover, the crop is widely adapted to marginal lands in High Hill with cold stress and also well adapted to lands where low fertile and dry soils are the unique stresses. Its cultivation has been found with low infestation of crop pests and diseases; and thus grain can be stored for years without storage pests, which makes it a perfect food grain commodity for famine prone areas (NARC 1995). It is specially valued for filling specific niches, or needs and because it often succeeds under stressful situations where other crops generally fail to grow. Several food preparations are made from finger millet. The most common is a thick porridge locally known as "*dhindo*". Other preparations are pancakes and roasted thick breads. Finger millet is also popular for making fermented beverages among certain communities of the country. As much as one-fourth of the total production of finger millet in Nepal goes into fermented alcoholic beverages "*raksi*". Finger millet is one of the most important food crops of the economically suppressed but physically hard working people. It is appreciated by the people because it is digested slowly (apparently due to its rather high fibre content) and thereby furnishes energy for hard work throughout the day after being eaten at a single morning meal (Seetharam et al 1986). The harvest residue of finger millet particularly green as well as dry straw is extensively used as feed for livestock. Despite these advantages of the crop it still fails to enjoy the status of rice, and considered as inferior or poor man's diet in the rural society.

Proso Millet

Proso millet (*Panicum miliaceum* L.) is a tetraploid (2n=4x=36) species in the Poaceae family. It is a warm season crop also known as broomcorn millet, hog millet, white millet, yellow millet, or common millet (Jana and Jan 2006). It is one of the first domesticated crops grown in Northern China for at least 10,000 years (Liu et al 2016). It is cultivated in Himalayan belt of Afghanistan, Bhutan, China, India, Nepal, Pakistan as well as in Central Asia for human consumption whereas in Europe and America, it is mainly grown for avian consumption. It has the shortest growing cycle of 60-90 days. The crop also has low water and nutrient requirements, allowing it to be cultivated at a wide range of altitudes, even on marginal land where other cereals do not succeed (Lagler et al 2005). It is also a health food because of its unique nutritional benefits; it features protein content especially those of alkaline ones, which are higher than in crops such as wheat, rice, and oats, an abundance of easily absorbed amino acids, and a relatively balanced array of trace elements and vitamin precursors (Dong and Zheng 2006). It has good nutritive value with, on an average, 12.5% protein, 1.1% fat, 70.4% carbohydrate, 2.2% fiber and 1.9% minerals such as iron, zinc, copper and manganese (Saud 2010, Saha et al 2016).

In Nepal, proso millet (*Chino*) is the second important food security crop among group of millets with wide range of utility. The grain is used for making *bhat* (boiled), *kheer* (pudding) and *raksi* (liquor). The flour can be used for making *dhindo* (porridge) and *roti* (pancake and flat bread). It is the crop of future in the context of changing climate with great potentiality to cope with food insecurity in remote areas of the country. Currently, it is grown in Karnali zone with the average productivity of about 800 kg/ha (MoAD 2015). In Nepal, proso millet is grown in 1900 ha with the productivity of 0.81 t/ha (DoA 2015). Major districts producing proso millet are Mugu, Dolpa, Humla, Jumla, Kalikot, Bajura and Jajarkot (DADOs of different districts 2015).

Foxtail Millet

Foxtail millet [*Setaria italica* (L.) P.Beauv.], regarded as a native of China, is one of the world’s oldest cultivated crops. It is the second most widely planted species among millets in the world and the most important millet in East Asia (Kumari et al 2011, Ning et al 2015, Sheikh and Singh 2013, Xiaomei et al 2016, Zhang et al 2014). It is also known as Italian millet, German millet or Hay millet but locally known as *Kaguno* in Nepal. Foxtail millet grain contains 12.3% protein, 4.3% fat, 60.9% carbohydrates, 14.0% dietary fibre and 3.3% minerals, with 31g calcium, 290 mg phosphorus, 5mg iron and vitamins than major staple crops rice and wheat (Saha et al 2016, Saud 2010). Foxtail millet (*Kaguno*) is the third important crop among group of millets with wide range of utility in Nepal. The cooked grain is used as bhat (cooked like rice), dhindo (porridge) and kheer (like rice pudding). Foxtail millet is valued by mountain farmers for its nutritional content and health promoting properties, ability to grow under low external input conditions and tolerance to extreme environmental stress, particularly drought. It is also recently appreciated because of medicinal benefits such as reducing blood glucose levels and cholesterol control in normal as well as diabetic patients. It is the crop of future in the context of changing climate with great potentiality to cope with food insecurity in remote areas of the country (Goron and Raizada 2015).

In Nepal, this crop is considered as traditional climate resilient and nutritionally dense crop but trend of cultivation and use is shrinking fast due to land use change, out migration, social values, change in food habit, depleting traditional knowledge and lack of research and formal seed distribution system and policy support such as subsidies on food imports and credits (Gurung et al 2017, Parajuli et al 2017, Palikhey et al 2017, Bisht et al 2006). In Nepal, foxtail millet is grown in 1000 ha with the productivity of 1.04 t/ha (DoA 2015). Major foxtail millet growing districts in Nepal are Mugu, Kalikot, Humla, Jumla, Bajhang, Bajura, Dolpa, Lamjung, Gorkha, Ramechhap, Kavre, etc. where crop is grown sole as well as mixed with finger millet, proso millet, beans, amaranths, sorghum, etc. Nepal is one of the centres of diversity of foxtail millet (Nakayama 1999) and has high genetic diversity of this crop (MoFSC 2002), however, very little research has been conducted and its status is still unexplored. Poor utilization of local genetic resources conserved in genebank for foxtail millet improvement and development program is evident due to i) absence of public and private sector plant breeding, and ii) unavailability of characterization and evaluation information for wider use.

Sorghum

Sorghum is one of the four major food grains of the world. Millions of African people depend on sorghum as a staple food. In recent years, this crop has been used as bio-fuel in developed countries. It is originated in central Africa, near Ethiopia or Sudan. It has very tall plant with similar look to maize that grows up to a height of 4 m. It is the third important crop among the food grains of India but less important in Nepal. It is cultivated in terrace bonds and used for food and fodder. Diversity within Nepalese sorghum accessions is not very high.

Barn Yard Millet

Barn yard millet (*Echinochloa frumentacea* Link) is among the minor millets grown in South and South-East Asia. Investigators suggests that it was probably originated somewhere in central Asia. It is annual grass grows up to a height of 60-120 cm. It is resistant to both drought as well as water logging. Sama grain contains 6.2% protein, 9.8% crude fibre, 65.5% carbohydrates and 4.4% ash. In Nepal, its cultivation is limited to western Mid Hill. It is hardy crop and is able to withstand adverse weather conditions as compared to other cereals. It is used as food for human consumption and feed for livestock and birds.

Pearl Millet

Pearl millet or bajra is one of the most important millet of the dry land area in India and Africa and considered as poor man's food. The crop is originated in Africa from where it spread to India and other countries. It is a tall, tillering annual plant usually grows to a height of 1-3 m. It is the most drought tolerant crop among the cereals and millets. Pearl millet has superior nutritive value to sorghum but inferior feeding value. The grain contains about 11.6% protein, 5% fat, 67% carbohydrates and 2.7% minerals. Pearl millet cultivation in Nepal is very limited to small area in Tarai and Lower Hills. Apart from the food items, farmers use this crop for fodder, feed and fermented beverages.

Kodo Millet

Kodo millet is a highly drought resistant crop. It is probably originated in south-east Asia. It is an erect annual grass growing up to a height of 50-100 cm. The grains contain 8.3% protein, 1.4% fat, 65.6% carbohydrates and 2.9% ash. This is recommended as the substitute of rice for diabetic patients. Its straw is of poor quality and harmful to horses.

GENETIC DIVERSITY IN MILLET SPECIES

Nepal has very wide ranges of altitudinal variation and millets can be grown from the lowest of 60 m up to 3500 m altitude. Similarly, the variation in land type, topography, rainfall, temperature, day length, etc. is also evident within the small boundary of the country. Due to these variations, there is high genetic diversity in small millets, especially in finger millet and foxtail millet. *Eleusine indica* and *Eleusine africana* are the two wild forms of finger millet that have been reported their existence in Nepal along with the cultivated finger millet (Bhandari et al 2003). A systematic study of collection, characterisation and evaluation of local millet landraces and introduced exotic varieties of Africa and India has been carried out by Hill Crops Research Program (HCRP) after its establishment. During 1975-1995, more than thousand accessions of different millet species were collected from various parts of the country and conserved at HCRP Kabre (Upreti 1995, Baniya et al 2001). Unfortunately, those germplasm were lost due to firing of HCRP office building during political conflict period (**Table** 3).

Dudhe and Hade are the two seed types which are under traditional cultivation in small patches in mid and far western High Hill districts of Nepal. Research on proso millet in the country is almost nil till now. Crop diversity within Nepalese proso millet landraces have not been studied yet. This is due to lack of poor availability of characterization and evaluation data and access of such information for wider use. Diversity within foxtail millet accessions is higher compared to proso millet accessions.

Table 3. Present conservation status of different millet species and lost accessions

Crop	Accessions under long-term conservation at NAGRC	Accessions under active collection at HCRP*	Accessions lost during insurgency at HCRP**
Finger millet	850	782	790
Proso millet	51	48	160
Foxtail millet	55	44	106
Barnyard millet	2	0	4
Sorghum	15	0	20

Pearl millet	1	0	0
Kodo millet	3	0	1
Total	977	874	1081

** HCRP 2015, ** HCRP 2002.*

After the establishment of National Genebank in 2010, collection and conservation of millets germplasm got high priority. Now, NAGRC holds more than 950 accessions of different millet species in medium and long-term conservation (Ghimire et al 2015) (**Table** 3), among them, 90% collections are of finger millet (**Figure** 3). Most of the finger millet collections are from Dolakha, Baglung, Sindhupalchok, Myagdi, Kaski districts whereas most number of collections of proso millet and foxtail millet are from Humla and Jumla districts. Farmers have named these finger millet landraces based on shape and size of the heads, planting season, quality (**Table** 4).

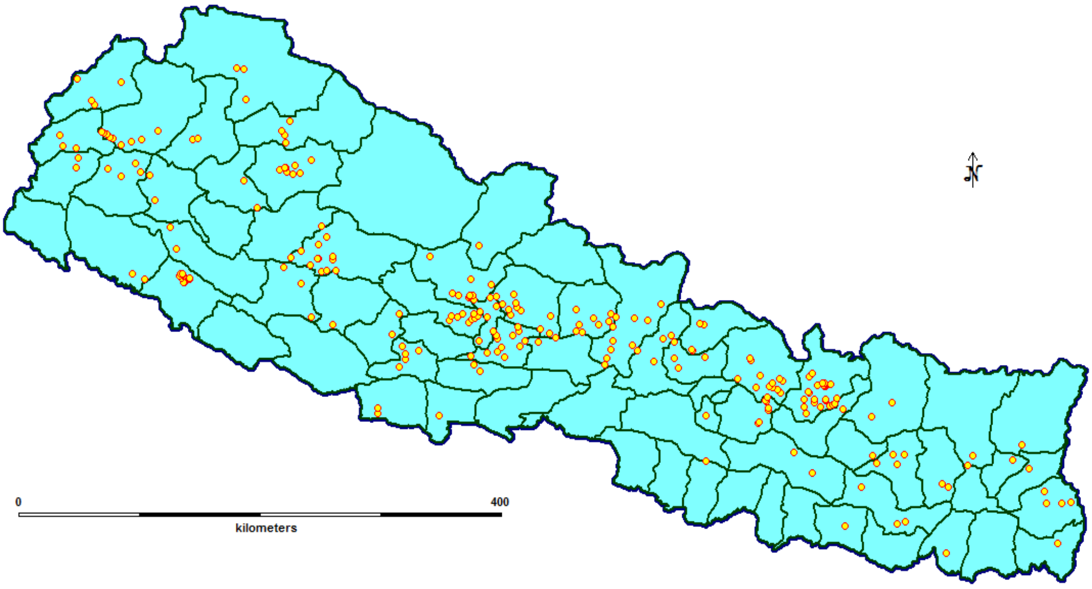

Figure 3. Map of Nepal showing the collection sites of 850 finger millet accessions.

Table 4. Names of some local landraces of finger millet of Nepal conserved at NAGRC, Khumaltar.

By shape/size of finger	By size of finger/ growing season/duration	By other characters
1. Batule	1. Aghaute	1. Bhainsi
2. Chhatre	2. Asare	2. Bhanchuwa
3. Chulthe	3. Asoje	3. Dhaule
4. Chyalthe	4. Chaumase	4. Dudhe
5. Dalle	5. Kattike	5. Jhyaure
6. Jhope	6. Lekali	6. Jwain
7. Jhyape	7. Pachhaute	7. Kalo
8. Lampate	8. Paundure	8. Maduwa
9. Lopre	9. Sano	9. Nangkatuwa
10. Lurke	10. Temase	10. Pahenlo
11. Matyangre	11. Thulo	11. Rato
12. Mudke		12. Samdhi
13. Nangre		13. Seto
14. Tauke		

CHARACTERIZATION OF MILLET GENETIC RESOURCES

Considerable works have been done on the morphological characterization of Nepalese finger millet accessions since 1972 after the establishment of HCRP. In recent years, a total of 537 accessions collected and conserved in NAGRC were characterized at Khumaltar based on agro-morphological traits and found high diversity within Nepalese landraces (Bhattarai et al 2014). Similarly, 50 finger millet landraces received from NAGRC were characterized at Rampur, Chitwan condition for their morpho-agronomical traits and showed significant phenotypic variation among the accessions (Bastola et al 2015). The natural variation present within landraces is important for selection and development of varieties for the different agro-climatic regions of Nepal, since creation of diversity artificially is tedious and bit difficult due to limited resources. Forty-four accessions each of proso millet and foxtail millet were also characterized at NAGRC during 2015 and observed great variation among foxtail millet accessions but comparatively low variation among proso millet accessions (**Table** 5).

Table 5. Characterization millet genetic resources at NAGRC

Crop	No. of accessions	Year	Observation
Finger millet	537	2011, 2012	High diversity
	60	2014	High diversity
	35	2015	High diversity
Foxtail millet	44	2015	High diversity
Proso millet	44	2015	Low diversity

UTILIZATION OF MILLET GENETIC RESOURCES

According to MoAD (2015), the average national productivity of finger millet since 25 years is static or even decreased by 1% (**Figure** 2). Research in the 4th important crop of the nation is inadequate. Despite of very rich genetic diversity on Nepalese finger millet landraces, very little research has been conducted in millets. Identifying suitable genotypes from existing accessions for biotic and abiotic stress resistance is one of the current thrust areas of finger millet research in Nepal (HCRP 2015). There are five varieties of finger millet released so far and among them, the first two varieties Okhle-1 and Dalle-1 were released thirty-five years' ago (**Table** 6). There is very less utilization of local genetic resources conserved in genebank for the crop improvement program due to lack of information about the desirable accessions in the genebank resulting from the poor characterization and evaluation data. In recent years, the demand of genebank accessions is increasing slowly from scientists and students for research purpose (**Table** 7). Characterization of Nepalese finger millet accessions using molecular markers is still a matter of distance for the national research priority.

Table 6. Finger millet varieties released in Nepal (Joshi et al 2017)

Variety	Origin	Release year	Plant height (cm)	Maturity (days)	Yield (t ha^{-1})	Finger type	Recommended domain
Okhle-1*	Nepal	2037	80	154-194	3.3	Compact	Mid to High Hill
Dalle-1	India	2037	110	125-151	3.3	Compact	Inner Tarai to Mid Hill
Kabre kodo-1**	Nepal	2047	82	147	2.3	Erect	Mid Hill (900-1900m)
Kabre kodo-2	Nepal	2072	91	153	2.5	Open	Mid Hill
Shailung kodo-1	Nepal	2072	100	155	2.5	Compact	High Hill

** Local landraces from Okhaldhunga. ** Local landraces from Surkhet.*

Table 7. Distribution of finger millet and foxtail millet germplasm to different users from NAGRC

Crop	No. of accessions	Year	To whom	Purpose
Finger millet	150	2012	Scientist, HCRP	Research
	50	2013	Student, AFU	Research
	300	2017	ARS Jumla, HCRP	Research
Foxtail millet	10	2011	Scientist, ABD	Research
	12	2015	Student, AFU	Research
	30	2015	Scientist, HCRP	Research
	8	2016	Farmers-Lamjung, Dolakha, Humla, Jumla	Research

UNIQUE AND ENDANGERED GENETIC RESOURCES

There are many unique landraces in different millet species. Some landraces among them are listed in the **Table** 8. Landraces like Maal kaguno and Dhan kodo are unique and endangered but crops like barn yard millet, kodo millet, etc are endangered since farmers abandoned the crops to grow due to lower yield, high labour demanding and processing difficulties.

Table 8. Unique and endangered landraces of different millet species

Crop	Landrace name	District	Unique/ endangered	Characteristic features
Finger millet	Paundurkodo	Across the Low Hills, river basins	Unique	Adapted to spring season cultivation, drought tolerant, medicinal value for human and animals.

Finger millet	Samdhikodo	Across Hills	Unique	White colour seeds, prestigious
Proso millet	Rato chino	Karnali region	Unique	Medicinal value, good eating quality, drought tolerant
Foxtail millet	Kalokaguno	Humla	Unique	Black color grains, medicinal value, drought tolerant
Foxtail millet	Maalkaguno	Gorkha, Lamjung	Unique, endangered	Quality porridge, medicinal value, good for lactating animals, effective in mastitis
Kodo millet	Dhankodo	Lamjung, Tanahun, Dhading	Unique, endangered	Small oval seeds with shining brown colour
Barn yard millet	Sama	Gorkha	Endangered	Drought tolerant, difficult for processing

WAY FORWARD

- Although National Genebank is holding more than 950 accessions of different millet species, there are still gaps or unexplored areas. Exploration of millet genetic resources from such areas with close collaboration with farmers, community seed banks and DADOs should be done. Safety duplication of these collected accessions is an urgent need to international genebanks like ICRISAT, RDA etc so that we can repatriate these accessions at any time when needed.
- Most of the millet genetic resources conserved so far have been characterized with morphological descriptors. Characterization at molecular level using DNA markers is the urgent need of the country. Diversity study of 300 finger millet landraces will be carried out at molecular level in near future. This will help to established representative core set of collections and genetic fingerprint of finger millet. Apart from finger millet, such studies need to be done for other important millet species like proso millet and foxtail millet.
- Hill Crops Research Program has the mandate for breeding and promotion of millets in Nepal. HCRP, despite of limited human and financial resources, is continuously working to develop new varieties with higher yield, good quality, disease resistance, etc. Utilization of conserved accessions in breeding program should be accelerated by NARC in close collaboration with other research institutions like LI-BIRD at national as well as ICRISAT at international level.
- Developing high yielding varieties for non-stress environments is always given high priority in the breeding program since it is easier to show the impact of the research system. But breeding for biotic and abiotic stress resistance for a crop like finger millet is always in low priority in global as well as national research system. As in global scenario, Nepalese finger millet is also facing major diseases like blast (leaf, neck and finger), leaf spot, etc. Some of the local varieties were having no or less diseases evident in the preliminary evaluation at NAGRC, Khumaltar. Continuous drought in recent years was the major production constraint in the mid and Far-western hills where finger millet is the main staple. Thus, NAGRC has plan to screen 300 finger millet landraces at phenotypic and DNA level to identify high yielding genotypes tolerant to biotic stress like blast and abiotic stress like drought using trait-linked SSR markers.
- There are five varieties of finger millet released so far but none of the other millets. Therefore, pre-breeding works on proso millet, foxtail millet and sorghum are necessary. With this, elite landraces could be registered and/or released officially for commercial cultivation.
- Availability of improved and quality seed of millets is a problem facing by the farmers. Seed multiplication of promising millet landraces through Community Seed Banks or farmers groups should immediately be started and mainstreamed as in other crops.
- Some crop species like proso millet and barn yard millet are highly tedious for processing after harvest. In remote hills and mountains, processing is done manually by women farmers and children. Development of handy processing equipments for such crops would be of prime contribution for the mountain farmers growing these millets. This would help to expand the area of these crops in future.
- Conservation through utilization is the key for any genetic resources. To enhance the use of these crops, awareness creation and promotional activities should be launched with value addition and product diversification. Efforts should be made to uplift the current status of the crop through various participatory on-farm research, innovative promotion, and inclusion of small millets in public food programmes.

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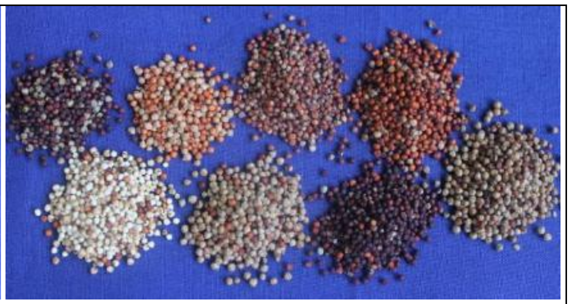
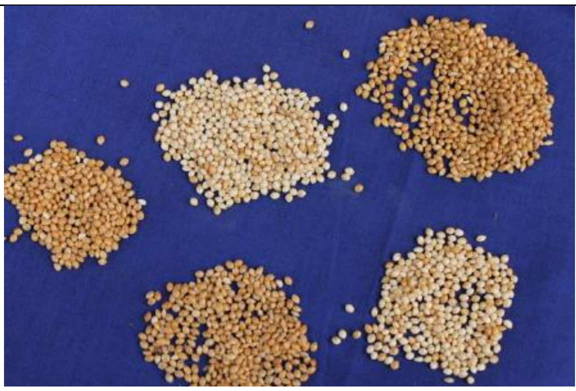
Annex 1. Some photos of millets

Head diversity in Finger millet



Grain diversity in Finger millet



Grain diversity in Proso millet

Grain diversity in Foxtail millet

Kalo Kaguno/Foxtail millet: *Setaria italica* (L.) P. Beauv.

Seto Kaguno/Foxtail millet: *Setaria italica* (L.) P. Beauv.

Sorghum/Great millet/Junelo: *Sorghum bicolor* (L.) Moench

Barn yard millet/ Sama: *Echinochloa frumentacea* Link

Barn yard millet/ Sama: *Echinochloa frumentacea* Link

Proso millet/Chino: *Panicum miliaceum* L.

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Food Legumes: Diversity, Utilization and Conservation Status

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ABSTRACT

Food legumes are important crops of Nepal in terms of their contribution to the dietary protein supply to human and livestock, rich source of micronutrients, role in crop diversification and intensification and maintenance of soil fertility through symbiotic nitrogen fixation. Crop residues are valuable as animal feed. About 11 percent of cultivated area in the country is occupied by grain legumes that included lentil, chickpea, grasspea, fieldpea, fababean, pigeonpea, soybean, blackgram, horsegram, ricebean, cowpea, mungbean. The family Leguminosae or Fabaceae comprises of 650 genera and 18000 species worldwide. About 100 genera and 379 species of legumes are widely distributed in varied agro-ecological zones ranging from Tarai to the alpine region of Nepal, with growth habit ranging from annual to perennial shrubs. Out of the 379 species of legumes which include grain, vegetable and forage legumes, 262 are native and 20 species belonging to sub group Papilionacae are used as food legumes. Highest food legume species diversity has been recorded in *Macrotyloma* (34 spp.), followed by *Crotalaria* (18 spp.), *Vigna* (15 spp.), *Lathyrus* (7 spp.), *Vicia* (6 spp.), *Cajanus (*5 spp.), *Trigonella* (5 spp.) and *Phaseolus* (4 spp.). Other genus having 1-3 species includes *Cicer* (3 spp.), *Mukuna* (3 spp.), *Glycine* (2 spp.), *Canavila* (2 spp.*), Pisum* (2 spp.), *Lablab* (2 spp.), *Pachyrrhizus* (1 sp.), *Psophocarpus* (1 sp.), *Lens* (1 sp.) and *Cyamopsis* (1 sp.). Research on grain legumes was initiated since 1976 and systemic collection of grain legume landraces was initiated from 1987 by Grain Legumes Research Program (GLRP). Past collection missions organized in collaboration with International Development Research Centre (IDRC), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Center for Agricultural Research in the Dry areas (ICARDA) and other institutes have resulted in the collection of 1107 landraces and provided opportunity for their inclusion in variety improvement program. National Agricultural Genetic Resources Center (NAGRC) has conserved 2936 landraces of different legumes, 951 landraces have been kept in genebanks of CG centers, while GLRP Khajura and Agronomy Division Khumaltar have active collections of 218 landraces and 627 exotic germplasm of various legume crops. Varietal improvement researches have been conducted in soybean, lentil, chickpea, cowpea, blackgram, mungbean, pigeonpea, ricebean, fababean, grasspea and kidney bean. Uptill now total released, registered and denotified varieties in food legumes are 51, 6 and 2, respectively.

Keywords: Agrobiodiversity, fabaceae, food legumes, grain legumes, grain Legume research program

INTRODUCTION

Nepal has diverse climatic variation and diverse culture. Three agro-ecological zones ie Tarai, Mid Hill and High Hill experience a wide range of climate from tropical to temperate and arctic. The variation is mainly attributed to immense changes in elevation from 60 to 8848 masl. The wide variation in agro-climatic condition within short range allows a number of species of grain legumes to be grown in the country. The family Fabaceae comprises of 650 genera and 18000 species worldwide. About 100 genera and 379 species of legumes are widely distributed from Tarai to the alpine region of Nepal (http://www.Ffloras.org). Out of the 379 species, 262 are native and the other species are either introduced or unknown (Shrestha 1994). Twenty species under Papilionacae subfamily are used as pulses or grain legumes (Shrestha 1994, Shrestha 1995, Regmi 1995), while some species like *Pachyrrhizus, Psophocarpus or Crotalaria* are used for tubers, pods or flowers, respectively.

Legumes may include annual herb or perennial shrub or tree species that have biological nitrogen fixation and any part of plants such as pod, seed, leaves, flower or roots are edible. Legumes plant parts are usually rich in protein as compared to cereals. Depending upon plant parts used legumes are categorized as grain legumes or pulses (dry seed), vegetables (leaves or flower or tender shoots or green pod or roots) or legume pasture crops (forage or fodder). Food legumes are important crops of Nepal in terms of their contribution to the dietary protein supply to the people and maintenance of soil fertility through symbiotic nitrogen fixation. Legume crop residues are important constituents of livestock feed. These crops occupy 10.7% of total cultivated area of the country. Among cultivated food legumes, lentil occupies a prominent place in terms of area and production (Shrestha and Neupane 2016). Food legumes that are utilized as dry bean are referred as pulses. Pulse crops such as chickpea or gram (*Cicer arietinum* L.), pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medikus ssp.

culinaris), grasspea or lathyrus (*Lathyrus sativus* L.) and fababean or broad bean (*Vicia faba* L.) are grown during winter months mostly in rotation with rice in residual soil moisture, while soybean (*Glycine max* (L.) Merr.), cowpea (*Vigna unguiculata* (L.) Walp., mungbean or greengram (*Vigna radiata* (L.) R.Wilczek), blackgram or mash (*Vigna mungo* L. Hepper), pigeonpea (*Cajanus cajan* (L.) Millsp.), horsegram or Kulthi (*Macrotyloma uniflorum* (Lam.) Verdc.), common bean or rajma or rajmash (*Phaseolus vulgaris* L.) and ricebean (*Vigna umbellata* (Thunb.) Ohwi & H.Ohashi) are grown as sole crop or intercrop with maize or on bunds during summer or spring or autumn seasons depending upon varieties and agro-ecological zones. Although FAO defines soybean as an oil crop it is still the food crop in mountainous region where it plays an important role in the maize based farming system and provides dietary protein to the rural people. In FAO statistics, dry bean includes *Phaseolus* spp. and *Vigna* spp. (except cowpea) and pulses nes includes pulse crops of minor relevance such as lablab or hyacinth bean (*Lablab purpureus* (L.) Sweet), sword or jackbean (*Canavalia* spp.), winged bean (*Psophocarpus tetragonolobus* (L.) DC., guar bean (*Cyamopsis tetragonolaba* (L.) Taub., yambean (*Pachyrhizus erosus* (L.) Urb.) etc are also being grown in Nepal. Other summer pulses of minor importance are Lima or butter bean (*Phaseolus lunatus* L.); adzuki bean (*Vigna angularis* (Willd.) Ohwi & H.Ohashi); scarlet runner bean (*Phaseolus coccineus* L.); moth bean or haricot bean (*Vigna aconitifolius* (Jacq.) Marechal); tepary bean (*Phaseolus acutifolius* A.Gray), Kause simi or velvet bean (*Stizolobium pruriens* (L.) Medik.) and other *Vigna* spp. (Akibode and Maredia 2011). Horsegram and ricebean are underutilized species in Nepal (ABTRACO 2006). Food legume species and their wild relatives found in Nepal are in **Table** 1**.**

FOOD LEGUME SPECIES

Cajanus

The genus *Cajanus* consists of one cultivated species pigeonpea (*Cajanus cajan* (L.) Millsp.) with chromosome number of 2n=2x=22 along with a genome size of 845 Mbp. It is an important grain legume in drier areas of central and mid-western Tarai, and in Mid Hills a new introduction. It covers about 5% of the total area and production of grain legumes (MoAD 2013). This crop can be grown in wasteland, terraces and on bunds and in agroforestry systems. It has got multiple uses as food, fuel and fodder crop and is grown for soil fertility improvement and reducing soil degradation in sloppy land. In general, monocrop of pigeonpea is taken in dry area of western Tarai, while bund planting is popular in central and eastern Tarai. Mixed cropping pigeonpea with maize, sorghum or sesame is popular among farmers in the Tarai.

Wild pigeonpea species: *Atylosia elongata* Benth. *Atylosia mollis* Benth., *Atylosia scarabaeoides* (L.) Benth., *Atylosia volubilis* (Blanco) Gamble, *Atylosia cajanifolia* Haines and *Atylosia Spp.*; syn. *Cajanus scarabaeoides* (L.) Thouars, often with tendrils intertwined with other shrubs/ grasses with bright yellow flowers and small pubescent pods are found growing from Tarai to High Hills in wastelands and forests. *Atylosia elongata* Benth., *Atylosia Scarabaeoides* (L.) Benth. and *Atylosia molis* Benth. have been reported in forests around Kakani (Shrestha and Shrestha 1996).

Canavalia

Two cultivated species: *Canavalia ensiformis* (L.) DC., and *Canavalia gladiata* (Jacq.) DC*.* have been reported in Nepal. Both the species have a diploid 2n=2x=22 chromosomes. Seeds are edible and other plant parts are used as fodder. The species are distributed from Mid Hills to High Hills.

Crotalaria

One species *Crotalaria juncea* L. known as sunhemp is grown extensively as a green manure crop. The leaves, tender twigs and flowers are consumed as vegetables. Eighteen species of the genus have been found in Nepal (**Table** 1). These are distributed from Tarai to High Hills.

Cicer

Chickpea (*Cicer arietinum* L.) is a popular winter crop of Nepal. Chickpea is a diploid with 2n=2x=16 chromosome and a genome size of approximately 750 Mbp (Arumuganathan and Earle 1991). The crop covers about 3% of the total area and production of grain legumes (MoAD 2013). It is mostly consumed as whole seed (boiled, roasted, parched, fried, steamed or sprouted), daal (decorticated split cotyledons boiled and mashed to make a soup) or as daal flour (*besan*). Plucking of tender leaves and twigs and using as green vegetable is a traditional practice among some communities in the Tarai. Seed is a good source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins. Its straw has also good forage value. The cultivated species is divided into two distinct types Desi and Kabuli. *Desi* types have small seeds with gray to brown testa or seed coat, and the flowers are pink. The Kabuli types are large white seeded, have white flowers and are more susceptible to insect pests. Two wild species *Cicer microphyllum* Benth. and *Cicer Jacquemontii* Jaub. & Spach have been reported in the Western High Hills of Nepal.

Cyamopsis

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.), commonly known as guar, is used as fodder, vegetable and green manure. Guar is a drought resistant, hardy and deep rooted annual legume. In recent times, it has become a major industrial crop due to the presence of galactomannan/gum present in the endosperm. Guar gum is useful in various industries like paper, textile, pharmaceutics, food, cosmaceutics, and explosives. Guar is a cultivated crop not found in wild conditions and hence its available landraces are the main source of genetic variability. Guar is strictly a self pollinated diploid legume with chromosome number 2n=14 and genome size of approximately 2.45 Giga Bases/C. Cross pollination is prevented due to the cleistogamous nature of flowers. Thus, the heterosis available is reduced, which makes commercial hybrid seed production difficult and non-economical. This can be overcome by production of improved varieties of guar through molecular marker based selection and breeding programs.

Glycine

Soybean **(***Glycine max* (L.) Merr.) has a diploid chromosome number 2n=2x=40 along with genome size 1100 Mbp. It is an important legume of Mid Hills which contribute 80% to total soybean area and production in the country. However, soybean is becoming popular as sole crop in Tarai and Inner Tarai due to high yield potential and high demand of soyameal in poultry industry. Seed contains 45-50% protein, 20% oil and is rich in vitamin B, C, E and minerals. It can be used as a good supplemental food with cereal especially in the underdeveloped country where majority population suffers from malnutrition. Soybean has a very diverse utilization as seed is used to prepare baby food and food for diabetic patients, soyamilk, tofu, soyasauce, green pods used as green vegetables and dry seeds roasted or fried eaten as snacks. Soybean oil is cholesterol free, widely used for cooking and in the production of vegetable ghee. Cake and meal are utilized for preparing various livestock and poultry feeds. Green foliage can be used as green manure and as a fodder crop. The species *Neonotonia wightii* (Wight & Arn.) J.A.Lackey called *Bhatamase* in Nepali is grown as a fodder crop from Tarai to the Hills.

Lablab

Lablab or hyacinth bean also called Hiunde simi or Tate simi in Nepali is an annual legume. The crop is grown from Tarai to the High Hills in frost free season. The green pods of various size and shapes are consumed as vegetables. Only one species *Lablab purpureus* (L.) Sweet, Syn. *Dolichos lablab* L., *Dolichos purpureus* L., *Lablab vulgaris* (L.) Savi is reported in Nepal. It is self fertilized with 2n=22and 24 with genome size of 367 Mbp. Fodder types are extensively grown in throughout the country in various altitudes.

Lathyrus

Grasspea (*Lathyrus sativus* L.) also known as Kheshari, Latara or Matara in local languages is adapted to both drought and excess soil moisture conditions (Adhikari et al 1987). Grasspea is an important food item. Most often it is used as daal (soup cooked with spices), atta (flour boiled in water) and satu (roasted flour mixed with water). It is often used as adulterant to chickpea and pigeonpea daal or flour (Bharati and Neupane 1989). The young plant is used as leafy vegetable, eaten with rice meal. They are also rolled and dried for off-season use as a vegetable (Bharati and Neupane 1989). Plant residue is valuable fodder for livestock. Fresh biomass yields of 5-6 t/ ha in addition to 1.8 t/ha of seed yields of local varieties have been reported (Neupane 1996). In spite of its multiple uses, the area and production is reduced drastically primarily due to discouragement in its consumption as Nepal government imposed a ban on marketing of grasspea since 1991/92 (NGLRP 1998). Dietary intake of large quantities over a longer period is believed to cause neurological disorder (lathyrism) due to the presence of neurotoxin ODAP [β-(N-Oxalyl)-L-α, β-diamino propionic acid]. ODAP content in local varieties is high and ranges from 0.6-0.8 %.

Grasspea is a diploid species with 2n = 14 chromosomes and genome size of approximately 8.2 Gb (Bennett and Leitch 2012) with a great potential for expansion in dry areas or zones that are becoming more drought-prone (Hillocks and Maruthi 2012). This species has been also recognized as a potential source of resistance to several important diseases in legumes (Vaz Patto and Rubiales 2014). Five wild relatives of grasspea have been reported in Nepal. *Lathyrus aphaca* L. (Pili matri), annual herb with yellow flower reported from Tarai is used as fodder. *Lathyrus odoratus* (L.) also called sweet pea (*Kerauphul* in Nepali) is a wild form of lathyrus grown as an ornamental plant in home garden. Other species are *Lathyrus pratensis* L.; *Lathyrus sphaericus* Retz., *Lathyrus humilis* (Ser.) Spreng.

Lens

Lentil (*Lens culinaris* Medikus spp. *culinaris*), locally known as Musuro, is a major grain legume accounting for about 62.5% of area and production of grain legumes. It is self pollinated, diploid with 2n=14 chromosomes and genome size of ~4 Gbp. The increasing trends in area, production and productivity are due to the availability of production technologies and its remunerative export market (small seed red lentils fetch higher price in Bangladesh), breeding lines and technical support from international centers, area expansion in new areas (introduction in Mid Hills and cultivation in rice fallow) and reduction in grasspea area due to ban on its marketing 1991/92 (NGLRP 2008). Although landraces of lentil (mostly black seeded) have been grown in high altitudes, improved varieties have been introduced in recent years in hills (5% area) where productivity is high due to longer growing season and less diseases. Lentil daal consumption is in rise as the cooking time is the shortest compared to other grain legumes. Lentil seed contains about 20-25% protein, and is a rich source of Fe, Zn and vitamins. Fe and Zn content in lentil seed ranged from 64-127 mg/100g and35-88 mg/100g, respectively (NGLRP 2006, 2008). Lentil consumption is thought to prevent Anemia (Fe deficiency) common in young women and in children worldwide. Fe requirement vary from 0.23-0.55 mg/day in children to 0.35-0.55mg/day in adults (FAO 2004).

Macrotyloma

Horsegram (*Macrotyloma uniflorum* (Lam.) Verdc. syn. *Dolichos biflorus* L., *Dolichos uniflorus* Lam.) is a diploid with 2n=2x=20, 22, 24 chromosomes and genome size of 400 Mbp. It is called Gahat in Nepali and is an important legume crop grown from Tarai to the Hills. In the Hills, it is grown in maize based system and in the Tarai as a sole or a mixed crop. Soup prepared from its seeds is consumed in winter months and is traditionally used for the removal of kidney stones. Differences in color of seed testa eg light red, brown, grey black or mottled and seed size have been observed in landraces. The genus has 34 wild species including *Desmodium gangeticum* (L.) DC. widely used as a fodder crop (http://www.Ffloras.org).

Mucuna

Mucuna pruriens (L.) DC., Syn. *Mucuna cochinchinense* (Lour.) A. Chev., syn. *Dolichos pruriens* L. called velvet bean is an annual climbing legume. It is one of the most important medicinal plants. It is used to treat many ailments, but is widely used for the treatment especially for Parkinson's disease because of the presence of 3, 4-dihydroxyphenylalanine (L-dopa) in seed. Velvet bean pods and plant parts possess dense hairs which gives a stinging effect on touch. It is used as fodder to animals, green manure and the seeds can be consumed after cooking properly. Three species have been reported from Nepal (**Table** 1).

Pachyrrhizus

Yam bean (*Pachyrhizus erosus* (L.) Urb.) called *Mishrikand* or *Kesour* is grown in the central Tarai. Yam bean is a diploid with basic chromosome number 2n=2x=22. The edible part is tuber and is eaten raw after peeling out the skin. Yambean is particularly used during Saraswoti Pooja. The tubers have 86–90% water, trace amounts of protein and lipids. Its sweet flavor comes from the oligo fructose inulin (also called fructo-oligosaccharide) which is a pre-biotic, is very low in saturated fat, cholesterol, and sodium. Seeds are poisonous have insecticidal properties. In spite of its high content of carbohydrates in the form of dietary fiber, it is a neglected crop.

Phaseolus

The genus consists of 4 species: Kidneybean (*Phaseolus vulgaris* L.) also known as *Simi, Rajma, or* Frenchbean, tepary bean (*Phaseolus acutifolius* A.Gray), scarlet runner bean (*Phaseolus coccineus* L.) and Lima bean (*Phaseolus lunatus* L.). *Phaseolus vulgaris* L. is a diploid 2n=2x=22 with genome size of 576 Mbp. The indeterminate long duration type of kidneybean is grown during summer in Mid/High Hills and the determinate early maturity type is grown during winter months (post rainy) in Tarai. It is an important cash generating legume in Jumla and adjoining hilly districts, and Mustang where mixtures of landraces with different size and seed coat patterns are harvested and sold in the market. In Chitwan, Nawalparasi, Makwanpur and Rupendehi districts, varieties PDR 14, Four-season, and Hetauda are popular under rice or maize based cropping system with partial irrigation. The area under rajma is in increasing trends due to ease in marketing and good return.

Pisum

Field pea (*Pisum sativum* L.) is an important crop and can be grown successfully in Tarai (<100 m) during winter to high mountain (3000 m) during summer months. It is also diploid 2n=2x=14 chromosomes along with a genome size of 4685Mbp. A great variation in seed size and seed color is observed in local field pea. Green peas are important as green vegetable. *Pisum sativum* ssp. *arvense* (L.) Asch. & Graebn. Poir called small pea is extensively grown in Kathmandu valley in rice based system.

Psophocarpus

Winged bean (*Psophocarpus tetragonolobus* (L.) DC.) is legume grown for its green pods, twigs and underground rhizome. It is a multipurpose crop being grown from Tarai to the Hills. Winged bean has a diploid genome of 2n=2x=18 and an estimated genome size of 1.22 Gbp/C (A.N. Egan, unpublished data).

Trigonella

Fenugreek (*Trigonella foenum-graecum* L.) is an important annual legume consumed as vegetable and the seeds as spices. Somatic chromosome numbers were observed as 2n = 14, 16, 30 and 46 and B chromosome was also observed in somatic cells of some taxa (Martin et al 2011). Four wild species recorded in Nepal are: *Trigonella emodi* Benth., *Trigonella gracilis* Benth., *Trigonella corniculata* (L.) L. and *Trigonella pubescens* Baker. Fodder species of fenugreek introduced from Australia was poorly adapted in the Tarai of Mid Western Nepal.

Vigna

Fifteen species of the genus have been recorded in Nepal (http://www.Ffloras.org). The major ones are *Vigna aconitifolius* (Jacq.) Marechal, *Vigna angularis* (Wild.) Ohwi. & H.Ohashi, *Vigna mungo* (L.) Hepper, *Vigna radiata* (L.) Wilczek, *Vigna umbellata* (Thumb.) Ohwi and Ohashi, *Vigna unguiculata* (L.) Walp. and *Vigna unguiculata* (L.) Walp. *var. sesquipedalis* (L.) H. Ohashi. Other species are growing wild in various parts of the country.

Blackgram (*Vigna mungo* (L.) Hepper) is an important summer grain legume in Mid Hills. It is a diploid with 2n=2x=22 chromosomes and genome size of 574 Mbp. Blackgram produced in the hills is considered to have better cooking quality. Landraces collected in 1998 and materials introduced from Bangladesh before 1988 were evaluated and single plant selections were made to identify/develop the best genotypes. Very recently, materials from India have been tested at various agro-ecological zones for yield performance.

Mungbean (*Vigna radiata* (L.) R.Wilczek) is a diploid 2n=2x=22 chromosomes and genome size of 509Mbp. It is a short duration (60-70 days) crop grown as rainfed crop after maize in bariland, and as irrigated crop in lowland after wheat harvest in the Tarai and Inner Tarai. More than 75% mungbean area is mainly concentrated in the eastern and central Tarai, where irrigation facility is available, while the remaining 25% area is in the western Tarai and foothills. Green foliage is used as fodder and green manure. Mungbean is considered as the most digestible among other pulses and its soup and sprout are widely used as healthy diet. Fried mungbean is popular as snack. Large quantity of mungbean is imported from India as domestic production is inadequate to meet the growing demand.

Ricebean (*Vigna umbellata* (Thumb.) Ohwi & H.Ohashi) locally known as Mashyang, Siltung, Jhilinge or Guras is one of the neglected and underutilized summer grain legumes cultivated mainly in the hilly areas under mixed cropping with maize with no additional inputs and care. Ricebean is known for its diverse distribution and is adapted to a range of altitudes from the lowlands to the High Hills, and across the country from the east to the far west. The crop has excellent food and fodder values and is grown for fodder, green manure and cover crop. The dry seeds are eaten boiled as daal (soup) and young immature pods are consumed as vegetables (Gupta et al 2009). It is an important food legume, particularly in the Mid Hills of Nepal, and has a pivotal role as a pulse in supporting the food security of the rural poor people. A great variation in seed color has been observed in landraces and research on development of high yielding short duration varieties was initiated through FOSRIN project since 2006. Ricebean is a diploid species with 2n=2x=22 chromosomes.

Cowpea (*Vigna unguiculata* (L.) Walp.) and *Vigna unguiculata* var. *sesquipedalis* (L.) H.Ohashi is diploid 2n=2x=22 with genome size of 576 Mbp. It is one of the important grain legumes consumed as green vegetable or dried pulse as daal. In Mid Hills, local cowpea (Kartike bodi, Makai bodi trailing type long duration landrace) is grown as an intercrop with maize. Short duration varieties are grown as a monocrop in the spring season or after rainy season in September with supplemental irrigation. Area and production are increasing every year because of availability of dual purpose (green pods as vegetable and dried pulse) short duration varieties.

Vicia

Fababean (*Vicia faba* L.) or broad bean (local name Bakula) is the minor grain legume. Fababean is a diploid 2n=2x=12 chromosomes with genome size of 12797 Mbp. Large seeded type *Vicia faba* ssp. *faba* is commonly grown in Kathmandu valley and adjoining districts as a kitchen garden vegetable, whereas small seeded *Vicia faba* L. syn. *Faba minor* Roxb. with green or black color testa are grown as a field crop or in a home garden in the Tarai. Large pods are consumed mostly as green vegetable and dry seed as roasted bean and small seed usually splitted and consumed as soup. Wild species: *Vicia anugustifolia* L., *Vicia rigidula* Royle syn. Lathyrus himalensis (Cambess.), *Vicia hirsuta* (L.) Gray, *Vicia bakeri* Ali, *Vicia tetrasperma* (L.) Schreb., *Vicia rigidula* Royle and *Vicia tenufolia* Roth grow as weeds in crop and pasture lands from Tarai to the High Hill.

Table 1. Cultivated Food legume species and their wild relatives in Nepal

English name	Nepali name	Scientific name
-	-	Vigna vexillata var. angustifolia (Schum. & Thonn.) Baker
Adzuki bean	Ratomas Maslahari	Vigna angularis (Willd.) Ohwi. & H.Ohashi
Bhatmashe	Bhatmase	Neonotonia wightii (Wight & Arn.) J.A.Lockey
Blackgram	Mas	Vigna mungo (L.) Hepper
Broad bean	Bakula (sano)	Vicia faba L. var. eu faba major
Broad bean	Bakula (thulo)	Vicia faba L. var. eu faba minor
Broad beans (wild)	Rahariya simi	Vicia angustifolia L.
Broad beans (wild)	Kutuli kosa	*Vicia rigidula* Royle
Chickpea	Chana	Cicer arietinum L.
Cluster bean	Juppe simi	Cyamopsis tetragonoloba (L.) Taub., syn. Cyamopsis psoralioides (Lam.) DC.
Cowpea	Bodi	Vigna unguiculata (L.) Walp.
Cowpea	Bodi	Vigna unguiculata var. catjang (Burm.f.) Bertoni
Cowpea	Bodi	Vigna unguiculata var. unguiculata
Fenugreek	Methi	Trigonella foenum-graecum L.
French bean, Common bean	Ghui Simi, Dal simi, Asare simi	Phaseolus vulgaris L.
Grasspea	Khesari, Latara	Lathyrus sativus L.
Horsegram	Gahat	Macrotyloma uniflorum (Lam.) Verdc.
Jackbean	Khunde simi	Canavalia ensiformis (L.) DC.
Lablab bean	Tate simi	Lablab purpureus (L.) Sweet, syn. Dolichos lablab L.
Lathyrus pea	Kerauful	Lathyrus odoratus L.
Lentil	Musuro	Lens culinaris subsp. *culinaris*
Lima bean, butter bean	Simi	Phaseolus lunatus L.
Mothbean	Kulthi	Vigna aconitifolius (Jacq.) Marechal
Mungbean	Mugi	Vigna radiata (L.) R.Wilczek
Pea	Matar Kerau	Pisum sativum L.
Pea	Sanu Kerau	Pisum sativum subsp. *arvense* (L.) Asch. & Graebn.
Pigeonpea	Rahar	Cajanus cajan (L.) Millsp.
Ricebean	Mashyang, Siltung	Vigna umbellata (Thunb.) Ohwi & H.Ohashi
scarlet runner bean	Simi	Phaseolus coccineus L.
Soybean	Bhatmas	Glycine max (L.) Merr.
Sunhemp	Sanai, Chinchine	Crotalaria juncea L.
Swordbean	Tarbare simi	Canavalia gladiata (Jacq.) DC.
Tepary bean	Simi	Phaseolus acutifolius A.Gray
Velvet bean	Kause simi	Mucuna pruriens (L.) DC., syn. Mucuna cochinchinense (Lour.) A. Chev., syn. Dolichos pruriens L., syn. Stizolobium pruriens (L.) Medik
Velvet bean	Kause simi	Mucuna macrocarpa Wall., Mucuna nigricans (Lour.) Steud.
Vetch	Aakata (Wild species)	Vicia hirsuta (L.) Gray
Vetch	Kutuli kosa (Wild species)	Vicia bakeri Ali
Vetch	Munmun (Wild species)	Vicia tetrasperma (L.) Moench

English name	Nepali name	Scientific name
Vetch	Kutuli kosa (Wild species)	Vicia rigidula Royle
Vetch	Kutuli kosa (Wild species)	Vicia tenufolia Roth
Wild	Pili matari	Lathyrus aphaca L.
Wild	-	Lathyrus pratensis L., Lathyrus sphaericus Retz., Lathyrus humilis (Ser.) Spreng.
Wild	Gahate ghas	Desmodium gangeticum (L.) DC.
Wild chickpea	Jungali chana	Cicer microphyllum Benth., Cicer Jacquemontii Jaub. & Spach
Wild Cowpea	Bodi	Vigna nepalensis Tateishi & Maxted
Wild Fenugreek	Methijhar	Trigonella emodii Benth., Trigonella gracilis Benth., Trigonella corniculata (L.) L., Trigonella pubescens Baker
Wild pigeonpea	Jungali rahar	Atylosia elongata Benth., Atylosia scarabaeoides L. Benth., Atylosia volubilis (Blanco) Gamble, Atylosia cajanifolia Haines
Winged bean	Pate simi	Psophocarpus tetragonolobus (L.) DC.
Yambean, Potato bean	Kesour, Misrikand	Pachyrhizus erosus (L.) Urb.
Yardlong bean	Tane bodi	Vigna unguiculata var. sesquipedalis (L.) H.Ohashi
Zombi pea	-	Vigna vexillata (L.) A.Rich.

COLLECTION, CHARACTRIZATION AND EVALUATION OF GERMPLASM

Landraces of grain legumes have been grown by the people from times immemorial. However, due to the introduction of high yielding varieties of cereals and also legumes, expansion of irrigated area, and introduction of input responsive cereals, grain legumes have been pushed to more marginal areas and some of the landraces are being eroded due its replacement by high yielding exotic lines or varieties. Shift in cropping patterns and crop area among others have resulted in loss of landraces. For example, grasspea area has decreased from 51,170 hectares in 1984/85 to 5,662 hectares in 2013/14 and valuable landraces might have been lost.

Grain Legumes Research Program (GLRP) initiated systemic collection of germplasm in 1979 jointly with International Crop Research Institute for the Semi-arid Tropics (ICRISAT), and collected 100 pigeonpea and 45 chickpea landraces from 16 districts of Nepal. In 1987, Nepal Agricultural Association (NAA) with funding supports from International Development and Research Centre (IDRC), Canada collected 76 landraces of grasspea from 18 Tarai and Inner Tarai districts (Adhikary et al 1987). Following this, Winrock International and US Peace Corps sponsored for the collection of 43 landraces of lentil from 11 Tarai districts (Furman et al 1988). In 1995, legume germplasm collection was organized jointly by Center for Legumes in Mediterranean Agriculture (CLIMA) and NARC, and 693 accessions of different legumes (**Annex** 1 and 2) were further added to the existing germplasm (Robertson et al 1995). Landraces collected from the above collection missions were shared with PGRU/NARC-GLRP. Then National Legumes Research Program (NGLRP) collected 90 landraces of *Phaseolus* bean from Jumla and adjacent districts through Hill Agriculture Research Program (HARP) supported project in 1999. In addition, sporadic collection of grain legume germplasm by GLRP, Agronomy Division, other NARC centers and joint collection missions organized by Agriculture Botany Division from time to time has contributed to the existing germplasm in the country. A total of 2,936 landraces of different legume crops have been conserved at the Gene Bank of NAPGRC (**Annex** 3)**.** GLRP Khajura and Agronomy Division Khumaltar have active collections of 218 landraces and 627 exotic germplasm of various legume crops (**Annex** 4). Duplicate samples of landraces collected during joint collection missions have been maintained at gene banks of ICRISAT, ICARDA, AVRDC, and University of Manitoba, Canada. AVRDC has 8 genotypes of ricebean from 2000 m altitude in Bajura district (World Vegetable Center 2007).

Characterization of Grain Legume Germplasm

The first systemic characterization of legume germplasm using IBPGR descriptors was carried in 2087/88 at NARC research centers (Furman and Bharati 1989). Following the collection, 270 chickpea, 70 cowpea, 87 grasspea, 137 lentil, 53 mungbean, 227 pigeonpea and 30 soybean germplasm were characterized by GLRP. Similarly, 230 soybean, 250 beans, 140 pea, 136 ricebean, 90 lentil and 171 grasspea accessions have been characterized as per the IBPGR descriptors at NPGRC, Khumaltar (Joshi et al 2013). Neupane et al (2007) conducted characterization of 90 common bean germplasm at ARS Jumla, and Pandey et al (2011) at RARS Lumle. Wide variations in morphology, yield components and yield have been observed among landraces. Suitable varieties identified through the study have been used in crop improvement program and some of the cultivars promoted in farmers' field. Bajracharya et al (2010) conducted molecular diversity analysis of 91 ricebean landraces from Nepal and 21 from India. Similarly, DNAs of 75 accessions of beans and 50 accessions of ricebean have been preserved at NAGRC, Khumaltar (Joshi 2017, Bajracharya et al 2010).

VARIETAL DIVERSITY

Grass pea: A wide range of variability was recorded in plant height, number of pods per plant seeds per pod 100 seed weight and grain yield in evaluation of 76 local and 17 exotic germplasm (Furman and Bharati 1989). Local germplasm lines were found to be more adopted higher yielding and early but were having smaller seed size than the exotic germplasm (Bharati and Neupane 1988). Landraces showed high level of ODAP content in the seeds (**Table** 2). In an attempt to promote grasspea lines with low level of ODAP in seeds, low ODAP lines 19-A, 20-A, CLIMA Pink, CLIMA-2 and BARI-2 were introduced from CLIMA, Australia through the ACIAR funded project "Lentil and lathyrus in the cropping systems of Nepal". Due to better adaptability of CLIMA Pink, 19-A and 20-A, these were introduced in grasspea growing pockets in some districts to replace the landraces with high level of ODAP (Neupane and Tiwari 2005). CLIMA pink has been adopted by farmers in Padharia village in Siraha district of Nepal.

Lentil: Lentil cultivars grown in Nepal are small seeded *pilosae* types belonging to the subspecies *Microsperma (*Bahl et al 1991) that have limited genetic variation (Erskine and Saxena 1991, Erskine et al 1998). These are characterized by small seeds, plant parts covered with white hairs and have red cotyledons, whereas the *Macrosperma* types introduced from Mediterranean region are bold seeded, have no pubescence in the foliage, flower and mature late in south Asian environment and have yellow cotyledons. In recent years, successful introduction of early flowering line Precoz (ILL4605) as a parent in crossing programs with *Microsperma* types has led to the development of high yielding varieties in the Indian subcontinent. All varieties released in Nepal are of *Microsperma* types with seed sizes ranging from small to medium (**Annex** 5). Lentil varieties HUL 57, DPL 62 and PL 4 introduced through SAARC Shuttle Breeding Project on Pulses "Breeding for the Development and Identification of High Yielding Varieties of Pulses for Sustainable Agriculture in South Asia were promising in terms of grain yield and size (bold) (NGLRP 2012).

Kidneybean: Ninety landraces of kidney were characterized as per the IBPGR descriptor at ARS Jumla (Neupane et al 2007). A wide range of variability was recorded in seed size, seed color and plant morphology and as many as 18 local names were given to beans. *Kharani Khairo, Mriggaula, Phokserang, Bhotesimi Bokasimi, Gheusimi, Ratodolpaya, Piyalasimi, Kalosimi, Setosimi, Rajma, Rajmash, Simi, Motosimi, Malesimi, Akashesimi, Hariyosimi, Lekalisimi* are some of the names by which beans are known to different ethnic groups in the area. Most of the local landraces were a mixture of different types, varying in seed size, shape, and color. Examination of seed samples revealed that color of the seed ranged from pink, purple, ash, cream, yellow, maroon, black, and violet, shining purple, red and different shades of the main color. Seed shape was predominantly elliptical. Others were ovoid, round, kidney shaped, flat or square and cuboids. Kidneybean genotypes PB0002 and PB0048 selected from landraces were high yielding and promising both for green pods and dry seeds for growing as a rainy season crop in the mid to High Hills of Mid/Far Western Region (FORWARD Nepal). Other landraces found promising at Jumla are KBL 2, KBL 3, KBL 3, KBL4, KBL5, and KBL6.

Blackgram: It is comparatively hardy pulse crop and is mostly grown in well drained upland Mid Hills regions of the country after maize harvest or is intercropped in with maize. Landraces are photo period sensitive and location specific. Much genetic variation is observed in this crop in Nepal. In some areas scented varieties have been recorded. It is a most profitable crop for the farmer because it commands good market price. Yellow mosaic is the major problem. In most cases, seed color is dull black. However, shiny black and shiny green seeded blackgram is also cultivated in Nepal. Only one variety Kalu has been recommended so far. Blackgram varieties IPU-2002-1, IPU-2002-2, NDU-1 introduced through SAARC Shuttle Breeding Project on Pulses were promising while Bhutanese varieties: Tsirang Local Yellow and Tsirang Local Black were severely affected by MYMV (NGLRP 2012). Other promising lines identified at GLRP were BLG0003-2-1, BLG0069-1, BLG0072-1, BLG0076-2, BLG0061-2-2 and BLG0068-3 and BLG-0067-1 and BLG0076-1.

Table 2. Grain legume Landraces with specific traits

SN	Crop	Local name	Special traits
1	Soybean	Sathiya	Puff when roasted, brown testa color, matured in 90 days, determinate with white flower, grown in rice bund and as intercrop in maize

SN	Crop	Local name	Special traits
		Thulo Bhatmas	Late maturity, bold seeded and tasty
		Kalo Bhatmas	Early (90 days maturity), short plant stature, black testa color, bold seeded, seeds valuable for Hindu rituals
2	Blackgram	Chillo Chhebetar	Better consistency of Daal soup, faster cooking, tasty
		Phushro mas	Better consistency of Daal soup, faster cooking, tasty
		Kalo mas	Better consistency of Daal soup, faster cooking, tasty
		Mugi mas, Hariyo mas	Green seeded blackgram , grown after early rice as a relay or sequence crop in Deukhuri valley
3	Lentil	Kalo Musuro	Tasty, good cooking quality
		Local Musuro	Tasty, fast cooking, small seeds, high export potential, recognized as Tasty, Small, Pink lentils in international market
4	Pigeonpea	Dhanusha Local (coded as PR 5147)	Small seeds, better taste and cooking quality, Resistant to Sterility Mosaic Virus Disease (SMD)
		Rampur local	Early, multicolored, white brownish or spotted seed coat, resistant to sterility mosaic
5	Common bean	Jumli Simi	Good taste , faster cooking, high market price, multi-colored
		Asare Simi	Early maturity, semi determinate, suitable for both green pod and dry seeds, grown in Kathmandu valley
6	Mungbean	Mugi sthaniya (Saptari local)	Small seeds, plant architecture Pyramid shaped, tasty and fast cooking
7	Cowpea	Kartike Bodi	Late maturing, trailing, seeds black-eyed, green-pods used as vegetable and dry seeds as pulses
		Makai Bodi	Medium maturity, grown as mixed crop with maize, used as green pod and dry seeds
8	Grasspea	Latara or Matara or Khesari	Blue/violet flowered crop grown in the Tarai/Inner Tarai under relay cropping with rice. Seeds used as pulses and straw as fodder to the livestock. Seeds contain high levels of neuro toxin ODAP
9	Horsegram	Ghode Gahat	Bold mottled seed coat, Daal tasty, grown in Ramechhap district

Mungbean: Mungbean area is very much concentrated in the eastern part of the country. It is mostly grown in the rice wheat system where irrigation facilities are available. It is sown in March-April and harvested before the unset of monsoon rains. One or two picking are done and then the crop is residue is incorporated into the soil as green manure. Three varieties have been recommended cultivation. Mungbean varieties such as HUM 12, IPM 16, HUM 12 and HUM 1 introduced through SAARC Shuttle Breeding Project performed better in terms of grain yield and seed size as compared to Saptari local (NGLRP 2012). Other promising lines identified are: NIMB-101, VC6173A and VC 6368(46-40-4), Bari Mung and VC-6173 (B-10). BARI Mung and HUM-16 identified as having stable in yield, synchronous and early maturity, bold and shining seeds and tolerant to mungbean yellow mosaic virus.

Soybean: In evaluation of soybean at Rampur, high diversity found in seed coat color of the soybean landraces. Out of thirty three accessions, thirteen had black seed coat color; two had buff, one grey, three imperfect black, two reddish brown, eight yellow and remaining four had yellowish white seed coat color. Flower color and patterns were also found diverse among accessions. Out of the thirty three local landraces, twenty one had white flower color, four had purple throats, and three had purple flower. Five landraces had trailing type, typical little leaves like wild type along with purple flower colors. This study indicated the presence of high levels of genetic variability among the soybean accessions. Cluster analysis using seven morphological traits grouped 101 soybean accessions collected from National Agricultural Genetic Resources Centre (Genebank) and exotic lines from IITA, Nigeria into five major groups at the genetic distance of 267.82, and 84 landraces were grouped into cluster I. Cluster analysis has facilitated for the selection of parents having distant relationship to obtain greater heterosis. Out of the eight varieties released so far, one variety Hill has been denotified (**Annex** 5).

Pigeonpea: Pigeonpea is the third most important legume crop in Nepal. It is mostly grown under upland conditions as a sole crop or mixed crop with maize and on paddy bunds. Pigeonpea on bunds is popular in the eastern part of the country, whereas it is grown as sole crop in the western part as mixed crop in the Mid Hills and Tarai. Long duration varieties are popular in the western part of the country whereas medium duration varieties and post rainy season are popular in the eastern part. Apart from release of two varieties from the landraces, dual purpose (vegetable and seed) variety ICP7035 is at the final stage of registration/release.

Breeding lines developed from crosses at Nepalgunj are: NP-02-3-10, NP02-4-17, NPJ-08-1-1, NPJ-08-2-6 and NPJ-08-4-6.

Chickpea: Chickpea is grown on relatively heavier soils under rice-chickpea and maize-chickpea cropping system and also as a mixed crop with linseed, barley and rape seed mustard. Eight varieties consisting of seven Desi and one Kabuli type have been released so far. Crossing program is in place for development of high yielding, Botrytis gray mold (BGM) and wilt tolerant varieties.

Ricebean: Ricebean is self-pollinated crop but natural out crossing has been reported by various authors. It is highly photosensitive short-day crop so its cultivation is restricted to rainy season in Hills. However, indeterminate cultivars when sown in August showed determinate growth habit. A great variation in seed color has been observed in landraces. A total of 218 ricebean accessions were collected from different districts of the country in early 1970's. High yielding accessions identified are LRGR 91, LRGR 111, NPGR 05364 and NPGR 00008 (NGLRP 2010).

UTILIZATION OF LANDRACES IN VARIETY IMPROVEMENT PROGRAM

Following the principles of conservation through utilization, efforts have been made to utilize landraces in variety improvement program through official release of the variety directly or as a parent in the crossing program to transfer desirable traits of landraces to high yielding genotypes or lines. NARC has released pigeonpea varieties Bageshwori and RampurRahar-1, chickpea varieties Trishul and Dhanush, lentil variety Sindur, asparagus bean (*Vigna unguiculata* var. *sesquipedalis*) varieties Khumal Tane and Sarlahi Tane from landraces (Upadhyay 1999). Apart from high yields, pigeonpea variety Bageshwori, a selection from landrace from Dhanusha district is resistant to sterility mosaic virus disease (SMD) and it has been used as a source of resistance in crop improvement program (ICRISAT 2007). In the context of increasing demand of vegetable soybean, crossing program has been initiated at Agronomy Division Khumaltar. Derivatives of cross between the landrace Kalo Bhatmas and Tarkari Bhatmas 1, a selection from Huichin #2 are in the advanced stage of testing under sole cropping and intercropping with maize (Agronomy Division 2015). Black lentil, a landrace from Rasuwa district has been selected by GLRP for release/registration. In pigeonpea, Dhanusha Local and *Atylosia scarabaeoides* (L.) Benth., a wild relative, have been used in a crossing program with adapted varieties ICPL 99089, ICP 7035 and Bahar -1. Derivatives of the crosses are in the advanced stage of evaluation.

However, due to the multiplicity of grain legumes species and the inadequacy of scientific manpower at NARC, efforts towards utilization of landraces in variety improvement program has been far from satisfactory and import of elite lines or segregating population from CG centres has got priority in the Grain Legume Research Program. To address the issue, collaborative crop breeding program with CG centres has been initiated wherein suitable crosses for Nepali environment are made in CG Centres and the advanced lines and segregating materials brought to Nepal for local selection and advancing as a variety.

SOCIO-CULTURAL USE OF LEGUMES

A number of legume crops have special socio-cultural and religious significance in the Nepali community (**Annex** 6). In this context, blackgram, black seeded soybean, horsegram, mungbean and pea (Regmi 1983) and ricebean (Khadka and Acharya 2009) have special significance. Ricebean has cultural and religious values in Nepalese society. *Batuk and Bara* prepared from ricebean is used during wedding ceremony and other social functions in Magar and Newar communities. The Nepalese have a tradition of preparing soup (*Kwanti*) from a mixture of nine grain legumes during the festival of Janai-Purnima. *Khichadi* is a traditional dish prepared from a mixture of rice and blackgram or ricebean on the occasion of Maghe-Sankranti, a festival celebrated by Nepalese during mid-January. Black soybean has a special place in Newari culture and finds its place as an important constituent of *Syabaji.* In some villages of Karnali zone, instead of rice grains the broken cotyledons of Kidneybean is used for putting in the forehead as *Akshata.* Blackgram find sits place in many rituals in Nepali community.

CONCLUSION AND WAY FORWARD

Nepal has a rich diversity in food legume species. These legume crops are indispensable part of the prevailing farming systems in various agro-ecological zones of the country. Due to the role played by legumes in human food, livestock feed and maintenance of soil fertility, and increased market demand of legumes, the area and production of these crops has increased in recent years. However, due to the introduction of input intensive high yielding varieties of cereal crops, population pressure on land area and other developmental interventions, there has been shift in area of pulses, resulting in losses in agrobiodiversity at the species and variety level. Past efforts on collection and conservation of landraces have to be supported by their utilization in crop improvement program. Collection of landraces from new area and of neglected species eg ricebean, horsegram should get top priority. We suggest the following intervention areas for the conservation of PGR in the context of Grain Legumes:

- Priority for collection of horsegram, pea, common bean, and ricebean germplasm
- Collection of lentil germplasm from High Hills/Mountains, cowpea germplasm from Mid Hills
- Characterization and maintenance of database of legume landraces and their wild relatives for easy access to breeders
- Prioritizing using of landraces in crop improvement program to confer local adaptation traits into new varieties
- Establishment of satellite breeding programs at different agro-ecological zones as per importance of grain legume crops
- Characterization and evaluation of germplasm at agronomic, biochemical and molecular levels to support crop improvement program
- Identification of trait specific germplasm and gene pools of food legumes for use in crop improvement program
- Ensuring maintenance of germplasm in a safe and secure way

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Annex 1. Summary of grain legume germplasm collection missions

Collection mission	Year	Crops														
		Chp	Pgp	Len	Grp	Phb	Bgm	Mbn	Soy	Pea	Fbn	Cp	Fng	Vic	Rbn	Oth
ICRISAT/NARC	1979	45	100													
NAA/IDRC	1987				76											
US/Peace Corps	1988			43												
CLIMA/NARC	1995	70	29	140	90		44	9	6	116	93	3	13	51		19
NGLRP	1999					100										
LIBIRD/NARC/FOSRIN															70	
Total (1117)		**115**	**129**	**183**	**166**	**100**	**44**	**9**	**6**	**116**	**93**	**3**	**13**	**51**	**70**	**19**

Note: Chp=Chickpea, Pgp=Pigeonpea, Len=Lentil, Grp= Grasspea, Phb= Phaseolus bean, Bgm=Blackgram, Mbn=Mungbean Soy=Soybean, Pea= Pea, Fbn= Fababean, Cp=Cowpea, Fng=Fenugreek, Vic=Viceae species, Oth=others, Rbn=Ricebean

Annex 2. Status of legume landraces at NAGRC, Khumaltar and other world centers

SN	Species	NAGRC, Khumaltar	Other centers			
			ICARDA	ICRISAT	Agriculture Canada	AVRDC
1	Soybean	539	6			
2	Lentil	490	140			
3	Blackgram	166	44			
4	Pigeonpea	279	29	129		
5	Lathyrus	164	100		76	
6	Pea	188	99			
7	Pea arvense	-	17			
8	Chickpea	-	70	191		
9	Fababean	62	93			
10	Mungbean	82	9			
11	Ricebean	150				8
12	Cowpea	221	3			
13	Common bean	498				
14	Horsegram	56				
15	Adzuki bean	7				
16	Hyacinth bean	9				
17	Sword bean	7				
18	Fenugreek		13			
19	Kidney bean	2				
20	Vicia species		51			
21	Common spring vetch	16				
22	Others		19			
	Total	**2936**	**693**	**320**	**76**	**8**

Annex 3. Total number of legumes germplasm available at GLRP, Khajura

SN	Crop	Total active germplasm	Exotic lines	Local landraces
1	Lentil	146	145	1
2	Chickpea	116	115	1
3	Grasspea	30	25	5
4	Kidneybean/ Rajma	21	15	6
5	Mungbean	171	56	115
6	Cowpea	86	82	4
7	Soybean	150	113	37
8	Blackgram	40	1	39
9	Pigeonpea	85	75	10
	Grand Total	**845**	**627**	**218**

Annex 4. Summary of grain legume germplasm characterized as per IBPGR Descriptors at GLRP

SN	Crop	Total	Landrace	Exotic
1	Chickpea	237	121	116
2	Cowpea	72	0	72
3	Kidneybean	100	90	10
4	Lathyrus	87	82	5
5	Lentil	137	124	13

SN	Crop	Total	Landrace	Exotic
6	Mungbean	53	2	51
7	Pigeonpea	227	128	99
8	Soybean	230	73	157
	Total	**1043**	**530**	**513**

Annex 5. Released varieties of food legumes in Nepal as of 2017

SN	Variety	Accession no	Source	Release year
	Lentil			
1	Sindur	LO-111-25	Nepal	1979
2	Sisir	P43	India	1979
3	Simrik	T36	India	1979
4	Shikhar	LL 4404	Pakistan	1989
5	Simal	LG 7	India	1989
6	Khajura Musuro 1	LG 198	India	1999
7	Khajura Musuro 2	PL 639	India	1999
8	Shital	ILL 2580	ICARDA	2004
9	Sagun	ILL 6829	ICARDA	2009
10	Maheshwor Bharati	ILL 7982	ICARDA	2009
11	Khajura Musuro 3 (RL 4)	ILL 6037 x ILL 8007	Nepal	Technical committee 2017
	Chickpea			
1	Dhanush	Landrace	Nepal	1980
2	Trishul*	Landrace	Nepal	1980
3	Radha	JG 74	India	1987
4	Sita	ICC4	ICRISAT	1987
5	Koseli	ICCC32	ICRISAT	1991
6	Kalika	ICCL82108	ICRISAT	1991
7	Tara	ICCX840508-36	Nepal	2009
8	Avarodhi	Avarodhi	India	2009
	Soybean			
1	Hill*	(Downfield x XHaberlandt) x Sib of Lee	USA	1976
2	Hardee	D 49-772 x Improved Pelican	USA	1976
3	Cobb	F 57-737 x D 58-3358	USA	1989
4	Ransom	(N 55-5931 x N55-3818) x D56-1185	USA	1989
5	Seti	KS 419 x KS 525	Taiwan	1989
6	Lumle-1	Local	Nepal	1997
7	Tarkari Bhatmas-1	Huichin#2	China	2004
8	Puja	PK 416	India	2006
	Pigeonpea			
1	Bageshwori	PR 5147	Nepal	1991
2	Rampur Rahar-1	Local	Nepal	1991
	Blackgram			
1	Kalu	T 9	India	1971
	Mungbean			
1	Pusa Baisakhi		India	1975
2	Pratikshya	VC 6372(45-8-1)	AVRDC	2006
3	Kalyan	NM 94	AVRDC	2006
	Cowpea			
1	Aakash	IT82D-752	IITA	1990
2	Prakash	IT82D-889	IITA	1990
3	Surya	IT86D-792	IITA	2004
4	Malepatan-1	IITA Nigeria	IITA	2011
5	Gajale Bodi	IT98K205-8	IITA	Technical committee 2017
	Asparagus bean			
1	Khumal tane		Local	1994
2	Sarlahi tane		Local	1994

SN	Variety	Accession no	Source	Release year
	Kidney bean			
1	Trishuli Geu Simi		Nepal	1994
2	Jhange Simi-1		Nepal	1994
	Field Pea			
1	Sarlahi Arkel		India	1994
2	New Line		India	1994
3	Sikkime		India	1994
	Registered food legume varieties			
	Cowpea			
1	Double harvest		China	2010
2	Karma stickless		Thailand	2013
3	NO-324		Japan	2013
4	Sila-464		Thailand	2013
5	Chandra 041 OP		Thailand	2010
	Pole bean			
1	Mandir OP		Thailand	2010

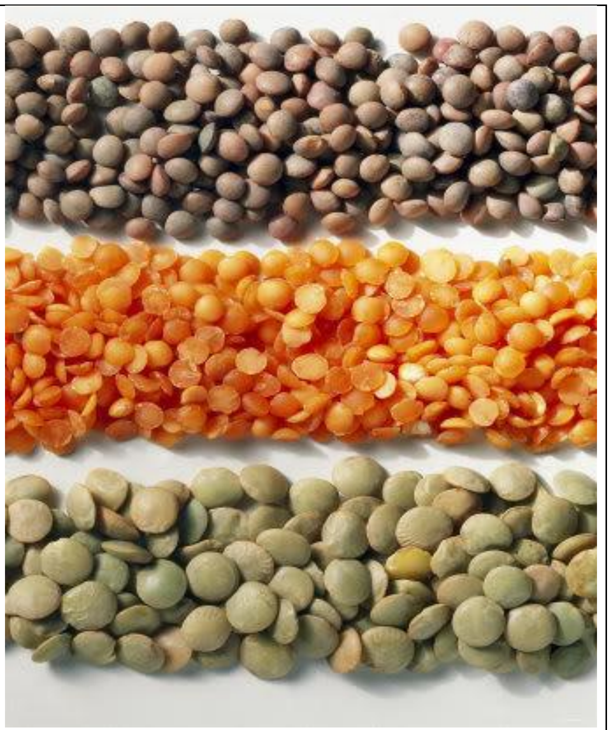
*Denotified

Annex 6. Religious cultural importance of grain legumes

Species	Religious uses
Blackgram	Bara made from blackgram is offered to ancestors during *Pitripooja* by Hindus, For Rahu and Ketu graha Shanti, In Newar community, Blackgram is offered to Saturn during graha pooja conducted in the birthday. During *Hanuman Pooja* in Shrawan, Bara from Blackgram is offered to the deity. Blackgram leaves are eaten during *Narak Chaturdashi* in the first lunar of Kartik, *Samayabaji* with Bara is offered to Bhagawati.
Chickpea	Roasted chickpea offered to Shantoshi Mata Pooja on Friday, for offering sweets to Goddess Saraswoti during Saraswoti Pooja
Common bean	In Karnali zone, broken cotyledons of beans are used for Tika in the foreheads.
Horsegram	Grahadaan of Saturn, wedding auspicious day obstacles, it is used
Lentil	Lentil is offered to pacify *Mangal* (Mars)
Mungbean	Mungbean seeds are used in Mercury planet (Bhudhagraha shanti). In *Rama Ekadashi,* Mung laddo is offered to Lord Keshav, Krishna-Satyabhama
Pea	Offered to Shukra graha during birthday in Newar community, in Swasthani pooja pea and roasted wheat is offered, water-soaked small pea is thrown during chariot ceremony of Chandeshory fair in Banepa
Mungbean	Mungbean seeds are used in Mercury planet (*Bhudhagraha shanti*). In Rama Ekadashi, Mung laddo is offered to Lord Keshav and Krishna-Satyabhama
Soybean	Black seeded soybean is a constituent of *Samayabaji* (a mixture of salted beaten rice *Syavabji*, (choyela) black soybean, cowpea and dried fish) offered to Goddesh Bhagawati. It is also used to pacify Saturn, and bad- spirits
Yambean	Extensively used in Saraswoti pooja, or by women fasting in *Ekadashi* in the Central Tarai
Ricebean	During *Gaura Parba*, a festival celebrated widely in Far Western Region of Nepal, ricebean is one of the five grains used in preparing *Biruda*, an offering made to the festival deity.

Source: PP Regmi 1983-Patram Puspam.

Annex 7. Some grain legumes



Diversity of Lentil (*Lens Culinaris* subsp. *culinaris*)

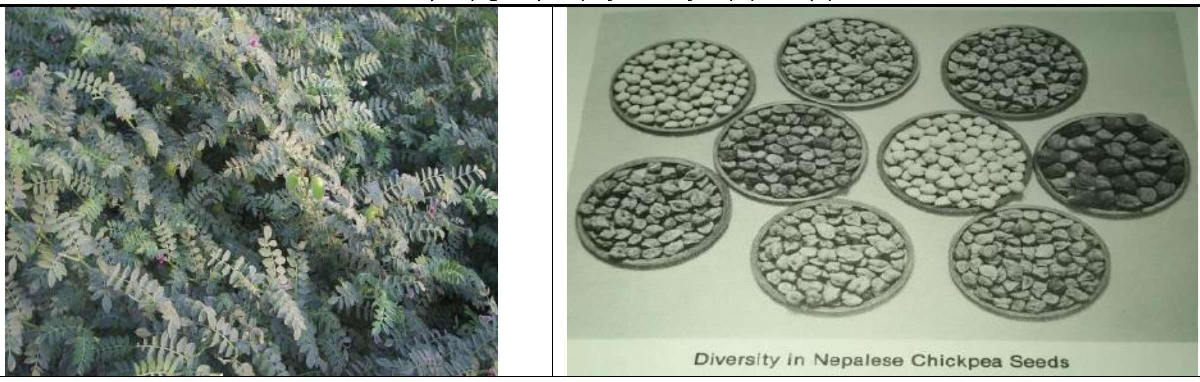
Diversity of Mungbean (*Vigna radiata* (L.) R.Wilczek)

Diversity of common bean (*Phaseolus vulgaris* L.)

Diversity of Ricebean (*Vigna umbellata* (Thunb.) Ohwi & H.Ohashi)

	
Grasspea (*Lathyrus sativus* L.)	Sunhemp (*Crotalaria juncea* L.)
	
Fababean (*Vicia faba* L. eu major)	Fababean (*Vicia faba* L. eu major)
	
Diversity of Cowpea (*Vigna unguitlata* (L.) Walp.)	

Diversity of pigeonpea (*Cajanus cajan* (L.) Millsp.)



Diversity of chickpea (*Cicer arietinum* L.)

Diversity of Soybean (*Glycine max* (L.) Merr.)

Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal (BK Joshi, HB KC and AK Acharya, eds). Proceedings of 2nd National Workshop, 22-23 May 2017 Dhulikhel; NAGRC, FDD, DoA and MoAD; Kathmandu, Nepal

Oilseed Genetic Resources: Diversity and Utilization Status in Nepal

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ABSTRACT

Nepal produces diverse oilseed crops in a great variety of environments and cropping patterns. Seven species of oilseed crops are under cultivation. Rapeseed (Tori) is the major oilseed crop cultivated in all agro-ecological regions of the country. Yellow Sarson, Rayo, Groundnut, Sesame, Niger, Sunflower and Linseed are other edible oilseed crops cultivated in small scale. Castor, an industrial oil crop is wildly grown in the waste land and Safflower is confined in kitchen garden in central Tarai but these crops are not included in oilseed crop in Nepal. National Oilseed Research Program, Nawalpur, Sarlahi has mandated to generate technologies on eight oilseeds crops and has given high priority on Toria, mustard and groundnut and low priority in sesame, yellow Sarson, niger, sunflower and linseed. Diversity in Toria exists at genotypic level and different ecotypes are found in different agro ecological regions. Lumle Tori-1, Morang Tori-2 and Surkhet local Tori-3 are the outcomes of local selection. Diversity in sesame also exists and different maturity groups are available. Nawalpur Khairo Til-1 and Nawalpur Jhuse Til-1 were released from local selection of sesame and niger, respectively. Depending on pod size, groundnut local cultivars have been reported as Jethi Badam, Mahili Badam and Kanchhi Badam. Kailali, Dang, Chitwan, Bardiya and Banke are the major Toria growing districts of Nepal. Till now 16 varieties of oilseed crops have been released and one registered for general cultivation. Moisture stress in rainfed oilseed crops, declining soil fertility and native honeybee population, soil acidity, foggy winter, alternaria blight disease and aphids are the major constraints in rapeseed and mustard production. Inadequate scientific staffs and resources are the major constraints in plant genetic resources utilization in oilseed crops.

Keywords: Declining, diversity, local cultivar, niger, sesame, soil fertility, toria

INTRODUCTION

Oilseed crops are important cash crop of Nepal. Oilseed crops occupied about 5% of the total cropped area and ranked sixth after rice, maize, wheat, grain legumes and millets in terms of acreage. The oilseed area, production and yield were 224582 ha, 194536 ton and 866 kg/ha, respectively during 2013/14 (MoAD 2014). During the last 30 years period the area, production and yield of oilseed crops have increased by 75.7,131.5 and 31.8%, respectively (**Annex** 1). The growth figures (**Figure** 1) reveals that the productivity continues to remain low and therefore, major steps are required to enhance productivity rather than increasing the area under these crops. Its' importance is high as there is high domestic demand and have high export potential. Oilseed crops are the source of minerals, proteins and vitamins and help these under nourished group of people. Oils and fats are concentrated sources of calories. One gram of fat provides 9 calories against 4 by starch or protein. In addition, oils and fats of plant origin are superior to that of animal origin (Chaudhary 2008). Rapeseed and mustard are the most cultivated oilseed crop in Nepal (**Annex** 2), central development region has the largest area of oilseed crops (**Annex** 3) and Tarai has the most cultivated area (**Annex** 4).

Nepal produces a wide diversity of oil crops in a great variety of environments and cropping patterns from east to far western regions, from the High Hills to the Tarai (Koirala 1995). Rapeseed and mustard are the major oilseed crops cultivated in all agro-ecological regions of the country from High Hill (2500 masl) to Tarai and Inner Tarai (58 masl). There are two main seasons for growing oilseed crops in Nepal and accordingly they are grouped into summer and winter oilseeds. Groundnut, sesame, and niger are summer season oilseed crops. Rapeseed-mustard and linseed are winter oilseed crops. Sunflower can be grown round the year; however, it is suited for cultivation in spring and winter season in Tarai and Inner Tarai environment. Safflower is also grown in central Tarai as green vegetable not for oil crop. However, its oil is nutritionally superior to all other oilseed (Ghimire 2014). Radish seed is also used for oil extraction mix with Tori seed especially in Mid Western Hill. Chiuri or butter tree (*Diploknema butyracea* (Roxb.) H.J.Lam is also a source of vegetable ghee in Mid Hill. Dhatelo, walnut, wild peach and apricot are the source of edible oils in high mountains (KC 2014). Similarly, Castor is an industrial oil crop wildly found in the waste land and home yard in Tarai and Inner Tarai. It's cultivation is limited in certain places like Chitwan. Other industrial oil producing trees viz Sal (*Shorea robusta*

Gaertn.), Mahuwa (*Madhuca indica* J.F.Gmel.) and Jatropha (*Jatropha curcas* L.) are also found in Nepal (Ghimire 2013). National Agriculture Genetic Resource Center, Khumaltar has recognized 13 species as oil producing plants in Nepal (Joshi 2017). Coconut (*Cocos nucifera* L.), Nepali butter tree (*Bassia latifolia* Roxb.), Himalayan cherry (*Prinsepia utilis* Royle) and Artichoke (*Helianthus tuberosus* L., *Cynara scolymus* L.) produces oils from their fruits but they are not commercially grown as oilseeds in Nepal. 150 accessions of different oilseed crop species are conserved in seed bank and 92 rapeseed accessions were characterized and evaluated at National Agriculture Genetic Resource Center, Khumaltar (Joshi et al 2013). At present 354 rapeseed mustard, 77 groundnut, 67 niger, 43 linseed and 34 sesame accessions were maintained and evaluated at NORP, Nawalpur, Sarlahi (ORP 2016).

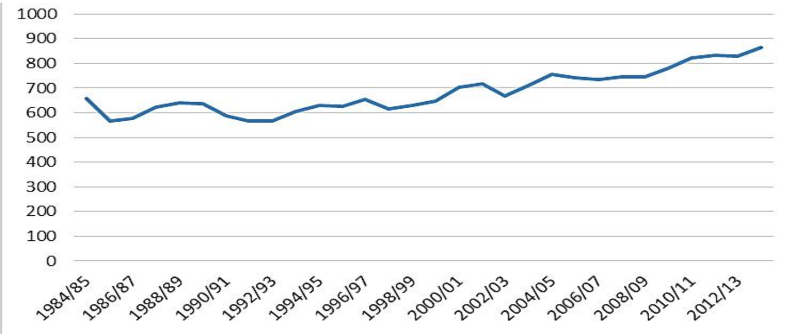

Figure 1. Oilseed productivity (kg/ha) over last 30 year (Figure in **Annex** 1).

Table 1. Oilseed crop species

SN	Common name	Nepali name	Scientific name
1.	Black Mustard*	Black mustard	Brassica nigra (L.) K.Koch
2.	Brown Sarson	Brown Sarson	Brassica rapa subsp. sarson (Prain) Denford) Syn. Brassica campestris var. sarson (Prain)
3.	Castor	Adir	Ricinus communis L.
4.	Ethiopian/Abyssinian mustard	Karan rai	Brassica carinata A.Braun
5.	Groundnut/peanut	Badam	Arachis hypogaea L.
6.	Indian Mustard	Rayo, rai, raichi, tora, barsale	Brassica juncea (L.) Czern.
7.	Linseed	Aalas	Linum usitatissimum L.
8.	Niger	Ram Til, Jhuse Til, Filunge	Guizotia abyssinica (L.f.) Cass.
9.	Rapeseed	Tori	Brassica rapa subsp. rapa Syn. Brassica campestris var. toria Duthie & Fuller
10.	Safflower	Kusum	Carthamus tinctorius L.
11.	Sesame	Til	Sesamum indicum L.
12.	Sunflower	Suryamukhi	Helianthus annuus L.
13.	Swede rape	Gobhi Sarson	Brassica napus L.
14.	Taramira*	Taramira	Eruca sativa Mill.
15.	Yellow Sarson	Sarson	Brassica rapa ssp. yellow sarson Syn. Brassica campestris var. yellow sarson

**Not grown in Nepal.*

Table 2. Some information on botany of oilseed crops

SN	Crop	Chromosome, 2n	Mode of pollination	Family	Order	Fruit type
1	Tori	20 (diploid)	Cross	Crucifereae	Rhodales	Siliqua
2	Yellow Sarson	20 (diploid)	Self (upto 30% cross pollination)	Crucifereae	Rhodales	Siliqua
3	Mustard	36 (tetraploid)	Self (upto 30% cross pollination)	Crucifereae	Rhodales	Siliqua
4	Gobhi Sarson	38 (tetraploid)	Self	Crucifereae	Rhodales	Siliqua
5	Karan rai	34 (tetraploid)	Self	Crucifereae		Siliqua
6	Groundnut	40	Self	Leguminosae	Rosales	Pod
7	Sunflower	34	Cross	Compositae	Campanulales	Head/capitulum
8	Sesame	26	Self (10-50% cross)	Pedaliaceae	Tubiflorae	Capsule
9	Niger	30	Cross	Compositae		Capitulum
10	Linseed	30	Self	Linaceae		Capsule

Source: NoRP 2010.

Table 3. Species of rapeseed and mustard

SN	Common name	Nepali name	Species
1.	Mustard/Black mustard*		Brassica nigra (L.) K.Koch
2.	Mustard/Karan rai		Brassica carinata A.Braun
3.	Mustard/Rayo	Rayo/Raichi/Thulo Tori	Brassica juncea (L.) Czern.
4.	Rapeseed/Gobhi sarson	Kauli Tori	Brassica napus L.
5.	Rapeseed/Brown sarson		Brassica rapa L. ssp. *brown sarson*
6.	Rapeseed/Taramira*		Eruca sativa Mill.
7.	Rapeseed/Toria	Tori	Brassica rapa L. ssp. *toria*
8.	Rapeseed/Yellow sarson	Sarsyu	Brassica rapa L. ssp. *yellow sarson*
9.	White mustard*		Brassica alba (L.) Rabenh.

**Not grown in Nepal, Source: NoRP 2010.*

RAPESEED AND MUSTARD

Rapeseed and mustard are the number one edible oilseed crops of Nepal. This includes Tori, sarson and rayo. They occupy around 85% of the total oil crops area (191792 ha). Area of Tori in Nepal is 173254 ha with production of 152263 mt and productivity 0.879 mt/ha; mustard 7074 ha, production 6125 mt and productivity 0.866 mt /ha and sarson 11464 ha, production 9709 mt and productivity of 847 kg/ha (MoAD 2014). Among rapeseed mustard, 77% area is under Tori in Nepal (NICDP 2015). Around 5% area is under yellow sarson and 3% in rayo/rai especially in relay condition after rice and mixed with wheat especially in Tarai, Inner Tarai and Mid Hill conditions. Gobhi sarson (*Brassica napus* L.) is also grown in small scale in Mid and Far Western development region especially in Tarai and river basin area of Mid Hills. But area under this crop is negligible.

Rapeseed and mustard are third most important edible oilseeds of the world after soybean and palm oil (NRCRM 2000). Seven important annual oilseeds belong to the tribe *Brassiceae* are grown worldwide. Under the name rapeseed comes three ecotypes of Indian rape, *Brassica rapa* L. (Syn. *Brassica campestris* L.), namely, *Brassica rapa* L. ssp. *toria*; *Brassica rapa* L. ssp. b*rown sarson*; *Brassica rapa* L. ssp. *yellow sarson*, Swede rape or gobhi sarson (*Brassica napus* L.) and Taramira (*Eruca sativa* Mill.). Indian mustard (*Brassica juncea* L. Czern.) commonly called rai/raya/rayo/raichi, Ethopian/Abyssinian mustard or karan rai (*Brassica carinata* A.Braun) and black mustard (*Brassica nigra* (L.) K.Koch) are commonly known as mustard. The genomic relationship among the six *Brassica* species based on interspecific hybridization and cytogenetical evidence showed that *Brassica nigra* (n=8; B), *Brassica oleracea* L. (n=9; C) and *Brassica campestris* (n=10; A) are primary diploid species and that *Brassica carinata* (n=17; BC), *Brassica juncea* (n=18; AB) and *Brassica napus* (n=19; AC) are amphidiploids, naturally derived from the crosses between corresponding pairs of the primary species (**Figure** 2). Due to presence of extensive duplications, the diploids, *Brassica nigra*, *Brassica oleracea* and *Brassica campestris* are thought to be an evolved ascending aneuploidy series from an ancient progenitor with six basic pairs of chromosomes. Understanding the relationship among these *Brassica* species has enabled plant breeders to create synthetic amphidiploids and to transfer useful agronomic characteristics from species to species through interspecific hybridization.

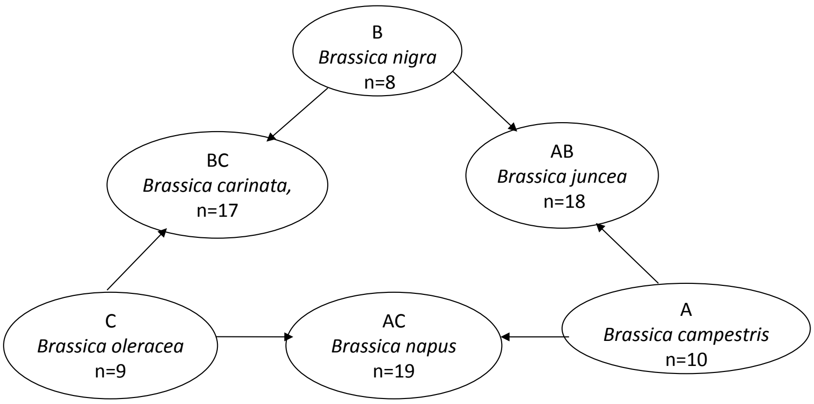

Figure 2. The triangle of U summarizing the genetic relationship of cultivated *Brassica* species.

The rapeseed and mustard seed contains 40-45% oil and 24% protein. Rapeseed mustard oil in nutritionally far superior to any other vegetable oils, because of sufficiently low level of saturated fatty acids (7%), moderate level of poly unsaturated fatty acids linoleic (omega-6) and linolenic (omega-3) which is highly balance (12:10) and higher amount of monounsaturated fatty acids like oleic and erucic acid (70%). Rapeseed mustard oil is safe for healthy people as well as for people with weak heart and those suffering from other chronic diseases (ORP 2016). Tori is generally grown under rainfed upland condition after harvest of summer maize and upland rice.

Mustard (*Brassica juncea* (L.) Czern.) is also most potential winter oil seed crop. It is grown in rice based system as mix crop with wheat, chickpea, lentil and linseed. Relay seeding in standing paddy is common practice in most parts of Nepal and India. It is very responsive to high input especially nitrogenous fertilizer and irrigation water (Ghimire et al 2000). The productivity of mustard is very low due to unavailability of high yielding varieties, minimum fertilizer use, late planting caused *alternaria* disease and aphid attack. On the other hand very limited genetic stock with narrow genetic base is available at our condition. Improvement of mustard generally depends on exploitation of available naturally occurring genetic variability in the cultivated species. Mustard has mostly been confined to Indian sub-continent has limited variability left for direct selection for higher seed yield (NRCRM 2000). Considering these points selection of short duration, disease and insects tolerant, high yielding genotypes is continued at NoRP, Nawalpur, Sarlahi. The adopted strategy of varietal improvement of rapeseed mustard is collection of local land races, evaluation of local and introduced varieties for high yield potentiality, tolerant to *alternaria*, white rust and aphids. Many Indian released varieties of mustard were introduced in Nepal from various sources. Mustard varieties viz, Pusa bold from IARI and Krishna from Pant Nagar were introduced and released in the same name in 1989. Many superior released varieties from India were also evaluated in yield trial across the country and found high yielding but late in maturity. Similarly, local collections were made in different years and designated the entry name as ICT and ICJ. ICT stands for Indigenous Collection of Toria and ICJ stands for Indigenous Collection of *Juncea*, first two numerical values represents year of collection and next two digit collection number. Maximum collections in rapeseed mustard were made from mid-western region of Nepal especially from Banke, Bardiya and Surkhet. As a result, maximum diversity in mustard was assembled from Mid Hills of Mid Western region. Some landraces are grown in mix cropping system with wheat in irrigated condition and called barsale in Surkhet areas. Some landraces are found dwarf, profuse branching and early in maturity and suitable for rainfed condition. Yellow sarson is also cultivated in irrigated land. Two types of yellow sarson are found: one is thin pod and another thick pod. ICS 9108 and S4 genotypes were found promising at NoRP, Nawalpur condition (Ghimire 2001).

Groundnut

Groundnut is the sixth most important oilseed crop in the world. In Nepal it is one of the important food legume crop grown during rainy season. Land Resource Mapping Project (LRMP) report showed over 5,72,000 ha of land is potential for groundnut cultivation in Nepal (Paudyal et al 1992). Groundnut was mainly found growing in central region in the Tarai and Eastern and Mid/Far Western Mid Hills**.** The crop is raised as sole crop or mixed with maize. The produces are used for roast but not for oil purpose in Nepal. It contains 48-50% oil and 26-28% protein and is rich sources of dietary fibers, minerals and vitamins. It is composed of 19% Saturated Fatty Acids, 48% Mono unsaturated fatty acid and 20% Poly unsaturated fatty acid (ORP 2016)**.** During seventies, groundnut cultivation in Nepal was confined only in kitchen garden, however, during early eighties, this crop started to grow commercially and area was gone around 6000 ha and increased again up to 10000 ha during nineties. In recent years, groundnut area is again gown down to 3625 ha with the production 4469 mt and productivity 1.233 mt/ha (MoAD 2014). The decrease in area is mainly due to high cost of cultivation, higher labour requirement and inadequate availability of groundnut seeds. On the other hand early monsoon enables the farmers to grow cereal crop in the season.

B4 (Valencia type) is the first variety of groundnut which was quite popular among the growers due to attractive pod with well filled 2-3 kernel/pod and easy in harvesting. Large numbers of germplasm/varieties are under evaluation and yield trial supplied by ICRISAT.

Sesame

Sesame (*Sesamum indicum* L.) was considered as a traditional oil crops of Nepal, occupied 5 percent of oil crop area across the Tarai/Inner Tarai during nineties (Paudyal et al 1992) and now restricted to 2 percent. Most of the seed produce is marketed (42%) and is used either for export or for oil extraction for use as a component of refined oil and vegetable ghee (Paudyal et al 1992). Because of the high price of the seed, return was highest among all oilseed crops. The crop fits well in sesame Tori and maize/sesame-Tori cropping patterns. Its seed is used for worshiping, confectionaries and pickle preparation (Ghimire 1999). Sesame is a summer crop mainly grown in Tarai, Inner Tarai and Foot Hills of Nepal. It is grown in spring season as Baishakha Til in irrigated areas of central and eastern Tarai and rainy or post rainy season in other parts of country. In recent years sesame area is gown down to 4682 ha with production 6327 mt and productivity 1.352 mt/ha (MoAD 2014). A total of 178 collections were made from local and exotic sources (Koirala 1995) at NoRP, Nawalpur. Among these germplasm one local landraces (DN-4) from Central Tarai, Chitwan was identified as high yielding and early in maturity. This line was released for the general cultivation in Tarai (west of Siraha) and Inner Tarai region of Nepal in the name of "Nawalpur khairo Til-1" during 2000 and is still being cultivated by the farmers.

Niger

Niger (*Guizotia abyssinica* (L.f.) Cass.) is a minor summer oilseed crop as well as important cash crop of Nepal. Niger is locally called Jhuse Til, Philunge and Ramtil. It is grown in low fertility areas in poor soil in the Mid Hills and Tarai (Koirala 1995). It is mostly grown as mono crop, however it can be taken as mixed crop with groundnut, cowpea, finger millet, hoarse gram etc. The oil content of niger seed is 40-45% and used for cooking, lightening and industrial (soap) purpose. Niger seed is exported to outside countries as bird feed. The area under this crop could not be enhanced due to lack of improved seed supply and poor yield potential. The total area under Niger is 2937 ha, production 2091 ha and productivity 0.712 mt /ha (MoAD 2014).

The price of grain was more than Rs. 30/kg still the area under this crop could not be enhanced due to lack of improved seed supply and poor yield potential. The niger was found to occupy 5 percent area in Hill and one percent in Tarai of the oilseeds area (Paudyal et al 1992)**.** A total of 25% in the Hills and 56% in Tarai of the crop was marketed (Paudyal et al 1992). However, in the past yields was low and input costs were also low resulting in a fair to good net return as the seed price was high (exported out of Nepal for bird feed). Large number of germplasm has been collected across the country and constantly evaluated in NoRP and farmers field. Among these germplasm one local landraces (Acc.No.5355) was identified as high yielding and released for the general cultivation in Hills and Tarai region of Nepal in the name of "Nawalpur Jhuse Til-1" during 2000.

Sunflower

Sunflower (*Helianthus annuus* L.) is said to be yet another potential oilseed crop in Nepal. The area under sunflower is around 5983 ha with production 4416 mt and productivity 0.738 mt/ha (MoAD 2014). This crop grows well from Tarai to High Hills within a temperature range of 20-25 ^{0}C (Paudyal et al 1992). The crop can withstand a little frost. Sunflower is reported to be a drought tolerant plant and may require only 300-600 mm of rainfall during the main growth period. Uplands with soil ranging from sandy to clay loam with good drainage system are suitable for its cultivation. Maize-sunflower-Tori, sunflower-Tori and rice/maize-potato-sunflower may be suitable cropping patterns for this crop. Sunflower in the past used to be grown as an ornamental plant in Nepal, however in recent years its commercial cultivation has got momentum (ORP 2016). As urban population is becoming more health conscious and they have started consumption of sunflower oil because it is good for heart patients. The cultivation of sunflower has drawn attention by the growers now a day. However, the problems of birds at maturity and processing of sunflower seeds have limited its cultivation. The main production is come from central and eastern Tarai region. The crop grows well in deep alluvial soil of river basin area and suitable for inter crop with sugar cane. Two varieties (Modern dwarf and Perodovic) have been identified for cultivation. But officially no varieties have been released for its general cultivation. However, Indian hybrids are quite popular and commonly grown by the farmers due to synchronization of heading, uniformity in plant height and attractive head and seed size.

Linseed

Linseed (*Linum usitatissimum* L.) is a winter oilseed crop both as oil and fiber crop, but in Nepal it is cultivated for oil extraction purpose only (ORP 2016). It is the second most important oilseed crop of Nepal after rapeseed mustard. The area under linseed was reported to be around 50000 ha. Recently area covered by this crop is 15564 ha, production 9136 ton and productivity 0.587 t/ha (MoAD 2014). Its cultivation is spread throughout the Tarai and Inner Tarai of Nepal especially in relay system with rice. The most suitable soil for the cultivation of linseed is clay soil rich in organic matter. Linseed oil is not considered as edible oil. However, it is edible from farmers' perspective, particularly among the poor. This indicates that there is need for high yielding strains with improved oil quality. Linseed was found to be grown in the Tarai, Inner Tarai and Mid Hills (Paudyal et al 1992). Almost all the crop was seeded into rice field two weeks before the rice harvest, with no further inputs before the linseed harvest. The oil of linseed is used for industrial purpose in soap and lubricant manufacturing.

Only limited research has been done to improve linseed in Nepal and no variety has been developed yet. Local landraces are being grown by the farmers. NoRP has collected and evaluated local landraces along with some exotic germplasm introduced from Australia. At present NoRP has conserved about 43 germplasms of linseed which includes 6 Australian varieties. Two varieties from Australia are of edible type which is called Linola type (Australian CV PBR and Wellenga) and another Australian public var (Glenga) (ORP 2016).

Safflower

Safflower is a winter oilseed crop. Its seeds are used for oil extraction. Its seeds contain 28-32 percent oil and rich in polyunsaturated fatty acid (linoleic acid: 78%). Its cultivation is confined in central Tarai only as green saag (vegetable). Gila landraces has been reported with seed yield potential of 800-900 kg/ha and matures in 130-135 days (Joshi 1990).

STRATEGIES OF OILSEED RESEARCH

NoRP has been mandated to generate technologies on 8 oilseeds crops (ORP 2016). Keeping in view the resources and manpower available and technology demand by the stakeholders, NoRP has prioritized the mandated crops as follows:

- High priority crop: Tori, mustard, and groundnut are given high priority for research and seed multiplication. Considering the importance of rapeseed mustard, as edible oil at national level and groundnut for food security and income generation, the research and seed production on these crops have been accorded high priority.
- Low priority crop: Sesame, yellow sarson, niger, sunflower and linseed are low priority crop. Presently the germplasm of these crops have been maintained and seeds are multiplied in low volume.

DIVERSITY STATUS OF OILSEED CROP AT SPECIES, SUB-SPECIES AND GENOTYPIC LEVELS

Rapeseed Mustard

Nepal is rich in Toria biodiversity because Foot Hills of Mahabharat range consider origin of Toria and find nitch base Toria cultvars in Nepal. The North Eastern and North Western regions of India hold primary genetic variability in rapeseed and mustard (Paroda et al 1987). Different ecotypes of Toria are found in different parts of the country viz, surkhet Tori, chitwan Tori, bardiya Tori, dang Tori, kailali Tori, dailekh Tori, morang Tori, lumle Tori and so on. Surkhet local Tori has profuse branching and bears branches from the base and short duration. While Morang local Tori is somewhat late and branching height is tall. Chitwan local Tori is dwarf (bushy appearance) and early in maturity. Oil content is also varied in Tori ecotypes. Surkhet local Tori content 42 per cent oil and as gone in upper height of bariland more oil content has been reported by the farmers. Normal Tori suffers from frost damage and sowing time has to be adjusted to escape cold injury at reproductive stage. However, Kal Tori probably Turnip rape (*Brassica napus*) tolerates frost and winter chilling and remains dormant in severe winter and sudden growth pick up while temperature rises in late winter. Kal Tori is grown especially in Kathmandu valley and Banepa areas. Such type of oil crop (very good in winter hardiness and its growth points, sink and leaves creep) found in China (Zhang 1986). Kal Tori may be ecotypes of brown sarson: lotni. The lotni is predominantly cultivated in colder regions of Kashmir and Himachal valley (NRCRM 2000). There are two different ecotypes of brown sarson: lotni (self-incompatible) and Tora (self compatible). Kal Tori requires winter chilling for their bolting/flowering. Tori generally mature in 60-70 days but Kal Tori generally took longer period for maturity than Tori.

Similarly, in mustard different biotypes are found across the country especially in western Hills. These mustard crops are grown as mix crop with winter crops especially with wheat, barley, chickpea, lentil and linseed. Extensive collection of rapeseed and mustard was done in past and evaluated at NoRP, Sarlahi in the name of ACC No. 5300, ACC No.5592, ACC No.5719, ACC No.6773, ACC No.6800, etc in Toria. The later collection was named as ICT 2001-25 and so on. ICT stands for Indigenous Collection of Toria, following 4 digit figures years of collection and last 2 digit collection number of that species. 186 accession of Toria are under evaluation at NoRP, Nawalpur.

During IDRC project period efforts were made to collected local germplasm from different parts of the country and introduced exotic germplasm as well. These materials were eventually evaluated at NoRP in yield trial and tested in farmers' field across the country. As a result, five varieties of Toria and two varieties of mustard/rayo have been released for general cultivation (**Table** 4). Three local landraces of Tori viz, Lumle Tori 1, Morang Tori 2 and Surkhet local Tori 3 were selected and released/register for different agro ecological region of Nepal. However, one old variety ie T-9 of Toria has denotify from the list of notified varieties.

Yellow Sarson (*Brassica campestris* var. *yellow sarson*) are also two types, thick pod, thin pod; dropping and straight pod type. Yellow Sarson is preferred by farmers due to thin seed coat resulting more oil recovery. Yellow Sarson has limited diversity compare to Toria and mustard in Nepal. 16 accession of yellow Sarson are under evaluation at NoRP, Nawalpur. Diversity in Indian mustard (rayo/raichi/tora/barsale) also exists at genotypic level. Some genotypes are long duration with tall plant height and generally found with mix cropping system with wheat. Others are medium duration and short duration type. These tall and long duration biotypes have long siliqua compared to short duration biotypes. Those biotypes grown in bariland rainfed condition are medium or short duration types and they bear short siliqua. Dwarf and short siliqua producing mustard landraces called Kathe rayo which is used for condiment purpose having more pungency in their seeds. 117 accession of mustard are under evaluation at NoRP, Nawalpur.

Gobhi Sarson and karan rai are introduced species and their diversity is negligible in Nepal. Gobhi Sarson is grown in mid and far western region in irrigated condition. However, Karan rai has found growing in Rolpa districts. Other vegetable types of mustard (broad leaf mustard) are also found and their seed are used as condiments.

Groundnut

Diversity in groundnut is very nominal. There are three types of groundnut viz, Virginia type, Valencia type and Spanish types under cultivation (Joshi and Regmi 1990). Virginia type belongs to *Arachis hypogaea* and *Arachis hirsuta* sub species. Our popular variety B4 is a Valencia bunch type. This type of groundnut is easy for harvesting/uprooting and quite popular in central Tarai region. It bears 2-3 seed in each pod. In Hills, Virginia runner type of groundnut is common and grown mix with maize and serves as cover as well as forage crops. It has big pod with 2-3 kernnel per pod and are confectionary type. It is used mainly for roasting purpose. Jethi badam, Mahili badam and Kanchhi badam are local cultivars (Joshi and Regmi 1990) grown in different parts of country. 51 accession of groundnut from ICRISAT are under evaluation at NoRP, Nawalpur.

Sesame

Diversity in sesame is quite good in Nepal. Sesame is grown in two seasons and named accordingly as Baishakha Til (spring season) and main season (Rainy/post monsoon) Til. Baisakha Til is cultivated in Siraha districts in irrigated condition and generally planted in the month of Baishak (March/April) and harvested in Asadh (June/July). Similarly, rainy/post rainy season sesame is grown in Sarlahi, Siraha, Sunsari, Udaypur and Saptari which are long duration and with black seed color. Sesame is also grown in Tars and river basin area of Mid Hills viz, Dhadind, Gorkha, Tanahu. These are branching type with various seed color. Seeds of Baisakha Til are generally grey brown in color with fewer husks in their seed. These are popular in pickle preparation. Sesame is of different growth habit. Some are short duration, some are medium duration and some are long duration. Their branching pattern is also varied. Some are profuse branching type and few are non-branching type. In Mid Western Tarai (Banke) non-branching sesame being grown by the farmers which have white color seed. Sesame seeds are found in different color like black, jet black, white, reddish brown, black brown, greenish brown, creamy white and mixed (Koirala 1995, Ghimire 1996). Sesame in Chitwan is of short duration type with brown seed color. DN series of sesame germplasm were collected from Chitwan. In Banke districts monocum type of sesame is grown which is white seeded and non-branching type. In central Tarai tall and long duration type of sesame is found. It is generally mixed with other kharif crop especially with niger, maize and pigeon pea. The seed color is also varied from white, black, grey and brown. Two type of sesame found: one is none branching type and other branching type. Sarlahi local is branching type with maximum primary branch. Some matures in 70 days and some take 140-150 days to mature. During IDRC project period large number of collection were made at NoRP, Nawalpur and maintain in different name like DN series (Chiwan collection), DH series (Danusha collection), Si series (Siraha collection). Mo series (Mahottari collection), Sal series (Sarlahi collection), Kanchanpur, Sunsari and Nuwakot collection. DN-4 gemplasm collected from Chitwan has released in the name of Nawalpur Khairo Til-1 in 2000. 34 accessions of sesame are under evaluation at NoRP, Nawalpur.

Niger
Niger is also a crop of hill and very limited diversity is found in this crop. Most of the varieties are branching type with black seed color. ACC No. 5355 germplasm from Agribotany Khumaltar has released in the name of Nawalpur Jhuse Til-1 in 2000. 67 accessions of Toria are under evaluation at NoRP, Nawalpur.

Linseed
Linseed is industrial oil crop but in Nepal it is grown as edible oilseed crop. Its cultivation is mostly confined in Tarai and Inner Tarai in rice fallow system. The diversity in linseed is very limited. The existing landraces is short in plant height with branching habit. The color of seed is pale yellow or light brown. 43 accessions of linseed are under evaluation at NoRP, Nawalpur.

Sunflower
The diversity in sunflower is negligible in Nepal. Two genotypes viz, Peredovic, tall one and Modern, short genotypes are cultivated since long time in central Tarai especially in Sarlahi districts (Ghimire 2000). There are some ornamental type of sunflower found in the home garden of Kathmandu valley and other parts of the country. These are branching type. Two accessions of sunflower viz, Peredovic and Modern dwarf are under evaluation at NoRP, Nawalpur.

Safflower
Safflower is also found in some home garden of central Tarai. It is used for green sag purpose. The diversity is negligible in this crop.

Castor
Different types of castor plant are found in waste land. One is green foliage and another is reddish green foliage. Their capsules are also two types: one spiny and another spineless. Seeds are also in different color. One is white color and another brown color with black steak. Castor plant is found from Tarai to Mid Hills (Kaporkot, Salyan and Rolpa; 1600m amsl).

DISTRIBUTION AND HOT SPOT AREAS OF DIFFERENT OILSEED CROP IN NEPAL

Toria
Toria is grown throughout the country from Tarai to High Hills. Major Tori growing districts are Kailali (20000 ha), Dang (18515 ha), Chitwan (12200 ha), Rautahat (9850 ha), Bardiya (9600 ha), Morang (9731 ha), Banke (6897 ha), Kanchanpur (6500 ha), Sarlahi (6000 ha), Parsa (6020 ha), Rupandehi (6140 ha), Sindhuli (4538 ha), Udaypur (3977 ha), Nawalparasi (3194 ha), Lalipur (3000 ha), Myagdi (2996 ha), Sunsari (2200 ha), Jhapa (1950 ha), Bara (1925 ha), Makwanpur (1755 ha), Saptari (1750 ha) and Dhanusa (1500 ha).

Sarson
Sarson is grown in Tarai, Inner Tarai and Mid Hills of Nepal. Major Sarson growing districts are Nawalparasi (2695 ha), Salyan (813 ha), Saptari (800 ha), Jhapa (500 ha), Dhanusa (411 ha), Sindhli (359 ha), Kabhrepalanchoke (341 ha), Myagdi (341 ha), Parsa (305 ha) and Ramechhap (267 ha) (NICDEP 2016).

Rayo/raichi
Rayo is grown in Tarai, Inner Tarai and Mid Hills of Nepal. Major rayo growing districts are Banke (1430 ha), Saptari (1050 ha), Kabhrepalanchoke (516 ha), Myagdi (516 ha), Sindhuli (220 ha), Bardiya (210 ha), Jhapa (125 ha), Morang (116 ha) and Okhaldhunga (115 ha), Nawalparasi (97 ha), Gorkha (92 ha), Sarlahi (70 ha) and Darchula (50 ha) (NICDEP 2016).

Sunflower
Major districts of sunflower cultivation are Sunsari (5250 ha), Rupandehi (300 ha), Jhapa (275 ha), Bardiya (210 ha), Morang (135 ha) and Saptari (105 ha), Kabrepalanchoke (80 ha), Sarlahi (80 ha), Myagdi (80 ha), Sindhuli (55 ha) and Sindhupalchoke (50 ha) (NICDEP 2016).

Groundnut
Major groundnut producing districts are Banke (985 ha), Salyan (210 ha), Myagdi (169 ha), Kabhrepalanchoke (169 ha), Bardia(160 ha), Gorkha (153 ha), Sarlahi (120 ha), Nawalparasi (100 ha), Rupandehi (90 ha), Tehrathum (50 ha), Dhankuta (50 ha), Okhaldhunga (43 ha), Sindhupalchoke (40 ha), Kaski (40 ha), Parsa (25

ha), Sindhuli (25 ha), Rolpa (25 ha), Pachthar (24 ha), Nuwakot (15 ha), Parbat (9 ha) and Mugu (9 ha) (NICDEP 2016).

Sesame

Major sesame producing districts are Siraha (500 ha), Banke (415 ha), Kailali (400 ha), Chitwan (300 ha), Morang (241 ha), Dhanusa (215 ha), Nuwakot (225 ha), Udaypur (142 ha), Jhapa (195 ha), Sarlahi (110 ha), Saptari (110 ha), Tanahu (109 ha), Kanchanpur (108 ha), Nawalparai (100 ha), Sunsari (90 ha), Gorkha (51 ha), Myagdi (41 ha), Kabhrepalanchoke (40 ha), Kaski (37 ha) and Rupandehi (32 ha) (NICDEP 2016).

Niger

Niger is grown in Morang (760 ha), Chitwan (250 ha), Salyan (217 ha), Kabhrepalanchoke (170 ha), Myagdi (170 ha), Dhankuta (150 ha), Nuwakot (135 ha), Jhapa (120 ha), Dhading (120 ha), Tanahu (54 ha), Sarlahi (50 ha), Sindhupalchoke (40 ha), Sindhuli (30 ha), Okhaldunga (19 ha), Ramechhap (10 ha), Rolpa (8 ha), Gulmi (7 ha) and Lamjung (5ha) districts (NICDEP 2016).

Linseed

Its cultivation was maximum in Siraha (4560 ha), Sunsari (1850 ha), Nawalparasi (1410 ha), Morang (1326 ha), Udaypur (1025 ha), Bardiya (680 ha), Kailali (550 ha), Rupandehi (540 ha), Parsa (528 ha), Saptari (455 ha), Jhapa (350 ha), Dhanusa (349 ha), Chitwan (260 ha), Sarlahi (150 ha) and Banke (95 ha) district (NICDEP 2016).

Table 4. Oil crop varieties released and recommended in Nepal

SN	Crop	Variety	Year of release	Origin	Yield (t/ha)	Recommendation domain
1.	Tori	Type 9	1980	India	0.8	Whole plain (denotified)
		Vikas (PT 303)	1989	India	1.0	Whole Tarai
		Pragati (PT 507 B)	1996	India	1.0	Whole Tarai
		Lumle Tori 1	1996	Nepal	0.9	Mid Hills
		Unnati (M 27)	2005	India	2.2	Tarai and Mid Hills /rainfed
		Preeti (PT 30)	2005	India	2.6	Tarai and Mid Hills/irrigated
		Morang Tori 2	2012	Nepal	1.6	Tarai and Inner Tarai
		Surkhet local Tori-3	2014	Nepal	0.9	Western Tarai, Mid Hills
2.	Mustard	Pusa bold	1989	India	0.9	Whole Tarai
		Krishna	1989	India	1.1	Whole Tarai
		Morang rayo*	2017	Nepal	0.9	Tarai, Inner Tarai
3.	Groundnut	B-4	1980	India	1.5	Whole Tarai/midium
		Janak	1989	India	2.5	Whole Tarai/late
		Jyoti	1996	India	2.0	Whole Tarai/late
		Jayanti	1996	India	2.2	Whole Tarai/early
		Rajarshi	2005	India	2.8	Whole Tarai/medium
		Baidehi	2005	India	3.3	Whole Tarai/early
4.	Sesame	Nawalpur khairoteel-1	2000	Nepal	0.9	West of Siraha (Tarai)
5.	Niger	Nawalpur Jhuseteel-1	2000	Nepal	0.9	Tarai and Mid Hills

**Approved by variety released sub committee*

RARE, ENDANGERED, UNIQUE AND LOST LANDRACES

Genebank of Agri-bonaty division, Khumaltar had supplied 249 germplasm accessions of different oilseed crops (mustard-129, sesame-41, Sarson-24, niger-24, linseed-12 and broad leaf mustard-19) to NoRP, Nawalpur, Sarlahi during 1995 for their characterization and evaluation (FAO 1995). These germplasm were evaluated and some of them are maintained at NoRP, Nawalpur.

Unique Landraces

The widely adapted composite variety of sunflower ie Peredovic (EC68414) was introduced from Russia during 1970 and cultivated in different place from Tarai to high mountain (Ghimire 2000). It has big attractive single head (15-22 cm diameter) with black seed color. Seed contains about 44 per cent oil. Plants attain a height of 160-185 cm with thick stem and resistance to lodging. Peredovic is quite suitable for cultivation from Tarai to High Hills up to Jumla valley. This is tall cultivar suitable for mix/inter cropping and boarder planting with maize and other summer crop. Due to photo insensitive nature of crop it is also grown round the year. Crop matures in 90-95 days in spring, 80-90 days in rainy season and 125-135 days in winter season with average productivity of 1.5-2.5 t/ha.

Similarly, Ghorlikharka landrace of Sarson has reported as highest oil content in their seed (Joshi et al 2013). On the other hand Surkhet local Tori also contain maximum oil content (42%) in their seed (Ghimire 2012). As the altitude increase the oil contains also increases in Surkhet local Tori especially in agroforestry based system. Surkhet local Tori is a drought tolerant, early maturing and suitable for early planting in maize-Toria-wheat cropping system in Mid Western Hills. Similarly, grey brown color type sesame genotypes are highly preferred by Kathmandu people for chutney purpose because of less fiber contain on it. Nawalpur Khairo Til-1 is one of the preferred variety for this purpose.

MAJOR CONSTRAINTS

Oilseed crops are considered as neglected crops in Nepal and they are cultivated in poor marginal soils where other crop cannot be grown successfully. However, oilseed crops are energy rich crop and require substantial amount of plant nutrition for its better growth and development and ultimately yield. The wide gap between the attainable yield potentials and farmers yield are due to various abiotic, biotic, socio-economic and technological factors (Ghimire at al 2011).

Abiotic Constraints

Moisture stress in winter

Though the oilseed crops are drought tolerant crops and being grown in rainfed condition, irrigation is necessary for better yield. At least one supplementary irrigation at flowering time is very essential for achieving higher yield in most of the oilseed crops. Screening of drought tolerant local cultivar in oilseed crop is lacking.

Declining soil fertility

There is sharp declining in soil fertility in upland condition where light sandy and sandy loam soils exist. The micronutrient especially boron has been suspected to be limiting element in soils which causes poor siliquae setting in rapeseed and mustard. Low nutrient requiring germplasm may be selected from the local materials.

Soil acidity

Soil acidity is the main problem in most part of the country, so reclamation of soil through liming is must and availability of agriculture lime should be ensured. Screening of acidic soil tolerant genotypes in rapeseed mustard and other oilseed crop is felt necessary.

Foggy weather in winter

Continuous foggy weather in winter may lead to severe diseases and insect pest attack in rapeseed mustard crop which reduces seed yield drastically. Under such condition disease and cold stress tolerant line may be selected from local gene pool.

High rainfall/humidity in summer

High rainfall and humidity in rainy season may cause diseases and insect pest pressure in summer oilseed crops (sesame, niger, groundnut and sunflower) and reduces the seed yield. In such condition disease and insect pest tolerant genotypes may be developed through screening of local germplasm.

Biotic Constraints

Diseases problem

- Alternaria blight (*Alternaria brassicae*) is a serious problem in rapeseed and mustard
- Late leaf spot (*Cercosporidium personatum* Berk & Curt or *Phaeoisariopsis personata*) and rust (*Puccinia arachidis*) disease in groundnut
- Alternaria leaf spot (*Alternaria helianthi*) on sunflower

Insect problem

- Aphid (*Lipaphis erysimi*) is the major problem in rapeseed and mustard which reduces seed yield to a great extent.
- Termite (*Odontotermes obesus*) problem in groundnut

Weed problem

- Weeds especially Orobanche (*Orobanche aegyptica*) causes yield reduction in rapeseed and mustard.
- Heavy weed infestation in groundnut in rainy season

Pollination problem

- Declining native honeybee population and affects in pollination which causes poor seed setting in rapeseed.

Socioeconomic constraints

- There is very limited scope to expand the oilseed area in the country.
- Oilseeds are grown under marginal and sub-marginal conditions
- Other oilseed crops like groundnut, niger, sesame have occupied very limited area.
- Oilseed crops receive less priority and attention in farming context. Priority by the farmers and government is for cereals and not for oilseeds.
- Poor adoption of improved technologies in oilseed production.

Technological constraints

- Limited number of improved varieties and most of the area is under local cultivars. Suitable improved varieties are lacking for specific agro-climatic conditions of the country.
- Very limited seed multiplication and inadequate supply of quality seed in oilseed crops.
- Soybean is not included in oilseed crop by the Ministry of Agricultural Development (MoAD) in Nepal.
- Inadequate number of plant breeders in oilseed crop is the major constraints in plant genetic resources utilization.
- Difficult to maintain the originality of local germplasm due to highly cross pollinated nature of the oilseed crop.
- Maintenance part is very difficult and most of the old collection has lost their originality. Nawalpur Khairo Til-1 sesame variety developed from local selection was grey brown color seed, now found in different color due to varietal admixture.
- We have large collection of local germplasm in rapeseed mustard and there may be duplication in some collection and found difficultly in removing the duplication.

WAY FORWARD

- Extensive collection of local landraces of oilseed crops (rapeseed mustard, sesame, niger, linseed) from different parts of country is still needed to assemble all the local genetic resources available in the country.
- Utilization of local genetic resources in varietal improvement work (screening, hybridization) in the national commodity program and research station.
- Molecular level study (DNA finger printing, gene mapping) is required to identify sub-species of rapeseed (Kal Tori/bal Tori) and special trait like early maturity, high oil content, pungency, disease and insect resistance found in particular landraces.
- DNA finger printing in rapeseed mustard germplasm is necessary to remove duplication and find out the real variability in the local gene pool.
- Hybridization work in oilseed crop in general and rapeseed mustard in particular must be initiated by utilizing indigenous genetic resources.
- Crop improvement utilizing local genetic resources in Nepal is negligible. Potential of landraces have not been studied. Therefore, pre breeding program should be strengthened (Joshi et al 2013).
- There is a need of extensive characterization, evaluation and tagging of economically important traits to facilitate and utilize the APGRs.
- Climate change is causing problems in crop production worldwide and sources of genetic diversity are necessary to breed crops tolerant to heat, drought, and more frequent extreme weather (https://academic.oup.com/jhered/article/105/4/555/2961894/Center-of-Origin-and-Centers-of-Diversity-in-an). Therefore, oilseed crop best fitted in such situation.
- Patenting the special local cultivar found in the country (rapeseed mustard local cultivars in western hills may have high oil content traits and sesame in central Tarai with foliar blight tolerant gene).
- Hybrid oilseed (sunflower and mustard) crop should be popularized among the grower for enhancing the oilseed production in the country.
- There is a good scope of organic production of edible oil and feed (seed and cake). Niger seed is export commodity for bird feed to third countries.
- Castor cultivation should be encouraged in waste land, river bank area and buffer zone to protect the environment and get income from castor bean as industrial oil.

- Oilseed crops should be included in food and nutritional security program especially in remote areas.
- The underutilized and high value oil bearing plants/crops should also be explore for their potentialities in oil production especially in hills and mountain region.
- The postharvest technology especially in sunflower processing in small scale is necessary for increasing the area of sunflower especially in Tarai of Nepal.
- Soybean and corn must be utilized first in oil extraction and then defatted cake for feed industries.
- The joint efforts should be made from research, extension and private sector for the commercialization of oilseed production in the country.
- The other oilseed species viz, Chiury (*Diploknema butyracea* (Roxb.) H.J.Lam), Dhatelo or Himalayan cherry (*Prinsepia utilis* Royle), Silam (*Perilla frutescens* (L.) Britton), Bhango (*Cannabis sativa* L.), Walnut (*Juglans regia* L.), wild apricot (*Prunus sp*) should be exploited for meeting the nutritional security of poor people of hills and mountain. Similarly easy oil extraction machine is felt necessary in remote areas.

Following interventions are proposed for enhancing productivity of oilseed crops in Nepal (NARC 2010)

- Conservation of local landraces of rapeseed mustard
- Development of varieties of rapeseed and mustard with suitable traits (early maturity, high oil content, tolerance to *alternaria* blight and aphid)
- Development of groundnut varieties with suitable traits (early maturity, bunch type, resistance to leaf spot and rust)
- Development of linseed varieties for edible oil (Linola type)
- Institutionalize seed production and distribution mechanism of source seed
- Develop integrated soil management technology for major oilseed crops
- Develop integrated crop management technology for major oil seed crops including mix cropping studies
- Develop integrated pest management technologies for major oil seed crops (alternaria blight in rapeseed and sunflower, foliar diseases and insect pest in groundnut)
- Strong coordination and linkages with extension and private agencies for the effective implementation of scaling up program of oilseed production technology in major oilseed growing districts

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Annex 1. Area, production and yield of oilseed crops in Nepal since 1984/85

Year	Area (ha)	Production (t)	Yield (kg/ha)
1984/85	127820	84030	657
1985/86	137920	78390	568
1986/87	142890	82500	577
1987/88	151490	94370	623
1988/89	154860	99190	641
1989/90	153660	98060	638
1990/91	156310	92140	589
1991/92	154570	87840	568
1992/93	165240	93690	567
1993/94	177486	107535	606
1994/95	184460	116300	630
1995/96	185000	115990	627
1996/97	182110	119250	655
1997/98	179216	110226	615
1998/99	190429	119731	629
1999/00	189629	122751	647
2000/01	188455	132331	702
2001/02	187820	134950	719
2002/03	186720	124931	669
72003/04	186741	132865	711
2004/05	187823	141989	756
2005/06	188062	139322	741
2006/07	184218	135660	736
2007/08	180328	134286	745
2008/09	181361	135494	747
2009/10	198540	155050	781
2010/11	213706	176186	824
2011/12	214835	179145	834
2012/13	215600	179000	830
2013/14	224582	194536	866

Annex 2. Area, production and average yield of different oilseed crops in Nepal, 2013/14

SN	Crop	Area (ha)	Production (t)	Yield (kg/ha)
1.	Rapeseed and mustard	191792 (85.4)	155943	838
	Tori	173254 (77)	152263	879
	Sarson	11464 (5.1)	9709	847
	Rayo	7074 (3.1)	6125	866
2.	Linseed	15564 (6.9)	9136	587
3.	Groundnut	3625 (1.6)	4469	1233
4.	Sesame	4682 (2.0)	6327	1352
5.	Niger	2937 (1.3)	2091	712
6.	Sunflower	5983 (2.6)	4416	738

Annex 3. Area, production and average yields of oilseeds crops by development region wise, 2013/2014

Name of region	Area (ha)	Production (t)	Yield (kg/ha)
Eastern	47839	37442	783
Central	66212	58827	888
Western	28562	22576	790
Mid western	49172	50565	1028
Far western	32797	25127	766
Nepal	224582	194536	866

Annex 4. Area, production and average yield of oilseed crops by agro-ecological zones of Nepal, 2013/2014

Agro-ecological zone	Area (ha)	% of total area	Production, t	% of total production	Yield (kg/ha)
Mountain	5914	2.63	3457	1.78	717
Hills	49598	22.09	45324	23.30	899
Tarai	169071	75.28	145755	74.92	844
Nepal	224582		194536		866

Source: MoAD 2014.

Annex 5. Some oilseed crops

Castor/ Adir: *Ricinus cummunis* L.

Safflower/ Kusum: *Carthamus tinctorius* L.

Sunflower/ Suryamukhi: *Helianthus annuus* L.

Surkhet local Tori-3: *Brassica rapa* L. ssp. *toria* Syn. *Brassica campestris* var. *toria* Duthie & Fuller

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Biodiversity Status and Conservation Options for Vegetable Crops (Leafy and Stem, Fruit, and Legume)

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ABSTRACT

Nepal is a land of extreme and land of wonder with her geo-edapho-climatic variability. Almost all types of world climate and a wide range of bio-diversity exist. Leaving aside the vast number of micro-flora, the larger plants group alone is believed to be existing more than seven thousand in species. In case of food plants 172 families, 296 genera, 599 species and 35 sub-species are found in the country. Out of 599 species of food plants 400 species belong to horticultural groups of which 200 species are vegetable crops. Among 200 species of vegetables around 50 species are in cultivation. The recent listing of vegetable species in use are 127 with 57 leafy, 14 stem, 36 fruit, 11 legume and 15 root and tubers. Among these 127 seventy-two varieties of 30 species are in seed production and marketing in Nepal. The recently developed National Biodiversity Strategy and Action Plan (NBSAP) 2014-20 has mentioned that the country's horticultural diversity includes around 400 species and subspecies of horticultural crops, including 45 species of seasonal fruits. An estimated 200 species of vegetables, including 11 different local varieties of potatoes, are grown in the country. Domestication and cultivation of vegetables has always been the integral part of agriculture in Nepal since time immemorial. However, the official effort of vegetable research and development could be traced back to mid 19th century when Rana Prime Minister Jung Bahadur Rana introduced European vegetables in Kathmandu valley. All exotic and indigenous vegetables those are used in Nepal are classified mainly on the basis of parts used in consumption as vegetables viz. leafy, stem, fruits and legumes. These vegetables are the sources of energy, help in growth and protects from diseases. The balance use of the vegetables of all kinds keeps us healthy and perfect. As per record from SQCC, total released and registered varieties are 329 of 35 vegetable crops. Among them 252 varieties are hybrids and rest 77 are open pollinated. Nepal released 35 varieties in 1995 and additional five varieties released from 1995 to 2014 totaling 40. After the establishment of gene bank, local varieties collected in National Genebank includes 1249 legumes, 493 fruits, 506 leafy vegetables. Few elite lines of the different vegetables, tolerant to high water logging, better yield ability and better taste have been identified for breeding and registration. All these vegetable species are diverse in their breeding behavior based on pollination behavior from highly cross pollinated to highly self pollinated one. However, some vegetables are vegetatively propagated. Among these species some commercial varieties are imported and adapted, whereas some are indigenous and released/recommended for general cultivation. The cultivation of these vegetables is omnipresent in different parts of Nepal in different seasons and agro-ecological zones. However their concentration and hot spots differ based on their commercial production and spread. Still there are many species maintained and used by people as local land races and yet are to be collected, evaluated, conserved and recommended for cultivation or to be conserved for future breeding purposes. Certain traditional varieties of vegetables are replaced by improved varieties and are now endangered for their existance. Example: Macchegaunle moola (white), Kakaniko moola (white), Saune Kakro variety of Mid Hill and sub-urban Kathmandu, Koire moola and Dungdunge sag etc. The conservation strategy, variety maintenance, breeders and foundation seed production are the challenges faced by NARC, DoA and private sector as well. The coordinated indigenous species collection and preservation and also coordinated variety maintenance program in all Government farms and designated private sector farms are the way forward for conserving in situ and collection in Genebank has been inevitable for future use.

Keywords: Agrobiodiversity, Agro-ecological zones, conservation strategy, gene bank, in-situ, on-farm, pollination

INTRODUCTION

Nepal lies between two large civilizations Aryans in the south and Mongols in the North. Nepal is the land of *Aarya-Mongol* civilization with multi-ethnic hybrid cultures. During ancient time cow herders (G*opalbansi*) who came to Nepal valley (present Kathmandu) from the Ganges Plain of modern-day India and sheep herders from Tibet and inhabited in northern Nepal. The history of Nepal has been influenced by its position in the Himalayas and its two neighbors, India and China. Due to the arrival of different settler groups from outside through the ages, it is now a multi-ethnic, multi-cultural, multi- religious and multi-lingual country and the people in common are Nepalese. Gopalbansi, Mahisapalaka, Lichchhavi, Kirats, Thakuris, Malla and Shaha ruled Nepal since ages (https://en.wikipedia.org/wiki/History_of_Nepal). All those rulers contributed to shape Nepal in the present state. Nepal's physiographic and agro-ecological setting, due to altitudinal variation and multi-sphere facings favors for different ethno-bio-diversities. The Indo-Aryans from south and Mongols from north settle in different altitude suitable to their climatic requirements. Thus, whosoever came to this part of the earth also brought plant materials including vegetables with them. Thus, domestication and cultivation of different vegetables as integral part of civilization and agricultural system goes back the era when present Nepal was scattered in many local states and royal units.

The British Empire in India and unification of Nepal in 18th century by Prithvi Narayan Shah impacted on vegetable diversities in Nepal. Modernization of agriculture in India started during British regime and it impacted in Nepal as well. Unofficial entrance of some seeds of vegetables to Nepal through pilgrimage and ex-army returnees from India also enriched vegetable diversities in Nepal. However, the recorded reports of some exotic vegetable cultivation in the manorial gardens of Rana (the then *de-facto* rulers of Nepal) could be traced back to mid-19th century when the then Nepal's Rana Prime Minister Jung Bahadur Rana and his dignitaries received the European vegetable seeds as gift during his visit to the United Kingdom and Europe. Slowly these vegetable seeds leached out to the local farmers of Kathmandu valley through the gardeners of Rana Palaces and the cultivation of temperate vegetables such as cauliflower, cabbage, onion, turnip etc became popular in Kathmandu valley. Along with these crops indigenous vegetables like broad leaf mustard, (rayo), pyuthane radish, pumpkin, gourds, taro, yam, cowpeas, beans, were cultivated for family use and for the local markets of Kathmandu.

NEPAL'S VEGETABLE BIODIVERSITY

Adapting diversified geo-edapho-climatic variability in Nepal almost all types of world climate and a wide range of bio-diversity exist. Leaving aside the vast number of micro-flora, the larger plants group alone is believed to be existing more than seven thousand in species in Nepal (Hara et al 1978). In case of food plants, 172 families, 296 genera, 599 species and 35 sub-species are found in the country. Out of 599 species of food plants 400 species belong to horticultural groups of which 200 species are vegetable crops (Regmi 1982). Among 200 species of vegetables around 50 species are in cultivation (Pandey 1995). The recent listing of vegetable species in use are 127 with 57 leafy, 14 stem, 36 fruit, 11 legume and 15 root and tubers presented in **Annex** 1. Among these 127 species 30 species and their seventy-two varieties are in seed production and marketing in Nepal. Rest species are maintained by farmers as local landraces in different agro-ecological zones. Some of them are of cultural importance and maintained as ethno-bio-diversity. The recently developed National Biodiversity Strategy and Action Plan (NBSAP) 2014-20 has mentioned that the country's horticultural diversity includes around 400 species and subspecies of horticultural crops, including 45 species of seasonal fruits. An estimated 200 species of vegetables, including 11 different local varieties of potatoes, are grown in the country (NBSAP 2014).

HISTORICAL DEVELOPMENT OF VEGETABLE IN NEPAL

After Jung Bahadur Rana who contributed in vegetable development in Rana's manorial garden, Chandra Samsher Rana established Agricultural Council as the first government entity for agricultural development in 1937. The council opened agricultural farms in Kathmandu valley in Tahachal and Balaju. Government initiated research and development in vegetable sector since 1940 with the testing of some exotic and indigenous vegetables in the Central Experimental Farms at Tahachal and Balaju nursery in Kathmandu. In these farms seeds of different vegetable varieties such as tomatoes and cabbage were produced. In Balaju nursery cabbage seed production was successfully done in 1946 (old record of Agriculture Council). During 1948 first agricultural farm outside Kathmandu valley in Parwanipur, Bara was established as multi crop research station where vegetable research for tropical region was one of the important activities.

Nepal started planned development from 1955/56 when the first five year plan was implemented with high priority to agriculture for better and efficient use of resources. Donors like USAID and Indian Cooperation Mission supported in agriculture including horticulture. Since 1956/57 a new program in agriculture development was initiated as "Tribhuwan Gram Bikash (Tribhuwan Rural Development)" with block development approach and Block Development Officers (BDOs) and Gram Sewaks and Gram Sevikas (Village Development Workers) were posted in village level for rural awareness and development. This program spread the diversities of vegetables to Hill and Tarai districts of Nepal.

During second five year plan (1962/63-1964/65), government opened different agriculture/horticulture farms /stations in the different agro-ecological zones of Nepal. The third five year plan (1965/66- 69/70) was the turning point in the horticultural development in Nepal. To provide due priorities to different sector and commodities the Department of Agriculture was reorganized in 1966/67 to five different departments (Department of Agriculture Education and Research, Department of Agriculture Extension, Department of Livestock Development, Department of Horticulture and Department of Fisheries). Department of Horticulture was housed in Kirtipur with two major sections namely Fruit Development Section and Vegetable Development Section. Kirtipur, Godavari and Putali Bagaincha Singhadurbar were the main centers of research and development for fruits, vegetables, potato and flower. Horticulture farms of different agro-eco-zones were under the Department of Horticulture (DoH). Vegetable research, seed production and seed sale used to be done by these horticultural farms which contributed in diversity status at species, sub-species and genotypic levels of vegetables with specific varieties.

During the fourth five year plan (1970/71-1974/75) the concept of regional development was adopted. Five departments were united to one single Department of Agriculture (DoA) and Regional Directorates were established in regions. Under the DoA, sub-sector development approach was realized in horticulture sector. Accordingly, Fruit Development Division (FDD), Vegetable Development Division (VDD), National Citrus Development Program (NCDP) and National Potato Development Program (NPDP) were established. During this plan period five new farms; Vegetable Seed Production Center Khumaltar, Horticulture Farm Sindhuli, Nucleus Potato Center Nigale/ Sindhupalckok, and Cardamom Development Farm Fikkal/ Ilam were also established. Establishment of VDD and Vegetable Seed Production Center Khumaltar during 1972 was the milestone in vegetable research and development. During fifth five year plan (1975/76 -1979/80) Nepal adopted agro-eco-zonal based approach in vegetable development. Vegetable seed production Center Rukum and Dadeldhura were established. VDD started functioning with clear mandate of research and development since 1975 adopting the eco-zonal based strategy for vegetable research, vegetable seed production and fresh vegetable production.

During sixth to eighth five year plan (1980/81 to 1994/1995), Fresh Vegetable and Vegetable Seed Production Project funded by the Swiss government through FAO as a Technical Cooperation Project worked in three phases as the counter part of VDD. This project further strengthened the approach initiated by VDD during fifth five year plan and continued till eighth five year plan. The commendable impacts of this period were given below.

1. Variety Development, Maintenance and Seed Production Center of Excellence

Seven Farm/Centers as center of excellence for vegetable research, variety development and breeders and foundation seed production were recognized as presented in **Table** 1.

Table 1. Farm/Centers selected for vegetable research and variety development

SN	Name of center	Altitude (M)	Micro-climate	Priority crops for research
1.	Horticulture Farm, Dhankuta	1200-1400	High rainfall, high humidity	Radish, mid-season cauliflower, broad Leaf mustard, pea, cress, spinach etc
2.	Horticulture Farm, Sarlahi	100	High rainfall, high humidity, hot summer, mild winter	Early cauliflower, radish, all solanacious and cucurbitaceous crops, beans, cowpeas
3.	Vegetable Seed production Center, Khumaltar	1350	High rainfall, high humidity, frosty winter	Radish, cauliflower, broad leaf mustard, beans, swiss chard, cress, spinach, turnip, tomato, eggplant, onion, chili, capsicum
4.	Horticulture Farm, Mustang	2522	Low rainfall, snow in winter, low humidity, mild summer	Late cauliflower, cabbage, carrot, broad leaf mustard (Marpha), late radish
5.	Horticulture Farm, Dolpa	2242	Low rainfall, snow in winter, low humidity, mild summer	Late cauliflower, cabbage, carrot, broad leaf mustard (Marpha), late radish
6.	Vegetable Seed Production center, Rukum	1440-1500	Mild rainfall, high humidity, warm summer, chilly winter	Radish, mid-season cauliflower, broad Leaf mustard, beans, cress, spinach, turnip, tomato, eggplant, sweet pepper, onion, peas, carrot, squash
7.	Vegetable Seed Production Center, Dadeldhura	1400	Mild rainfall, high humidity, warm summer, chilly winter	Radish, mid-season cauliflower, broad leaf mustard, beans, cress, spinach, turnip, tomato, eggplant, sweet pepper, onion, Peas, Squash

Besides above seven farms, two British aided farms- Lumle Agricultural Center (LAC) and Pakhribas Agricultural Center (PAC) also were linked and coordinated for vegetable research, development and seed production.

2. Variety Development and Varietal Characterization

During 15 years of FAO project support VDD established sound footings for research in different selected farms/centers (first phase of FAO 1980-83). During the second phase (1984-87) the project continued to support for variety evaluation and also developed a sound base for variety maintenance, and the production of breeders/nucleus and foundation seed. Prior to 1980/81, 25 vegetable varieties were already popular among farmers and organized seed production was in place. However, with project support, new stock seeds were imported to replace deteriorated seed stock. During 1981-91 the project supported the evaluation of 350 new germplasms of different vegetables collected from exotic and indigenous sources and selected 47 superior varieties. Including already popular 25 varieties and new varieties developed, 72 varieties were identified by 1991 and based on these research results, 35 vegetable varieties were released in 1995 and maintenance system was adopted. From 1995 to 2014 five new varieties were developed and released. Main distinguishing characters of released and pipe line varieties are presented in **Annex** 2.

3. Variety Maintenance

Based on the mode of pollination and breeding behavior of recommended vegetable varieties, the variety maintenance program and methods were developed during sixth and seventh five year plan by VDD and the project. To ease the variety maintenance work, varietal (morphological) characteristics of identified varieties with their marked genetic trait, maintenance methods, and technical procedures for each group of crops were developed and documented for the use and reference. A well-defined variety maintenance techniques and system of one farm one variety was adopted (**Annex** 3). Until 1990, there were 33 horticultural farms in various agro-ecological zones under unified DoA including seven centers of excellence and LAC and PAC for vegetables, research and variety maintenance one command of DoA/VDD and maintenance was easy. A variety maintenance chart was developed denoting farm/centers and varieties to be maintained and produce breeders and foundation seed. To clarify the maintenance scheme as for example cauliflower variety Kathmandu to be maintained by khumatar, Rukum and Dhankuta, Snow Ball was to be maintained by Dolpa, Kibo Giant by Dadeldhura and Deepali by Sarlahi and cabbage by Marpha. Similar arrangements were made with other cross pollinated crops as well. However, at present variety maintenance schemes are further modified by SQCC (**Annex** 4) but this arrangement is dysfunctional.

ESTABLISHMENT OF NEPAL AGRICULTURAL RESEARCH COUNCIL

A separate organization to put impetus effort in agricultural research, Nepal Agricultural Research Council (NARC) was established in 1990/91 and new departmental reorganization was made. The horticultural farm/centers were divided between NARC and DoA and thus vegetable research and variety maintenance was distorted. From 1995 to 2014 only five additional new varieties of vegetables were officially released but not linked to variety maintenance scheme and commercial seed production. Thus variety development, maintenance and seed production of Nepalese variety could not keep the pace with market demand.

Variety development, release, registration and maintenance are the key components of the seed value chain and seed vision framework. Development, maintenance and deployment of new location specific high yielding competitive varieties are prerequisites for bringing accelerated technological change and the means to increasing agricultural production and income. At present, however, the level of investment in terms of research fund and human resources for variety development and their maintenance is very low, and the availability of required organizational and institutional framework is weak. Investment analysis of resource pattern in agricultural research (NARC) is meagre and variety development and maintenance component receive less than one third (27%) of the research fund.

RELEASED, REGISTERED VARIETIES, ENDANGERED AND LOST LANDRACES

At present, limited number of farmer preferred improved varieties are developed, released and maintained in spite of the fact that increasing number of hybrids and improved varieties are being demanded and imported, particularly in the case of vegetables. Analysis revealed the following status of released, registered, endangered and lost landraces

- Officially released vegetable varieties 35 in 1995 and only 5 varieties released from 1995 to 2014 and at present released Nepalese vegetable varieties are 40 only (HRD/NARC 2016).

- The total registered vegetable varieties are 292 of 21 vegetables most of which are hybrids (SQCC 2016).
- Among 40 released Nepalese vegetable varieties are also not maintained well and breeders and foundation seeds are not available for commercial seed production and not properly linked with seed production.
- Among these released varieties, cauliflower varieties like Kibo giant, Dolpa snow ball, eggplant varieties Sarlahi green, Nurki, etc are not maintained well and are endangered.
- Certain traditional varieties of vegetables are replaced by improved varieties and are now endangered for their existence. Example: Macchegaunle moola (white), Kakaniko moola (white), Saune kakro variety of Mid Hill and sub-urban Kathmandu, Koire moola, and Dungdunge sag etc.

Considering this limited or slow release of new varieties, there is a need to rapidly increase the release of competitive varieties to provide diverse choices for farmers. The variety release and registration process needs to be faster and user friendly but should follow the minimum requirement of distinctness, uniformity and stability.

PIPELINE VARIETIES DEVELOPED BY DIFFERENT INSTITUTION

During recent past different institutions are in the process of developing vegetable varieties as presented in the **Table** 2.

Table 2. Pipeline varieties of vegetables in the process of release and registration in NARC and CEPREAD

SN	Pipeline varieties for the process of release in NARC		Pipeline varieties in the process of release and registration in CEPREAD	
	Crop	Genotypes	Crop	Genotypes
1.	Broad Leaf Mustard	➢ HRDBLM007 ➢ Manakamana	Cauliflower	Surkhet Selection-1
2.	Faba bean	➢ HRDFB001	Snake gourd	Surkhet Local
3.	Radish	➢ HRDRAD002	Okra	Kavre Selection
4.	Cucumber	➢ Madhu ➢ HRDCUM001	Bean	White Seeded
5.	Tomato	➢ HRD 109 ➢ CLL 2545 B ➢ F_1 14 X 7 ➢ F_1 20X6 ➢ F_1 20X 1	Onion	Baitadi Selection
6.			Cucumber	Bhaktapure

Source: HRD/NARC and CEPREAD, Nepal.

CONSERVATION EFFORTS OF LOCAL GERMPLASMS

Around 2137 accessions of different leafy, fruit and legume vegetables with orthodox seeds have been collected and conserved in National Genebank in medium term (15 years) and long term (100 years) and presented in **Table** 3 are mapped in **Figure** 1.

Table 3. List of local germplasms of leafy, legume and fruit vegetables conserved at National Genebank

SN	Crop name	Scientific name	Total
1.	Amaranths	Amaranthus sp.	64
2.	Ashgourd	Benincasa cerifera Savi	5
3.	Bittergourd	Momordica charantia L.	33
4.	Bottlegourd	Lagenaria siceraria (Molina) Standl.	22
5.	Brinjal	Solanum esculentum Dunal	34
6.	Broadbean	Vicia faba L.	60
7.	Cauliflower	Brassica oleraceae var. botrytis L.	6
8.	Chilly	Capsicum frutescens L.	24
9.	Clusterbean	Cyamopsis tetragonoloba (L.) Taub.	1
10.	Common field beans	Phaseolus sp.	482
11.	Cowpea	Vigna unguiculata (L.) Walp.	139
12.	Cucumber	Cucumis sativus L.	152
13.	Fenugreek	Trigonella foenum-graecum L.	9
14.	Gardencress	Lepidium sativum L.	2

SN	Crop name	Scientific name	Total
15.	Indian Mustard	Brassica juncea (L.) Czern.	64
16.	Okra	Abelmoschus esculentus (L.) Moench	92
17.	Peas	Pisum sativum L.	184
18.	Pumpkin	Cucurbita moschata Duchesne	50
19.	Rape mustard	Brassica campestris var. toria Duthie & Fuller	266
20.	Sarson	Brassica campestris var. sarson Prain	37
21.	Snakegourd	Trichosanthes anguina L.	10
22.	Soybean	Glycine max (L.) Merr.	381
23.	Spinach	Spinacia oleracea L.	1
24.	Spongegourd	Luffa cylindrica (L.) M.Roem.	54
25.	Tomato	Lycopersicon esculentum Mill.	4
		Total	2176

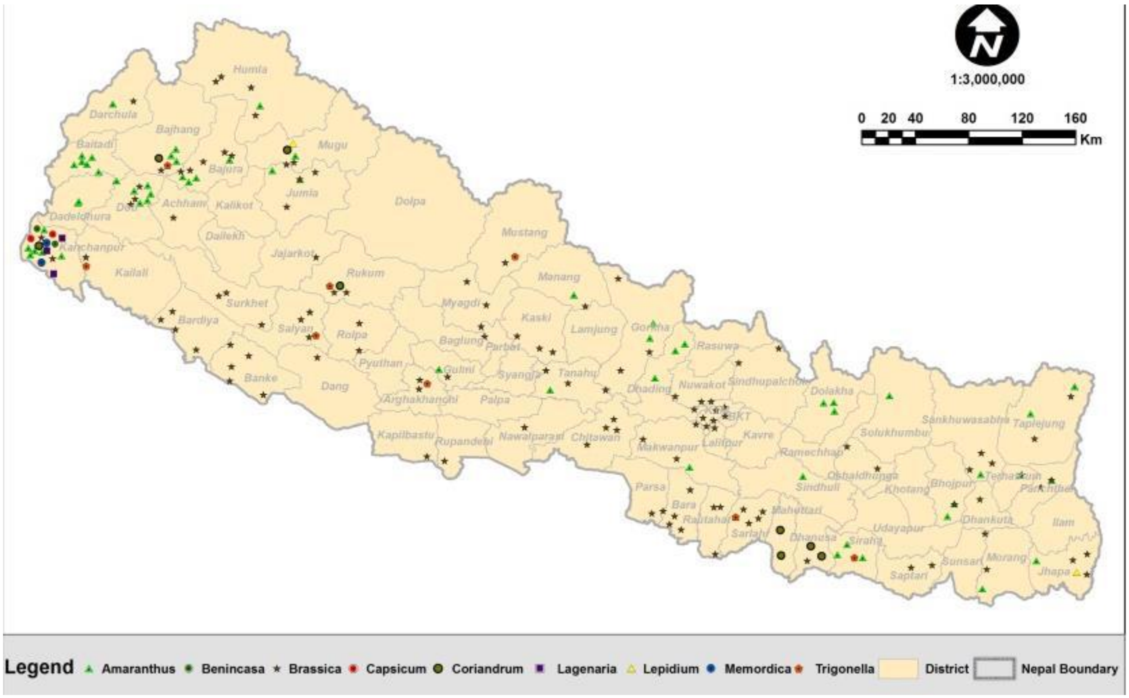

Figure 1. Distribution map of leafy vegetables in Nepal.

Detail morphological characterisation and pre-breeding work has been a regular work on this category. Around 16 lines of four vegetables have been selected as elite line for breeding purpose or for direct registration under local variety (**Table** 4). The Seed Law has provided a relaxed provisoin of variety registration of local germplasms. Utilising this, two local germplasms of rayo (*Brassica juncea* (L.) Czern.)*;* Dhunde rayo and Ghujmuje rayo from Dalchowki site has been registered with the technical assistance from National Genebank. These landraces are being maintained and produced by the Dalchowki community seed bank.

Table 4. Elite lines selected at Genebank

SN	Crop	Number	Characters
1.	Cucumber	2	Gynoeicious
2.	Chilli (Akabare)	8	Yield, true to type, water logging tolerance
3.	Okra	5	Yield, market acceptability
4.	Brinjal	1	Fruit and shoot borer tolerance

The vegetatively propagated crops are conserved in field genebank and detail characterisation is carried out. The field genebanks have been maintained at different stations of Nepal Agricutlure Research Council and efforts have been carried out to scale up the field genebank in farms owned by departments too. Field genebank of 74 Taro and 5 Chayote has been maintained in National Genebank at present. Similar set of Taro has been maintained at ARS, Malepatan too as safety duplication (**Table** 5).

Table 5. Germplasms maintained at Field genebank of National Genebank, Khumaltar

SN	Crop name	Genus	Species	Total
1.	Taro	Colocasia	Esculenta (L) Schott	74
2.	Chayote	Sechium	Edule (Jacq) Sw.	5
3.	Elephant Foot Yam	Amorphophallus	Campanulatus (Roxb) Blume ex Decne	2

REASONS FOR SLOW VARIETY DEVELOPMENT IN VEGETABLES

- While establishing NARC, most vegetable research farms (Khumaltar, Sarlahi, Rukum, Marpha and Dadeldhura) kept under DoA and not mandated for research.
- Vegetable research in NARC is in low key due to lack of specialized research farms, for long time HRD/NARC housed in VDD premises as an orphanage.
- The horticulture units of most NARC research centres are cereal crop dominated.
- Thus variety development, maintenance and seed production of Nepalese variety could not keep the pace with market demand and import of hybrid seed dominated to meet the demand.
- There is no international linkage for exotic vegetable germplasm import, evaluation, new variety development and government investment is low in vegetable research and new variety identification.
- Vegetable specific team of research including olericulturists, soil scientists, plant protection and post-harvest specialist in specific farm centre with full leadership of vegetable and crop specific regional research farms and demo farms with fully equipped lab is lacking both in NARC and DoA.
- There was no policy and program to go with Universities and private sector in vegetable research and development as public private partnership.

RECENT ADVANCEMENT IN VEGETABLE PRODUCTION

During recent years, Government of Nepal and many non- governmental organizations encouraged people to consume plenty of fruits and vegetables. Due to dietary awareness and health consciousness in urban areas the demand of fresh vegetable is increasing. Over the past 60 years many new techniques have been emerging in commercial vegetable production with the use of high quality seed and energy-intensive fertilizers. Adoption of modern protected greenhouse techniques to organic production and IPM technology without using any chemicals are becoming popular very fast. The present status of vegetable cultivation and production is presented hereunder (Table 6).

Table 6. Status of major vegetable production in Nepal

SN	Crop	Area (ha)	Production (mt)	Productivity (mt/ha)
1.	Amaranthus	1905.80	18455.65	9.68
2.	Ash Gourd	853.70	11604.05	13.59
3.	Asparagus	134.95	1526.50	11.31
4.	Asparagus Beans	4539.00	88649.47	19.53
5.	Balsam Gourd	265.58	2228.98	8.39
6.	Bitter Gourd	10082.15	131150.10	13.01
7.	Bottle Gourd	8611.52	129798.05	15.07
8.	Brinjal	8680.36	128029.51	14.75
9.	Broad Beans	1158.90	8394.36	7.24
10.	Broad Mustard Leaf	12791.65	150874.57	11.79
11.	Broccoli	2274.75	25009.48	10.99
12.	Cabbage	28071.40	468836.80	16.70
13.	Capsicum	1183.80	12269.25	10.36
14.	Carrot	2933.93	33629.90	11.46
15.	Cauliflower	34967.00	531944.75	15.21
16.	Chayote	1807.35	29564.65	16.36
17.	Chilli	9580.80	93931.21	9.80
18.	Chilli Akabare	988.40	4757.21	4.81
19.	Colocasia	4878.33	53231.89	10.91
20.	Coriander Leaf	1773.60	15854.35	8.94
21.	Cowpea	4620.70	56790.10	12.29
22.	Cress	1705.40	14450.00	8.47
23.	Cucumber	9396.80	152531.75	16.23
24.	Drumsticks	118.50	2047.85	17.28
25.	Elephant Foot Yam	706.00	12381.00	17.54

SN	Crop	Area (ha)	Production (mt)	Productivity (mt/ha)
26.	Fennel Leaf	63.00	494.10	7.84
27.	Fenugreek Leaf	1018.05	10064.86	9.89
28.	French Beans	2869.75	24953.30	8.70
29.	French Beans - Sword Type	1421.00	13632.15	9.59
30.	French Beans –Bush Type	1335.45	13354.98	10.00
31.	French Beans -Pole Type	4493.30	44830.35	9.98
32.	Kakari	345.75	4685.85	13.55
33.	Kundru	80.75	830.55	10.29
34.	Lettuce	72.40	587.00	8.11
35.	Okra	10781.40	122101.58	11.33
36.	Onion	20070.00	238590.74	11.89
37.	Other (Legumes)	4287.00	24643.06	5.75
38.	Other (Cucurbits)	1354.80	12623.14	9.32
39.	Other (Tubers)	620.63	6731.17	10.85
40.	Other (Vegetable)	6656.00	103343.41	15.53
41.	Others (Leafy Vegetables)	2090.00	21411.20	10.24
42.	Peas	6368.70	52536.70	8.25
43.	Pointed Gourd	1955.50	22443.50	11.48
44.	Pumpkin	7203.40	103169.60	14.32
45.	Radish	16915.70	251319.58	14.86
46.	Ridge Gourd	1006.50	12008.80	11.93
47.	Snake Gourd	1325.70	15776.77	11.90
48.	Spinach	1928.30	21144.50	10.97
49.	Sponge Gourd	7073.10	101044.72	14.29
50.	Squash	1340.35	16956.86	12.65
51.	Swisschard	690.20	8095.40	11.73
52.	Tomato	20046.03	345024.59	17.21
53.	Tree tomato	113.70	1121.70	9.87
54.	Turnip	443.30	4622.40	10.43
55.	Watermelon	1980.80	31724.10	16.02
56.	Yam	1359.58	19407.09	14.27
	TOTAL	**280806.71**	**3819809.12**	**13.60**

Source: VDD 2017.

DISTRIBUTION AND HOT SPOT AREAS IN NEPAL FOR VEGETABLE COMMERCIALIZATION

Hot spots areas for particular vegetable develop with comparative advantage and road accessibility infrastructure availability. Most vegetables being seasonal crops and affected by thermal induction (vernalization) and photoperiodic condition are not confined by political division and districts but by eco-logical belts and north south road corridors for accessibility. However, for general understanding the hot spot areas may be noted as follows:

- Cole crops: All ecological zones depending on local climatic situation
- Tomato: Central and Eastern region and Mid Hill from east to west
- Cucurbits : Mid Hill and Tarai with tropical, sub-tropical and warm temperate climate
- Melons: Tarai and river beds sub-tropical and warm temperate zone
- Okra, chilli and eggplant:Tarai and Mid Hill
- Crucifers: All-eco-zones
- Radish: Daman Palung, Aghor (Makawanpur), Kakani (Nuwakot)
- Carrot: Mustang, Chitwan
- Peas and Chayote: Eastern region

VARIETAL DISTRIBUTION IN DISTRICTS

The vegetable varieties distribution of major vegetable crops in selected districts from east to west is presented in **Annex** 6. Hybrid varieties of these vegetables are distributed all over Nepal. However, some varieties like Bhaktapur Local of cucumber, Pali of bitter gourd, Sirjana and Manisha of tomato, Mino Early and 40 Days of radish, Marpha Chaudapat and Khumal Chaudapat of broad leaf mustard, Red Creol and Nasik Red of onion, NS 1701 of chilli, Nurki of brinjal and Arka Anamika of okra are the most popular varieties. This shows that Nepali OP varieties of major vegetables are doing pretty well in the farmers' field.

OPPORTUNITIES FOR VEGETABLE EXPORT

Nepal has potential market access to different countries such as India, China, Singapore and Bangladesh etc. Commerce Policy, 2072 has identified vegetable and vegetable seed as the potential export commodity. Production of off-season vegetables for fulfilling the demand of tourism sector and neighbouring countries is abundant. Vegetable demand especially safe/organic vegetables is increasing due to nutrition consciousness and health benefits and increasing in urban population and income. In 2014/15, some 20,953 metric tons of vegetable, with the value of Rs 262,557,000.00 was exported to India and neighbouring countries. Mostly cabbage, potato, tomato, green peas, radish etc are exported (MoAD 2015).

MAJOR CHALLENGES IN VEGETABLE RESEARCH AND DEVELOPMENT

- Absence of comprehensive variety maintenance plan and procedure,
- Limited effort for breeding climate resilience and high yielding varieties,
- Inadequate functional arrangement for variety development and maintenance,
- Insufficient motivation of breeders to produce varieties based on farmers' changing needs,
- No concrete policy and programs on hybrid research,
- Lack of R&D component in private sector and collaboration with public sector,
- Poor linkage with international research institutions/universities mainly on germplasm import utilization,
- Inadequate coordination with research, development and academia,
- Inadequate breeders and other team members for vegetable breeding,
- Limited capacity to use modern techniques of plant breeding including biotechnology,
- HRD does not have a direct line of command to other NARC entities; the effectiveness of the coordination is experienced to be more personal than institutional,
- The present level of staff positions, their deployment and disciplinary expertise are not sufficient enough to respond to the varietal & technological demands,
- Poor supply and availability of technical services: seeds, saplings and trainings.

FUTURE PROSPECT AND WAY FORWARD FOR VEGETABLE DEVELOPMENT

Fresh vegetables play very important role in nutrition security, food security, income generation and livelihood improvement. Increased production and productivity of vegetables depends high quality seed including hybrids. Lessons learned from successes and pitfalls have resulted in shaping the future prospect and way forward. As we move along the path of progress, several opportunities will appear and these needs to be utilized for the benefit of wider farm families.

1. Variety Development

A large proportion of improved seeds particularly hybrids in vegetables are being imported, particularly from Japan, India, Thailand, Korea and China. Nepal must collect evaluate and develop pest resistance and stress tolerance varieties for climate resilience from local germplasms. In order to reduce the import of hybrids, NARC should have Hybrid Research Unit (HRU) under National Commodity Programs and Divisions with adequate fund and human resources as envisaged in Seed Vision 2013-2025. By 2025, it is envisaged that 30 hybrids comprising, 20 by public sector and 10 by privates and to increase seed replacement rate from 68 to 90 by 2025.

2. Variety Maintenance

Variety maintenance is an important component of quality source seed production. Maintenance of crop varieties in their original ecological domain is essential to produce quality source seed and retain original genetic vigour and unique characteristics of the varieties. However, currently, there is a limited use and compliance of zoning concept in maintenance of varieties. Based on the mode of pollination and breeding behavior of recommended vegetable varieties, the variety maintenance program and methods were developed during sixth and seventh five year plan by VDD and the project. To ease the variety maintenance work, varietal (morphological) characteristics of identified varieties with their marked genetic trait, maintenance methods, and technical procedures for each group of crops were developed and documented for the use and reference. A well-defined variety maintenance techniques and system of one farm one variety was adopted (**Annex** 3). Until 1990, in various agro-ecological zones there were 33 horticultural farms under unified DoA including seven centers of excellence and LAC and PAC for vegetables, research and variety maintenance one command of DoA/VDD and maintenance was easy. A variety maintenance chart was developed denoting farm/centers and varieties to be maintained and produce breeders and foundation seed. To clarify the maintenance scheme as for example cauliflower variety Kathmandu to be maintained by Khumatar, Rukum and Dhankuta, Snow ball variety was to be maintained by Dolpa, Kibo Giant by Dadeldhura and Deepali by Sarlahi and cabbage by Marpha. Similar arrangements were made with other cross pollinated crops as well. However, at present variety maintenance schemes are further modified by SQCC (**Annex** 4) but this arrangement is dysfunctional. Variety maintenance chart for vegetables prepared during eighties by VDD and recently revised by NSB has to be implemented based on agro-ecological zones, domains of the research centres and farms. Original genetic vigour and unique characteristics of some of the vegetable varieties have been published by CEAPRED (2014) and SQCC (2016) could be further revised and made in to use.

3. International and National Linkages and Collaboration

At present, the linkage and collaboration of national commodity programs with international institutions and private R&D organizations is limited. Development and strengthening link is essential for increased germplasm exchange and sharing of information and technology. Similarly, linkage of domestic plant breeding programs with National Genebank is weak. As a result, flow of new germplasm, modern technological information and the use of locally diverse genetic resources available are limited. It is suggested that Genebank operational guidelines need to be developed and implemented with special reference to vegetable crops. Research collaboration and partnership among NARC, AFU, DoA and NARDF needs reorientation and working towards national goal of hybrid variety development in vegetable crops. Researches of MSc and PhD students and faculty members must be linked with National Seed Vision.

Linkages with international institutions and universities and joint ventures for new variety development and hybrid seed production should be given high priority by both government and private sector. In nut-shell the following points may be considered:

- Designate farms, stations, zones and pockets for variety maintenance and biodiversity conservation whether they belong to DoA or NARC,
- Collaborate and assign lead role and supporting roles for crop breeding and maintenance for experts of NARC, DoA and Universities,
- Provide adequate support for hybrid varietal research and seed production through national research programs and private sector participation,
- Explore and develop organizational incentives for breeders and experts based on output indicators,
- Develop policies on hybrid research in public and private sectors with practical PPP,
- Develop/strengthen and use linkage with international institutions/academia,
- Develop human resources on modern plant breeding techniques (molecular breeding, biotechnology, etc),
- Infrastructures (disease diagnostic laboratory, storage system for breeder seeds and planting materials, post-harvest study labs, green house and net house structures, irrigation systems for fields) need to be developed,
- In most farm/centers research facilities like office buildings, laboratories, irrigation and drainage system, farm roads, scientist quarters, fences are in poor condition. So, they need to be well-developed and well equipped,
- Each of the ARS is suggested to be developed as a lead center for a specific vegetable commodity. Systematic vegetable breeding program is important and should be established immediately.

CONCLUSION

Vegetable is a complex sub-sector as it has to address a wide variety of vegetable species, sub-species and varieties adaptable to varying agro-ecological environments. Thus, research inputs from both public and private sector (Seed companies, non-governmental organizations and farmer's research) are very critical to meet the target set in Seed Vision and Agriculture Development Strategy (ADS). Considering the fact of rapid replacement of OP varieties by hybrids, the need of research has crucially emerged for identification of indigenous cultivars and demonstrating their commercial value, developing new OP varieties and parental lines for hybrid variety development. Public sector research could be led by NARC in collaboration with Vegetable Development Directorate and University of Agriculture and Forestry. Private sector research could be done by private seed companies and NGOs in partnership with public sector in participation with farmers.

Production, consumption and marketing of fresh vegetables have been increasing during recent decades. Farmers are demanding imported hybrid vegetable varieties that are high yielding, short durational and suitable to different agro-ecological environment and different season. However, this should not be at the cost of Nepali OP varieties which possess the immense potential of farmer's acceptance, adaptable to local climatic stress and tolerant to many pest and diseases. Therefore, investment in farmer's preferred priority vegetable crop research for new OP varieties and parental lines development for hybrid seed production and proper maintenance of released and registered varieties must be stream lined. Sustaining the seed value chain from breeder's (nucleus) seed to improved/labeled seed production with proper quality assurance through truthful labeling under a collaborative action involving all related government, non-government, private and cooperative stakeholders. Increase competitiveness of Nepali seed both in domestic and international market through quality assurance, branding and packaging. National Seed Vision has developed strategies and set targets to develop OP and hybrid varieties in vegetable to increase replacement to 90 from 68 during 2014 developing 30 hybrid varieties in vegetables.

Fresh vegetable production and marketing is always led by supply of good quality inputs mainly seed and market management. Safe products with no or within the limit of pesticides and mainly hazardous pesticide free products are in demand. Clean well branded nicely packed and well displayed fresh vegetable product is increasing in demand. Fresh vegetable market function and trader's behavior should be changed to benefit both fresh vegetable producers and consumers with well planned production program, regular supply chain and heading towards international standards of fresh vegetable market development.

The comparative advantages both for vegetable seed production and fresh vegetable production has to be harnessed in all the ecological zones of Nepal for year round commercialization of fresh vegetable production, consumption and export. Vegetable seed production of temperate to tropical crops from Tarai to High Hill must be utilized with proper zoning of seed production. Hill and High Hill are suitable for temperate vegetable seed production and Tarai, Inner Tarai and Low Hill basins are important for solanacious, cucurbits, and okra and legume seed production.

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Annex 1. Vegetable (leafy, stem, fruit and legume) names, family and kinds

SN	English name	Nepali name	Scientific name	Family	Kinds
Leafy vegetables					
1	Amaranth (Red)	रातोलट्टे	Amaranthus tricolor L.	Amaranthaceae	Leafy
2	Amaranth (grain)	लट्टे दाना	Amaranthus cruentus L.	Amaranthaceae	Leafy
3	Amaranth (grain)	लट्टे दाना	Amaranthus caudatus L.	Amaranthaceae	Leafy
4	Amaranth (Green)	हरियो लट्टे	Amaranthus viridis L.	Amaranthaceae	Leafy
5	Amaranth(Pig weed)	लुडेंसाग	Amaranthus spinosus L.	Amaranthaceae	Leafy
6	Cabbage	बन्दाकोपी	Brassica oleracea var. capitata L.	Brassicaceae	Leafy
7	Cabbage (Chinese)	चाइनिज बन्दा	Brassica chinensis L.	Brassicaceae	Leafy
8	Chayote	इस्कुल/इस्कुस	Sechium edule (Jacq.) Sw.	Cucurbitaceae	leafy
9	colocation /Taro	पिडालु/कर्कलो	Colocasia esculenta (L.) Schott	Araceae	Leafy/
10	Chicory	चिकोरी	Cichorium intybus L.	Asteraceae	Leafy
11	Celery	सेलेरी	Apium graveolens L.	Umbelliferae	Leafy
12	Chervil	चेर्भिल	Anthriscus cerefolium (L.) Hoffm.	Apiaceae	Leafy
13	Cang-kong	कर्मि साग	Ipomoea aquatica Forssk.	Convolvulaceae	Leafy
14	Cress	चम्सुर	Lepidium sativum L.	Crucifareae	Leafy
15	Coriander	घनियाँ	Coriandrum sativum L.	Umbellifereae	Leafy
16	Cocoyam/Taro	पिडालु/कर्कलो	Colocasia esculenta (L.) Schott	Araceae	Leafy
17	Endive	इन्डाइभ	Cichorium endivia L.	Asteraceae	Leafy
18	Fennel	सुँप	Foeniculum vulgare Mill.	Umbelliferae	Leafy
19	Fern (Black)	काली न्यूरो	Dryopteris cochleata (D. Don) C. Chr.	Aspidiaceae	Leafy
20	Fenugreek	मेथी	Trigonella foenum-graecum L.	Papillenaceae	Leafy
21	Garlic	लहसुन	Allium sativum L.	Amaryllidaceae	Leafy
22	Garlic (aromatic leaf)	जिम्बु	Allium hypsistum Stearn	Amaryllidaceae	Leafy
23	Garlic pear	सिप्लिकान	Crateva unilocularis Buch.-Ham.	Capparidaceae	Leafy
24	Goose foot	कालो बेथे	Chenopodium murale L.	Chenopodiaceae	leafy
25	Leek	छ्यापी	Allium porrum L.	Amyrillidaceae	Leafy
26	Lettuce leaf	जिरिको साग	Lactuca sativa L.	Labiatae	Leafy
27	Lettuce head	जिरिको साग(कोपी)	Lactuca sativa L.	Labiatae	Leafy
28	Lamb's quarter	बेथे	Chenopodium album L.	Chenopodiaceae	Leafy
29	Mint	पुदिना /बाबरी	Mentha longifolia (L.) L.	Labiatae	Leafy
30	Mustard (Black)	कालो तोरी	Brassica nigra (L.) K.Koch	Brassicaceae	leafy
31	Mustard (leaf)	रायो	Brassica juncea var. crispifolia L.H.Bailey	Brassicaceae	leafy
32	Mustard (Indian)	रायो	Brassica juncea (L.) Czern.	Brassicaceae	Leafy
33	Mustard	रायो	Brassica juncea var. cuneifolia Prain	Brassicaceae	leafy
34	Mustard (Nepali)	नेपाली रायो	Brassica juncea var. rugosa (Roxb.) Kitam.	Brassicaceae	leafy
35	Mustard (Curly)	जीरकि साग	Brassica japonica (Thunb.) Siebold ex Miq.	Brassicaceae	
36	Mustard (Colza)	सर्स्यू	Brassica campestris var. sarson Prain	Brassicaceae	Leafy
37	Onion	प्याज	Allium cepa L.	Ámaryllidaceae	Leafy
38	Onion (fragrant)	डुण्डु	Allium tuberosum Rottler ex Spreng.	Amaryllidaceae	Leafy
39	Pig Weed	लुडेसाग	Amaranthus lividus L.	Amaranthaceae	Leafy
40	Parsley	पार्सले	Petroselinum crispum (Mill.) Fuss	Apiaceae	Leafy
41	Parsnip	पार्सनिप	Pastinaca sativa L.	Apiaceae	Leafy
42	Purslane (horse)	पुनर्नवा	Trianthema portulacastrum L.	Portulaceae	leafy
43	Poker weed	जरिंगो	Phytolacca acinosa Roxb.	Phytolaccaceae	leafy
44	Purslane (common)	कुल्फासाग	Portulaca oleracea L.	Portulaceae	leafy
45	Rape	सर्स्यू	brassica campestris var. sarson Prain	Brassicaceae	leafy
46	Shallot	छ्यापी	Allium ascalonicum L.	Amaryllidaceae	Leafy
47	Spinach	पालुंगो	Spinacia oleracea L.	Chenopodiaceae	Leafy
48	Spinach (New Zealand)	न्यूजिलैण्ड पालुङ्गो	Tetragonia expansa Murray	Aizoaceae	leafy

SN	English name	Nepali name	Scientific name	Family	Kinds
49	Spinach (Indian)	पोई साग	Basella alba L.	Basellaceae	Leafy
50	Spiny Pigweed	काँडे लुँडे	Amaranthus spinosus L.	Amaranthaceae	Leafy
51	Stinging nettle	सिस्नु	Urtica dioica L.	Urticaceae	leafy
52	Sweet potato	सखरखण्ड	Ipomoea batatus (L.) Lam.	Convolvulaceae	Leafy
53	Swiss Chard	स्विस चार्ड	Beta vulgaris var. cicla L.	Chenopodiaceae	Leafy
54	Turnip	सलगम	Brassica rapa L.	Brassicaceae	Leafy
55	Vegetable mallow	लाफेसाग	Malva verticillata L.	Malvaceae	leafy
56	Water cress	सिमसाग	Nasturtium officinale R.Br.	Brassicaceae	Leafy
57	Water fern	निउरो	Dryopteris cochleata (D.Don) C. Chr.	Aspidiaceae	Leafy
Stem vegetables					
1	Asparagus	कुरिलो	Asparagus officinalis L.	Liliaceae	Stem
2	Cauliflower	काउली	Brassica oleracea var. botrytis L.	Brassicaceae	Stem
3	Kale (Chinese)	चिनी केल	Brassica oleracea var. acephala DC.	Brassicaceae	stem
4	Devil's Tongue	ओल	Amorphophallus campanulatus Decne.	Araceae	Stem
5	Knol khol	ग्याठ	Brassica oleracea L.	Crucifareae	Stem
6	Bamboo shoot	तामा	Bambusa spp.	Graminae	Stem
7	Himalayan bamboo shoot	निगालो टुसा	Arundinaria falcata Nees	Graminae	Stem
8	Smart weed (Thotne)	ठोटने	Polygonum molle D. Don	Poligonaceae	Stem
Fruit vegetables					
1	Ash gourd	कुभिण्डो	Benincasa hispida (Thunb.) Cogn.	cucurbitaceae	Fruit
2	Brinjal/eggplant	भण्टा	Solanum melongena L.	Solanaceae	Fruit
3	Brinjal (wild eggplant)	बन भण्टा	Solanum viarum Dunal	Solanaceae	Fruit
4	Brinjal (wild)	बिहिँ	Solanum torvum Sw.	Solanaceae	Fruit
5	Balsam apple	बरेला	Momordica balsamina L.	Cucurbitaceae	Fruit
6	chili / Cone pepper	हात्ती सुडे खुर्सानी	Capsicum frutescens var. conoides (Mill.) L.H.Bailey	Solanaceae	Fruit
7	Chili/Bird's eye	जिरे खुर्सानी	Capsicum microcarpum Cav.	Solanaceae	Fruit
8	Chili/red cluster	झिने खुर्सानी	Capsicum frutescens var. longum (Sendtn.) L.H. Bailey	Solanaceae	Fruit
9	Chili/Bell pepper	भेडे खुर्सानी	Capsicum frutescens var. grossum (Mill.) L.H. Bailey	Solanaceae	Fruit
10	Chili/Long pepper	लाम्चे पिरो खुर्सानी	Capsicum frutescens var. fasciculatum (Sturtev.) L.H.Bailey	Solanaceae	Fruit
11	Cucumber (field	काँक्रो	Cucumis sativum L	Cucurbitaceae	Fruit
12	Cucumber (garden)	भदौरे काँक्रो	Cucumis sativus var. sikkimensis HooK. f.	Cucurbitaceae	Fruit
13	Cucumber (long)	ककडि/लाम्काँक्री	Cucumis melo var. utilissimus (Roxb.) Duthie & Fuller	cucurbitaceae	Fruit
14	Gourd (Bitter)	तिते करेला	Momordica charantia L.	Cucurbitaceae	Fruit
15	Gourd (Bottle)	लौका	Lagenaria siceraria (Molina) Standl.	Cucurbitaceae	Fruit
16	Gourd (Sponge)	घिरौला	Luffa cylindrica (L.) M.Roem.	Cucurbitaceae	Fruit
17	Gourd (Ridge)	पाटे घिरौला	Luffa acutangula (L.) Roxb.	Cucurbitaceae	Fruit
18	Gourd (Snake)	चिचिण्डो	Trichosanthes anguina L.	Cucurbitaceae	Fruit
19	Gourd (snake wild)	बन चिचिण्डो	Trichosanthes cucumerina L.	Cucurbitaceae	Fruit
20	Gourd (Pointed)	परवल	Trichosanthes dioica Roxb.	Cucurbitaceae	Fruit
21	Gourd (Round)	टिण्डा	Citrullus vulgaris var. fistulosus Steward	Cucurbitaceae	Fruit
22	Gourd (Chattel)	बन करेला	Momordica cochinchinensis (Lour.) Spreng.	Cucurbitaceae	Fruit
23	Gourd (ivy)	गोलकाँक्री	Coccinia grandis (L.) Voigt	cucurbitaceae	Fruit
24	Lady's finger/okra	रामतोरियाँ	Abelmoschus esculentus (L.) Moench	Malvaceae	Fruit

SN	English name	Nepali name	Scientific name	Family	Kinds
25	Lady's finger (wild okra)	बन भिण्डी	Abelmoschus manihot (L.) Medik.	Malvaceae	Fruit
26	Melon (Musk)	खरबुजा	Cucumis melo var. reticulatus Ser.	Cucurbitaceae	Fruit
27	Melon (water)	तरबुजा	Citrullus lanatus (Thunb.) Matsum. & Nakai	Cucurbitaceae	Fruit
28	Melon (Orange)	घुर्मि	Cucumis melo var. agrestis Naudin	Cucurbitaceae	Fruit
29	Snap melon	फुट्कांक्री	Cucumis melo var. momordica (Roxb.) Cogn.	Cucurbitaceae	Fruit
30	Sun flower	सूर्यमुखी	Helianthus annuus L.	Asteraceae	
31	Tomato	गोलभेडा	Lycopersicon esculentum Mill.	Solanaceae	Fruit
32	Tomato (Cherry)	जीरे गोलभेडा	Lycopersicon cerasiforme Dunal	solanaceae	Fruit
33	Tomato (Tree)	रुखे गोलभेडा	Cyphomandra betacea (Cav.) Sendtn.	Solanaceae	Fruit
34	Pumpkin (Squash)	स्क्वासफर्सी	Cucurbita pepo L.	Cucurbitaceae	Fruit
35	Pumpkin (Nepali)	फर्सी	Cucurbita moschata Duchesne	Cucurbitaceae	Fruit
36	Pumpkin (winter)	हिउँदे फर्सि	Cucurbita maxima Duchesne	Cucurbitaceae	Fruit
Legume vegetables					
1	Bean (Cluster)	ग्वार सिमी	Cyamopsis tetragonoloba L.	Fabaceae	Legume
2	Bean (Soya)	भट्टमास	Glycine max (L.) Merr.	Fabaceae	Legume
3	Bean (Sword)	खुंडे सिमी	Canavalia gladiata (Jacq.) DC.	Fabaceae	Legume
4	Bean (Sword)	तरवारे सिमी	Canavalia ensiformis (L.) DC.	Fabaceae	Legume
5	Bean (Winged)	पखेटे सिमी	Tetragonolobus purpureus Moench	Fabaceae	Legume
6	Bean (Velvet)	काउसे सिमी	Mucuna cochinchinensis (Lour.) A.Chev.	Fabaceae	legume
7	Bean (Hyacinth)	हिउदे /टाटे सिमी	Dolichos lablab L.	Fabaceae	legume
8	Cow-pea (kattike)	बोडी	Vigna unguiculata (L.) Walp.	Fabaceae	Legume
9	Cow-pea (Tane)	तनेबोडी	Vigna unguiculata var. sesquipedalis (L.) Bertoni	Fabaceae	Legume
10	Drum stick	सजिवन	Moringa oleifera Lam.	Moringaceae	Legume
11	Pea	केराउ	Pisum sativum L.	Fabaceae	Legume
Roots and Tubers					
1	Beet root	चुकन्दर	Beta vulgaris L.	Chenopodiaceae	Root
2	Cassava	सिमल तरुल	Manihot esculenta Crantz	Euphorbiaceae	Root
3	Carrot	गाजर	Daucus carota L.	Apiaceae	Root
4	Radish (Pyuthane)	प्यूथाने मूला	Raphanus sativus L.	Brassicaceae	Root
5	Radish (White)	मूला सेतो	Raphanus sativus var. longipinnatus L.H. Bailey	Brassicaceae	Root
6	Rutabaga	रुटाबागा	Brassica napus var. napobrassica (L.) Rchb.	Brassicaceae	Root
7	Mountain Ebony	कोइरालो	Bauhinia variegata L.	Caesalpiniaceae	Flower
8	Potato	आलु	Solanum tuberosum L.	Solanaceae	Stem/stolen
9	Perilla	सिलाम	Perilla frutescens (L.) Britton	Lamiaceae	seed
10	Yam (air tuber)	गिट्टे तरुल	Dioscorea bulbifera L.	Dioscoreaceae	tuber
11	Yam (White)	घर तरुल	Dioscorea alata L.	Dioscoreaceae	tuber
12	Yam (Deltoid)	तरुल भ्याकुर	Dioscorea deltoidea Wall. ex Griseb.	Dioscoreaceae	tuber
13	Yam (Pentafoliate)	तरुल मिठेगिट्टे	Dioscorea pentaphylla L.	Dioscoreaceae	tuber
14	Yam (Karenpotato)	तरुल सुथनी	Dioscorea esculenta (Lour.) Burkill	Dioscoreaceae	tuber
15	Yam (giant taro)	घ्याम्पे तरुल	Alocasia macrorrhizos (L.) G.Don	Dioscoreaceae	tuber

Annex 2. Released vegetable varieties and their distinguishing characters

SN	Crops and varieties	Released year	Distinguishing characters
1	**Cauliflower**		
	Sarlahi Deepali	1994	Plants are medium tall of erect habit, green and waxy leaves having

SN	Crops and varieties	Released year	Distinguishing characters
			rounded apex. Curd are somewhat round, white to creamy white, compact, medium sized weighing 600-700g. Average yield is 15 t/ha.
	Dolpa Snowbal	1994	Late variety maturing in 130 days after transplanting, curd round, white, smooth, weight 1.5-2 kg. Suitable for autumn transplanting and spring harvest. A selection from Snowball-16.
	Kathmandu Local	1990	A well adapted mid-season variety maturing in 110-120 days after transplanting. Wide adaptability to the different conditions. Excellent white to creamy white, flatish compact curd, fine grained, semi-self-protected by outer leaves. Curd weight 1.5-2 kg.
	Khumal Jyapu	2014	Matures 65-80 days after transplanting and have around 1 kg size with better taste, developed by Horticulture Research Division, Khumaltar.
2	**Radish**		
	Chalis Dine	1994	Variety early, maturing 35-45 days. Roots white 15-25 cm long, pungency very low. Leaves are upright, erect, light green, non-hairy, sweet and shining white.
	Pyuthane Rato	1994	Late season variety, maturity 70-80 days after sowing, root red with white flash, 20-30 cm long, thick tapering. Red neck with light red or whitish red root end.
	White Neck	1994	Maturity 60-65 days. Roots 35cm long, 6-8 cm diameter, cylindrical, pure white and smooth. Flesh white, mild pungency. Leaves upright, light green in colour, top green. Yield 30-40 t/ha.
	Mino Early	1990	Early variety, maturity 45-50 days. Roots pure white, tapering rooted, have tendency to grow above ground level. Pungency mild. Leaf grayish green having deep cuts with spreading habit. Yield 30-40 t/ha.
3	**Broad Leaf Mustard**		
	Tangkhuwa Rayo	1994	Light green leaf with cream white leaf vein, very smooth and wavy leaf margin.
	Khumal Rato Pat	1994	Late variety, matures for first harvest in 60-70 days after transplanting; leaves are green with purple-red pigments, puckered, non-hairy, petioles curved and leaves are also curved to a cup-shape, fleshy, 25-30 cm long and 20-25 cm wide, bolts later than Khumal and Marpha broad leaf; yields 25-30 t/ha green leaves.
	Khumal Chaudapat	1994	Mature for first harvest in 40-50 days after transplanting and continues for another 100-120 days, leaves dark green, fleshy, non-hairy and puckered, 40-50 cm long and 25-30 cm wide, yield 30-40 t/ha green leaves.
	Marpha Chaudapat	1994	Mature for first harvest in 55-65 days after transplanting; leaves light green, non-hairy, puckered, 40-50 cm long and 20-30 cm wide with flat petioles; late bolter; yield 25-30 t/ha green leaves.
4	**Turnip**		
	Purple Top	1990	Leaves dark green with deep cuts, roots globe shaped white with purple exposed crown. Flesh white, maturity 60-70 days after sowing. Plants top erect. Suitable for autumn plantation.
	Kathmandu Rato	2015	Early variety, root matures in 50-55 days of sowing. Root globe to flatish, outer colour red, flesh white, strong flavour.
5	**Onion**		
	Red Creole	1990	Deep red skinned thick flat bulb, white flash, medium late variety, bulb matures in 160-180 days after transplanting. Bulb weight about 175g.
6	**Tomato**		
	Srijana (Registered)	2010	Hybrid variety developed by NARC, bacterial wilt resistant, fruit ovate & 60-80g weight, uniform and red and heavy yielder, indeterminate variety.
	Roma	1994	Mid-season variety; fruits ready for first harvest in 60-70 days after transplanting. Fruits smooth, uniformed fleshy thick, bi-chambered, less seed content, leaves broader, potato type, plant determinate and bushy.
	Monprecos	1994	Medium early variety, fruit ready for first harvest in 80- 90 days after transplanting, fruits globe shaped, smooth, uniformly red, bi-tri-chambered, firm flash seed content low, plant vigorous, indeterminate, erect.
	NCL-1	1994	Heat resistant and wilt tolerant variety, fruits ready for first harvest in 65-75 days after transplanting, fruits plum shaped to flatish round, firm,

SN	Crops and varieties	Released year	Distinguishing characters
			thick skinned, yellowish red with a slight green shoulder when ripe, suitable for rainy season and autumn season harvest. Plant semi-determinate to indeterminate depending upon climate. A selection from CL-1131 cultivar.
	Pusa Ruby	1990	Fruits ripe in 60-65 days after transplanting fruits flatish round, uniform red, smooth surface, seed content comparatively higher, determinate growth habit.
6	**Carrot**		
	Nantes Forte	1990	Very high quality roots. Suitable for autumn and spring plantation. Excellent internal and external colour. Roots 15-20 cm long, cylindrical blunt tipped. Matures in 90-100 days after sowing.
	New Kuroda Op (Registered)	2010	Well adapted variety for tropical and sub tropical conditions. Roots 15-20 cm long with conical flat shoulder, tapering towards the root end. Bright orange coloured surface with few deep eyes. Matures in 80-100 days after sowing.
7.	**Cabbage**		
	Copenhagen Market	1994	Mid season variety; mature 70-90 days after transplanting, head round, blue green, 1.5-2.5 kg, good for school garden.
8.	**Asparagus Bean**		
	Sarlahi Tane	1994	A bit early variety. Pods ready for first harvest in 50-60 days after sowing. Plants climbing, pods 25-30 cm long, light greenish white, seed black when ripe.
	Khumal Tane	1994	Climbing long podded type, pods 30-45 cm long white to greenish white, seeds red when ripe. Needs warm climate for successful results. Yields 6-8 fresh pods t/ha.
9	**Pole Bean**		
	Trishuli Ghiu Simi	1994	Popular climbing type pods 20-25 cm long. Green fleshy, long curved ('S' shaped), fibreless at prime picking period. Seeds light to coffee brown with purple eye ring. Yield 6-8 t/ha. Suitable for autumn and spring through summer harvest.
	Jhange Simi-1	1994	Bush type variety; resistant to common bean mosaic. Maturity 50 days after sowing. Pods dark green and 15 cm long. Yield 5-6 t/ha.
10	**Peas**		
	Sarlahi Arkel	1994	Early variety, ready for first picking in 60-65 days after sowing; pods deep green 7-8 cm long, well filled with 7-8 grains seeds wrinkled on drying; yields 5-7 t/ha green pods . Suitable for late autumn sowing and early spring harvest.
	New Line	1994	Mid to late season variety, flowers in 60-65 days of sowing, pods are ready for first picking in 85-90 days of sowing; plant medium tall and vigorous in growth; leaves are dark green and broader; flower borne in double; pods straight green, 7-8 cm long, well filled with 6-7 grains seeds wrinkled on drying. Suitable for autumn plantation.
	Sikkime	1994	Late variety, flowers in 80-85 days and pods ready for first picking in 105-110 days after sowing; plants are tall and vigorous; leaves are light green with very wide leaf lets; pods light green, well filled, short with 6-7 grain; seeds are bold, creamy whitish with black helium, smooth on drying, suitable for rainy season in High Hill. A selection form Sikkim Local variety.
11	**Capsicum**		
	Californe	1994	Fruits ready for first harvest in 80-90 days after transplanting; plants 70-75 cm tall, erect some what busy; leaves single entire broader than normal chilli, dark green with pointed tip, fruits are 3 to 4 lobed generally. Yields 25-30t/ha.
12	**Chilli**		
	Jwala	1994	A high yielding variety with long slender fruits, brilliant red when ripe. Selection of Pusa Jwala variety. Slightly earlier than other commercial varieties.
13	**Brinjal**		
	Nurki	1994	Plant medium, stem and leaves pinkish in colour, thronless leaves and stem but thrones in fruit petiole. Fruit 15-25cm long, soft, 4-5 fruits in a bunch. Maturity 60-70 days.

SN	Crops and varieties	Released year	Distinguishing characters
14	**Sponge Gourd**		
	Kantipure	2010	Recommended for Mid Hill, fruit 50-75cm long. Maturity 110-120 days.
15	**Cucumber**		
	Kushle	1994	Early variety, fruits ready for first harvest in 75-80 days after sowing. Fruits straight 15-25cm long with 6-10 cm diameter; fruit light green with more white towards distal end.
16	**Squash**		
	Ashare Squash	1994	Fruits are medium sized; flesh is tender and delicious at immature stage when it is used as vegetables. Duration 60-80 days. Yield 20-35 t/ha.
17	**Swiss Chard**		
	Susag	1994	Duration 60-70 days. Yield 20-35 t/ha.
18	**Bitter Gourd**		
	Green Karela	1994	Fruits are dark green, Duration 90-100 days. Yield 20-25 t/ha.
19	**Lady's Finger**		
	Parbati	1994	An early heavy yielding variety, more tolerable to yellow veinmosaic virus. Plant medium tall. Fruits fleshly, medium green in colour. Well adapted for spring, summer and rainy season harvest. A selection of Parvani Kranti variety.
20	**Spinach**		
	Haripate	1994	Plants ready for harvest in 50-60 days after sowing, leaves erect, smooth, vigorous, and green to dark green, petioles and lower base pinkish. Suitable for autumn and spring sowing.

Source: CPDD 2014, SQCC 2016.

Annex 3. Crop and variety-wise maintenance at various farms and stations developed during eighties

SN	Farm/Station and crop	Variety
1.	**VSPC Dadeldhura**	
	Knol Khol	White Viana
	Radish	Mino early
	Turnip	Improved White
	Broad leaf mustard	Khumal Red Leaf
	Tomato	Monprecos
	Peas	NLP
	French bean	Contender, Kentucky Wonder
	Cucumber	Local
2.	**VSPC Rukum**	
	Cauliflower	Kathmandu Local
	Radish	Mino Early
	Turnip	Purple Top White Globe
	Broad leaf mustard	Khumal Broad Leaf
	Cress	Local
	Onion	Red Creole
	Sweet pepper	California Wonder
	Tomato	Pusa Ruby
	Peas	Arkle
	French bean	Contender
	Squash	Black Zucchini
3.	**H. Farm Pokhara**	
	Radish	Mino Early
	Okra	Pusa Selection I
	Sponge gourd	Pusa Chikini
4.	**H. Farm Marpha**	
	Cauliflower	Snow Ball
	Radish	Tokinasi
	Turnip	Purple Top White Globe
	Broad leaf mustard	Marpha Broad Leaf
	Peas	Arkle
	Bean	Carlos Favourite
	Cress	Local
	Cabbage	Large Late Drum Head, Copenhagen market, Pride of India

SN	Farm/Station and crop	Variety
	Carrot	Nantes Forto
	Swiss Chard	Ford Hook Giant
	French bean	Kentucky Wonder
5.	**AS Lumle**	
	Knol Khol	White Viana
	Cauliflower	Kathmandu Local
	Radish	Pyuthane Red, 40-days
	Spinach	Patane
	Peas	Arkle, Sikkim
	Coriander	Local
	Fenugreek	Kasuri
	Eggplant	PPL
	Squash	Grey Zuchini
	Cucumber	Bhaktapur Local
6.	**VSPC Khumaltar**	
	Cauliflower	Kathmandu Local
	Radish	Mino Early
	Turnip	Purple Top White Globe
	Broad Leaf Mustard	Khumal Broad Leaf
	Peas	Perfection New Line, Sikkim
	French beans	Kentucky Wonder
	Tomato	Monprecos
	Okra	Pusa Sawani
	Spinach	Patane
	Squash	Grey Zuchini
	Cress	Local
	Broad bean	Local
	Chilli	Dandicut, Local
	Swiss Chard	Ford Hook Giant
	Fenugreek	Kasuri
	Cowpea	Kathmandu Red
	Cucumber	Bhaktapur Local
7.	**H. Farm Sarlahi**	
	Peas	Arkle, Bonville, NLP
	Tomato	Pusa Ruby, Roma, NCL-1, Sarlahi
	Okra	Pusa sawani
	Sweet pepper	California Wonder
	Beet spinach	All green
	Cucumber	Sarlahi Local
	Eggplant	Nurki, Sarlahi Green
	Watermelon	Sugar-baby
	Cauliflower	Pusa Deepali
	Radish	Pusa chetki
	Fenugreek	Kasuri
	Chilli	Pusa Jwala
	Eggplant	Nurki, PPL, Sarlahi Green
	Cowpea	Sarlahi Black
	Pumpkin	Local
	Bitter gourd	Green Karela, Coimbatore Long
	Bottle gourd	Pusa Summer Prolific Long
	Sponge gourd	Pusa Chikini
	Ash gourd	Local
8.	**AS Dhankuta**	
	Cauliflower	Kibo Giant
	Radish	White Neck
	Broad leaf mustard	Khumal Broad Leaf
	Peas	Perfection New Line
	Beans	Contender
	Tomato	Monprecos

SN	Farm/Station and crop	Variety
	Capsicum	California Wonder
	Onion	Red Creole
	Turnip	Purple Top White Globe
	Cress	Local
	French bean	Kentucky Wonder
9.	**AS Pakhribas**	
	Broccoli	Green Sprouting
	Cauliflower	Kathmandu Local
	Radish	Mino Early, 40-days
	Broad leaf mustard	Khumal Broad Leaf
	Cress	Local
	Table beet	Detroit Dark Red
	Chilli	Akabare
	Sweet pepper	California Wonder
	Peas	Bonville, Sikkim
	French bean	Kentucky Wonder
	Cowpea	Kathmandu Red
	Bitter gourd	Coimbatore Long
	Squash	Black Zucchini
	Sponge gourd	Pusa Chikini
10.	**H. Farm Panchkhal**	
	Eggplant	Pusa Kranti
	Cucumber	Kusume
11.	**H.S. Parawanipur**	
	Peas	Arkle
	Pumpkin	Local
	Tomato	Marglobe
	Eggplant	Sarlahi Green
	Bottle gourd	Pusa summer Profilic Long
12.	**AS Jumla**	
	Cabbage	Golden Acre
13.	**AS Dolpa**	
	Cauliflower	Snow Ball 16
	Carrot	New kuroda
	Broad leaf mustard	Marpha Broad Leaf
14.	**H. Farm Janakpur**	
	Radish	Chetki
	Peas	Perfection New Line
	Okra	Pusa Selection I
	Chilli	Cyanne
	Eggplant	Pusa Kranti
15.	**Ag. Farm Palpa**	
	Cauliflower	Early Snow Ball
	Radish	Pyuthane
	Onion	Nasik red
16.	**Ag Station Nepalgunj**	
	Tomato	Money Maker
	Eggplant	Pusa Purple Cluster
17.	**H. Farm Dailekh**	
	Broad Leaf Mustard	Marpha Broad Leaf
	Onion	Agri-found Dark Red
19.	**H. Farm Sindhuli**	
	Chilli	Yatsufusa
	Eggplant	Pusa Purple Round

Annex 4. Organizations responsible for maintaining crop varieties in Nepal as proposed by SQCC

Crop	Variety	Variety maintenance organisation
Tomato	Sirijana hybrid	Horticulture Research Division, Khumal, NARC
Tomato	Pusa Ruby	Sarlahi Horticultural Farm (DoA)
Tomato	NCL	Horticulture Research Station, Malepatan, NARC
Radish	Mino Early	Agriculture Research Station, Dailkeh, NARC
Radish	Pyuthane Red	Horticulture Farm (DoA), Palpa
Radish	40 days	Regional Agriculture Research Station, Lumle
Radish	Tokinashi	Horticulture Research Station, Jumla (NARC)
Rayp	Marpha Broad Leaf	Horticultural Farm Mustang (DoA)
Rayo	Khumal Red Leaf	Vegetable Seed Production Centre, Dadeldhura
Rayo	Khumal Broad Lead	Horticulture Research Division, Khumal, NARC
Onion	Red Creole	Agriculture Research Station, Dailkeh, NARC
Pea	Sarlahi Arkel	Regional Agriculture Research Station, Nepalganj (NARC)
Pea	Sikkim Local	Regional Agriculture Research Station, Lumle
Cauliflower	Kathmandu Local	Horticulture Research Division, Khumaltar, NARC
Forage (Oat)	Kamdhenu Jai and Netra jai	Forage and Pasture Research Division, Khumaltar (NARC)

Annex 5. Farmer's field vegetable variety maintenance and seed production pockets / zones

SN	Crops	Varieties	Suitable seed production pockets/zones
1	Tomato	NCL, Lapsigede, Monprecos, Pusarubi	Mid Hill and InnerTarai and Tarai
2	Carrot	Nantes Fort, Newkoroda	Mountain regions of Karnali
3	Onion	Redcreole	Mid Hill and Mountains of Mid Western region (Rukum, Rolpa, Dailekh, Pyuthan etc)
4	Turnip	Purpletop	Mountains and Mid Hill regions (Kalikot, Huml, Mugu, Rukum, Rolpa, Pyuthan)
5	Cress	Local	Mid Hill (Rolpa, Kalikot, Dailekh, Rukum)
6	Rayo	Khumal Broad Leaf, Khumal Red Leaf and Marpha Broad Leaf	High mountains and Mid Hill of Western (Mustang) and Mid Western (Karnali zones) and Central Mid Hill (Kavre, Dhading etc)
7	Brinjal	Nurki, PPL	Inner Tarai and Tarai region (Chitwan, Dang, Sarlahi, Udayapur) and lower valleys of Mid Hill region
8	Pepper	California Wonder	Mountains and Mid Hill of Mid Western (Kalikot, Dailekh, Rukum, Rolpa, Dang, Surkhet)
9	Chilli	Pusa Jwala	Mountains and Mid Hill of Mid Western (Kalikot, Dailekh, Rukum, Rolpa, Surkhet)
10	Lady's finger	Parbati, Parwani, Kanti	Inner Tarai and Tarai region (Chitwan, Dang, Sarlahi, Udaypur) and lower valleys of Mid Hill
11	Swisschard	Fordhook joint	High mountains and Mid Hill of Western (Mustang) and Mid Western regions (Karnali)
12	Spinach	Patane, Kande, All green	Mountains and Mid Hill of Mid Western regions (Kalikot, Dailekh, Rukum, Rolpa, Dang, Surkhet
13	Cucurbitaceaous vegetables	Saralhi green (cucumber), Jukini (Squash),	Inner Tarai and Tarai region (Chitwan, Dang, Sarlahi, Udayapur) and lower valleys of Mid Hill
14	Beans	Tane (khumal, Sarlahi), Four season	Mid Hill, Inner Tarai and Tarai region (Syangja, Kavre, Chitwan, Dang, Sarlahi, Udayapur)
15	Cauliflower and Cabbage	Cauli (KTM local), Dolpa Snowball local, Giant cabbage, Copenhegen market (Cabbage)	High mountain regions of Karnaili (Humla, Dolpa, Kalikot) and Mid Hill of Mid Western region (Rukum, Rolpa, Salyan, Pyuthan)

Annex 6. Distribution of varieties of major vegetables in the districts

SN	Crop	Variety	Rasuwa	Nuwakot	Chitwan	Panchthar	Morang	Palpa	Kapilwastu	Dang	Pyuthan	Kanchanpur
1	Cucumber	Bhaktapur Local	√	√	√	√	√	√	√	√	√	
		Ninja						√		√	√	
		Malini						√		√		√
		Dinesty		√	√			√		√		
		Japanese Green Long					√	√	√	√		

SN	Crop	Variety	Rasuwa	Nuwakot	Chitwan	Panchthar	Morang	Palpa	Kapilwastu	Dang	Pyuthan	Kanchanpur
		NS 404								√		√
		Kushle		√			√				√	
2	Bitter gourd	Pali	√	√	√	√		√		√	√	√
		Maya									√	
		Green Long					√	√			√	
		Pusa Domausami					√					
		Tejaswi					√	√				
		Creeper						√				
		Chaman							√			
		Summer Green							√			
		Jhagari			√				√			
3	Cauliflower	Kathmandu Local	√	√	√			√	√	√	√	
		Snow Mistic	√	√	√	√		√	√	√	√	
		Snow Crown		√	√	√	√	√	√	√	√	√
		Snow Dome		√								
		White Top		√								
		Silvercup 60		√	√			√	√		√	√
		Snoball 16			√		√	√	√		√	
		Himlata					√	√				
		Himdeb					√					
		Jyapu						√			√	
		Snow King			√							
		Milky Way			√							
4	Cabage	Green Coronet	√	√	√	√	√	√	√	√	√	√
		Copenhagen Market	√		√		√	√			√	
		Summer Cup										√
		Green Crown		√	√			√				
		Green Stone			√	√		√	√		√	
		Pride of India			√		√		√		√	
		T 621			√			√	√		√	
		KK Cross							√			
		Golden Acre			√				√			
5	Tomato	Sirjana	√	√		√		√		√	√	√
		Abinash	√				√	√	√	√	√	
		Gaurab 555								√		
		Siris								√		
		Nabin						√	√	√	√	
		Manisha		√	√		√	√	√	√	√	√
		Dalila		√				√				
		Himsona						√		√		
		Sanjhana				√						
		CL 1131			√		√		√			
		Roma					√		√			
		Pusa rubi			√		√		√			
		NCL 1							√		√	
		Baishali									√	
		Ramia						√	√		√	
6	Radish	40 Days	√	√	√	√	√	√	√	√	√	√
		Mino Early	√	√	√	√	√	√	√	√	√	√
		Tokinase			√	√		√	√		√	
		Pyuthane Red						√	√		√	
		All Season						√				
7	Broad Leaf Mustard	Marpha Chaudapat	√	√	√	√	√	√		√	√	
		Khumal Chaudapat	√	√	√	√	√	√		√	√	
		Tankhuwa Local					√					
		Khumal Ratopat			√				√			
8	Onion	Nasik Red 53	√	√	√	√	√	√	√	√	√	√
		Red Creol	√	√	√	√	√	√	√	√	√	√
		Agrifound Dark Red						√	√			
9	Chilli	Pusa Jwala	√	√	√	√	√	√	√			

SN	Crop	Variety	Rasuwa	Nuwakot	Chitwan	Panchthar	Morang	Palpa	Kapilwastu	Dang	Pyuthan	Kanchanpur
		NS 1701	√	√		√	√	√	√	√	√	√
		Anna 3										√
		Suryamukhi			√		√	√	√			
		Tejaswi					√					
10	Brinjal	Nurki	√	√	√	√	√	√	√			√
		Sarlahi Green	√	√	√							
		NS 797										√
		Purple Lomg		√	√		√	√	√			
11	Okra	Parbati	√	√	√				√			
		Arka Anamika	√	√	√	√	√	√	√	√	√	
		Parwani Kranti			√			√	√		√	

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Diversity and Utilization Status of Root and Tuber Crops Genetic Resources in Nepal

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ABSTRACT
Root and tuber (R&T) crops are second in their importance to cereals as a global source of carbohydrates and particularly due to high production potential in the areas unsuitable for cereal crops. There are more than 30 edible and non-edible R&T crops reported in the world and among them, taro (*Colocasia esculenta* (L.) Schott), yam (*Dioscorea alata* L.*),* cassava (*Manihot esculenta* Crantz), Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson), Peruvian ground apple (*Smallanthus sonchifolius* (Poepp.) H.Rob.), potato (*Solanum tuberosum* L.) and sweet potato (*Ipomoea* sp.) are the major cultivated R&T crops in Nepal. Taro is grown traditionally in home gardens of Nepalese farmers and contained huge genetic and cultural diversity. Yam is a perennial in nature but cultivated as annual crop. Two varieties namely 'Local Seto' and 'Local Rato' varieties of Cassava crop including 'Local Red' variety of Elephant foot yam are maintained at the field genebank of Kandamul Vegetable Development Center (KVDC), Sindhuli. Ground apple is newly introduced crop and the varieties grown so far are not identified. Potato is a major vegetable and staple food of the country, and is cultivated in 197,037 ha with the productivity of 13.1 t/ha. A total of 101 advanced potato clones introduced from International Potato Center, Lima, Peru as well as the germplasm of ten released varieties are maintained under in-vitro conditions of National Potato Research Programme (NPRP), Khumaltar. In field genebank, 19 advanced genotypes (introduced), 80 local collections and 42 NPRP-bred materials are characterized, multiplied and maintained so far. A total of 77 sweet potato germplasm consisting of 22 exotic and 55 local are maintained under field condition. Root and tuber crops are very much adaptive in low input agricultural systems and important for food and nutritional security. This paper reviews about the status on diversity and management aspect of R&T crop genetic resources.

Keywords: Field gene bank, food and nutritional security, in-vitro, genebank, root and tuber crops

INTRODUCTION

Plants yielding starchy roots, tubers, rhizomes, corms and stems are defined as Root and Tuber (R&T) crops (Scott et al 2000). Potatoes and yams are categorized as tuber crops, taro and cocoyams are derived from corms/underground stems and swollen hypocotyls, and cassava and sweet potatoes are storage roots. Many of the poorest producers from developing world depend on these crops and the importance of R&T crops in developed countries is also increasing as human food, animal feed and processed products as well. These crops contribute as source of food and nutrition as they produce large quantities of dietary energy and have stable yields under conditions in which other crops may fail (Low et al 1997). Though further investigation might be necessary to find out the centre of origin of these crops, most of R&T crops possess a huge genetic diversity at variety and landrace levels in Nepal. This diversity can be found in almost all of the agro-ecologies. However, genetic resources of many of these crops are threatened by erosion, mainly due to the human and complex natural factors (Joshi 2017). Expansion of modern agriculture, introduction of exotic crop varieties, loss and degradation of agricultural and forest land, over exploitation of genetic resources, and poor marketing opportunities for traditional R&T crops are becoming major threat to the crops (Scott et al 2000).

R&T crops contain mainly carbohydrates (16-24% of their total weight) with some protein and fat (0-2% each) (Wheatley et al 1995). More than 30 edible and non-edible species of R&T crops are grown today throughout the world and more than a dozen crops are grown under this group in Nepal. Among them, potato, sweet potato*,* taro*,* yam, elephant foot yam (ole) and cassava are common root and tuber crops. Rural people mostly involved in utilizing root and tuber crops and they maintain the traditional knowledge regarding their location, season, preservation, processing and culinary uses. Rural people particularly women involve in cultivating and trading the R&T crops and maintain their economic activities within the families.

Nepal has diverse agro-ecological and climatic conditions favorable for the production of R&T crops. Despite their importance in income generation, food and nutritional security and in some cultural context, little research and development attention have so far been given to these crops. Except potato; sweet potato, taro, yam, elephant foot yam and cassava are considered as underutilized crop species. R&T crops particularly potato, sweet potato, taro and yam contribute a major share in the traditional food systems of many people in Nepal and these crops play a major role in the food security of the people especially mid and High Hills of Nepal. The production of yam, taro and sweet potato still depend on local varieties. After the establishment of Nepal Agricultural Research Council (NARC) in 1991, many commodity research programmes and Horticulture Research Stations (HRS) were established across the country with the mandate of research on horticultural crop including R&T crops. National Agriculture Genetic Resource Centre (NAGRC) was established under NARC in 2010 with the mandate of the exploration, collection, multiplication, characterization (morphological, molecular, and functional), conservation and distribution of plant genetic resources (PGRs) including R&T crops in Nepal.

ROOT AND TUBER CROP SPECIES

Major roots and tuber crops species available in Nepal are given in **Table** 1. In sweet potato, the wild relatives *Ipomoea cairica* (L.) Sweet was reported (Genebank 2016). Taro belongs to the genus Colocasia within the sub-family Colocasioideae of the monocotyledonous family Araceae. Cultivated taro is classified as *Colocasia esculenta*, and the species is considered to be polymorphic (Onwueme 1999). The cultivated yam is classified as *Diascorea alata* but wild yams are classified as *D. bulbifera*, *D. versicolor*, *D. deltoidea* and *D. triphylla* (Bhandari and Kawabata 2005). Similarly, elephant foot yam and cassava are also reported in Nepal.

Table 1. Root and tuber crop species in Nepal

SN	Common name	Nepali name	Scientific name	
			Cultivated	Wild
1.	Cassava	Simal tarul	Manihot esculenta Crantz	-
2.	Elephant foot yam	Ole	Amorphophallus paeoniifolius (Dennst.) Nicolson	-
3.	Potato	Aalu	Solanum tuberosum L.	-
4.	Sweet potato	SakharKhanda	Ipomoea batatas (L.) Lam.	Ipomoea cairica (L.) Sweet
5.	Taro	Pidaalu Karkalo	Colocasia spp. Xanthosoma spp.	- -
6.	Yam	Tarul	Dioscorea alata L.	Wild yams (Dioscorea bulbifera L., Dioscorea versicolor, Dioscorea deltoidea Wall. ex Griseb., Dioscorea triphylla L.)

Potato is a major tuber crop in Nepal and the potato cultivation area is estimated to be 1,97,037 ha with total productivity of 13.1 t/ha (**Table** 2). Taro is cultivated in 4,211 ha with the productivity of 9.7 t/ha which is next to potato. But sweet potato, yam, Ole and other tuber crops are cultivated sparsely throughout the country.

Table 2. Area and productivity of major root and tuber crops in Nepal

Crop	Area, ha	Yield, t/ha
Potato	1,97,037	13.1
Sweet potato	1,545	9.1
Taro	4,211	9.65
Yam	908	13.83
Elephant foot yam (Ole)	663	18 .0
Other tuber crops	593	10 .0

Source: ABPSD 2015, Saha 2016.

R&T crops in Nepal are mainly used for human food but very little in processed form either for human consumption or animal feed. Since industries for manufacturing starch, alcohol and fermented beverages from R&T crops are still in very infant stage, R&T crops has not gained the importance in production at national level yet. Taro, yam, cassava and ground apple also serve as supplementary food sources for the farmers at different communities. Due to changing the food habits of the farmers, potato dominated food system at High Hill now changed and potato is dominated by cereals such as rice, wheat and maize. R&T crops play comparatively an important role in food systems especially of remote, often marginal areas with particularly low income levels and limited access to farm inputs. R&T also serve as source of cash income for low income farm households and as raw materials for processed products for both rural and urban consumption. In the past, almost all of the R&T crops were the food of rural and marginalized poor but with the increased awareness towards the value of these crops, rapidly urbanized population in recent years and their changed food habits have started to diversify their food intake from cereal-based diets to greater consumption of root and tuber crops.

Besides the food and nutritional importance, some R&T crops are very important for celebrating religious Hindu festival of 'Maghe Sankranti', the first day of the 'Magh' (January). In the past, sweet potatoes, yam, and taro were consumed once a year especially in 'Maghe Sakranti' but in recent years, the consumption of these tuber crops has been changed drastically. There is year-round availability of these tuber crops in local markets which signifies the increasing the importance of R&T crops in Nepal. Poverty and malnutrition are major problems in mid-western and far-western Nepal. Food deficit and Vitamin A deficiency has also caused stunting in children and severe health problems. R&T crops fit for marginal areas, low input condition and might have high yield potential under adverse climatic condition. However, the food potential of R&T crops has not been fully exploited. Utilizing the landraces of R&T crops, the food production potential can be enhanced. The genetic variations in landraces are very much useful for plant breeder to develop crop varieties to cope the extreme biotic and abiotic stress (Luitel et al 2016).

VARIETAL DIVERSITY ON ROOT AND TUBER CROPS

NPRP had introduced many germplasm from International Potato Center (CIP) Lima, Peru since its collaboration with CIP in 1974. In addition, NPRP is continuing its collaboration with Regional Office, CIP, New Delhi, India. Currently, 58 accessions (exotic) (**Table** 3) of CIP germplasm are morphologically characterized and maintained at in-vitro condition at tissue culture laboratory of NPRP. Likewise, 19 techno-tubers were received as minituber from India (**Table** 4) and 80 local potato germplasm (**Table** 5) are morphologically characterized and conserved in in-vitro condition (only exotic potato germplasm). Instead, local potato germplasm are multiplied at field genebank at Hattiban Research Farm of NPRP (**Table** 6). NPRP has so far released 10 varieties and registered two varieties of potato through varietal selection procedure using CIP germplasm. Since the potato is originated in South America, Andes Region and genetic diversity of potato in Nepal is not so high. However, the local ecotypes of potato are well-adapted in different parts of the country and they have phenotypic (foliage, tuber color, shape and size) diversity and as well as genetic diversity. These ecotypes are autotetraploid type. NPRP is also implementing the conventional breeding system in variety development process. NPRP has selected 42 clones from seedling generation which has been characterized and multiplied (NPRP 2016).

NPRP has an additional mandate to conduct the research on sweet potato since 2010. A total of 21 orange-fleshed sweet potato germplasm from CIP, Lima, Peru has been introduced and all the germplasm were tested at multi-locations and characterized at phenotypic level (**Table** 6). Similarly, 55 local landraces of sweet potato were collected from different parts of the country and morphologically characterized (**Table** 7).

Cassava, a starchy root crop that can be grown in poor soils, is raising a lot of interest given its resilience to climate change worldwide. Though the official statistics is not available so far, its demand is growing in Nepal. Other root crops such as yam, taro and cocoyam are traditional staples that play an important role in food security and income generation. Taro is traditionally grown in open field and in home garden. Interspecific and intraspecific diversity is found in taro. Different types of taro are being cultivated in the country for the different purposes. Taro cultivars are developed and selected by the farmers and they are the main custodians of the both genetic and cultural diversity (Pandey 2001). Taro germplasm is characterized and diversity in phenotypic level (petiole color, cormel shape, corm size, corm sheath, skin color, flesh color) is observed. At Field genebank of NAGRC, 54 taro (**Table** 8), 15 yam and 10 released potato varieties are maintained (Genebank 2016). Two varieties named Local Seto and Local Rato of cassava are maintained at TVDC, Sindhuli, one variety 'ocal Red of elephant foot yam is maintained at NPRP, Sindhuli (TVDC 2016).

Table 3. List of potato clones maintained at in-vitro Tissue Culture in NPRP, 2015/16

SN	CIP #	Breeder code	Pedigree		Received date	Source	Source
			Female	Male			
1.	306514.64	MN-10.64	303887.17(1)	303887.17(1)	13-Aug-14	In-vitro	CIP, Peru
2.	306087.132	MN-132	303887.6(1)	303828.20(1)	13-Aug-14	In-vitro	CIP, Peru
3.	306087.56	MN-14.56	303887.6(1)	303828.20(1)	13-Aug-14	In-vitro	CIP, Peru
4.	306087.72	MN-14.72	303887.6(1)	303828.20(1)	13-Aug-14	In-vitro	CIP, Peru
5.	306418.1	MN-15.1	303887.6(1)	303888.4(1)	13-Aug-14	In-vitro	CIP, Peru

SN	CIP #	Breeder code	Pedigree		Received date	Source	Source
			Female	Male			
6.	306018.4	MN-16.4	303887.6(1)	303803.16(1)	13-Aug-14	In-vitro	CIP, Peru
7.	306018.66	MN-16.66	303887.6(1)	303803.16(1)	13-Aug-14	In-vitro	CIP, Peru
8.	306154.126	MN-17.126	303826.2(1)	303835.19(1)	13-Aug-14	In-vitro	CIP, Peru
9.	306143.65	MN-13.65	303887.6(1)	303835.11(1)	13-Aug-14	In-vitro	CIP, Peru
10.	306418.53	MN-15.53	303887.6(1)	303835.19(1)	13-Aug-14	In-vitro	CIP, Peru
11.	306416.68	MN-3.68	303887.10(1)	303888.4(1)	13-Aug-14	In-vitro	CIP, Peru
12.	306513.57	MN-9.57	303887.17(1)	303835.11(1)	13-Aug-14	In-vitro	CIP, Peru
13.	306143.62				14-Aug-14	In-vitro	CIP, Peru
14.	304394.56		Shepody	391207=(LR93.050)	15-Aug-14	In-vitro	CIP, Peru
15.	381381.9	Rukinzo	378493.915	PRECOZ BULK			
16.	395017.242		393085.13	392639.8			
17.	703312						
18.	703825						
19.	396012.266		391004.1	393280.58			
20.	392025.7		Linea 21	386614.16=(XY.16)			
21.	395445.16						
22.	392797.22						
23.	393382.44						
24.	395112.32						
25.	397079.26						
26.	395017.229						
27.	392637.229						
28.	392637.10		387143.22	387170.9			
29.	399078.11		391686.5	393079.4			
30.	391058.175						
31.	393613.2						
32.	392759.1						
33.	399067.22						
34.	393536.13						
35.	394611.112						
36.	701165						
37.	39400.52						
38.	393381.106		388611.22	676008=(I-1039)			
39.	703287	Azul					
40.	393371.159		387170.16	389746.2			
41.	395443.103		BWH-87.289	385280.1=(XY.13)			
42.	397067.2						
43.	396033.102		392639.53	393382.64			
44.	399706.27						
45.	392633.54		387132.2	387334.5			
46.	391002.6		386209.1	386206.4			
47.	392973.48		KRASA	385280.1=(XY.13)			
48.	393083.2		387315.27	390357.4			
49.	399079.22		395274.1	395257.6			
50.	393371.164		387170.16	389746.2			
51.	395111.13						
52.	391930.13						
53.	391930.1		BWH-87.338	SELF			
54.	396287.5						
55.	391046.14		386209.1	387338.3			
56.	393073.179						
57.	306022.69	MN-20.69	303816.2(1)	303803.18(1)			
58.	304369.22		Mariela	676008=(I-			

SN	CIP #	Breeder code	Pedigree		Received date	Source	Source
			Female	Male			
				1039)			

Source: NPRP 2015.

Table 4. List of 19 introduced advanced potato clones maintained at field genebank of Khumaltar, 2015/16

SN	Accession	Source	SN	Accession	Source
1.	Tech 7016-397029.21	India	11.	Tech 7001-301024.14	India
2.	Tech 7020-304371.2	India	12.	Tech 7006-304350.1	India
3.	Tech 7019-388972.22	India	13.	Tech 7003-302498.7	India
4.	Tech 7014-393371.58	India	14.	Tech 7011-304387.17	India
5.	Tech 7015-396311.1	India	15.	Tech 7021-304405.47	India
6.	Tech 7012-391058.175	India	16.	Tech 7018-304394.56	India
7.	Tech 7008-304351.109	India	17.	Tech 7010-304368.46	India
8.	Tech 7005-304347.6	India	18.	Tech 7007-304350.118	India
9.	Tech 7004-303381.3	India	19.	Tech 7017-397079.6	India
10.	Tech 7009-304366.46	India	20.		India

Source: NPRP 2015.

Table 5. Local cultivars of 80 potatoes maintained at Field Genebank of Hattiban Research Farm, Khumalar, 2016/17

SN	Cultivar	Collection site	SN	Cultivar	Collection site
1.	Kathu Dallo	-	41.	Kalo Aankhe	-
2.	Lal Gulab	Dhanusha	42.	NPI (T/0012) (Lumle Red)	Lumle
3.	Halan Aalu	Dhankuta	43.	Thoti Kali	-
4.	NPI	-	44.	Local Red	-
5.	Koshi Pari Aalu	Siraha	45.	Jiri Local	Dolakha
6.	Seto Aalu	Morang	46.	Kagbeni	Mustang
7.	Isthaniye Seto Rato	-	47.	Hale red	-
8.	Solu Aalu Isthaniye	Solukhumbhu	48.	Isthaniye Rato	Jundhara
9.	Rato Aalu	Morang	49.	Chisapaani	-
10.	Setoma Rato Aankha	-	50.	Pakhribas	Dhankuta
11.	Kalo Khumbule	-	51.	HELAJ	-
12.	Agara	Siraha	52.	Isthaniye Seto	Kalikot
13.	Local Cherito	-	53.	Bhutange Aalu	-
14.	Seto Lahure Naagi	Myagdi	54.	Dim Wangchu Sherpa	-
15.	Halle	-	55.	Nigale Red Dallo	Nigaley
16.	Mustang	Mustang	56.	Isthaniye Rato	-
17.	Singali local	-	57.	Surya Mukhi	-
18.	Namche White	Sagarmatha	58.	Langar	-
19.	MyagdiThulo	Myagdi	59.	Panauti Red Dallo	Kavre
20.	Isthaniye Rato	Jumla	60.	Champi Red	Lalitpur
21.	Ramche	Myagdi	61.	Dada Pakhar	Sindhupalchowk
22.	Thotange Red		62.	Isthaniye Seto	Jumla
23.	Isthaniye Seto Dharti		63.	Kaleje Aalu	-
24.	Isthaniye Seto	Kalikot	64.	Seto Aalu Lamcho	-
25.	Namche Red	Sagarmatha	65.	Rosita	-
26.	Bangal Jyoti	-	66.	Saithi	-
27.	Bhyaleaalu	Dhankuta	67.	Belachaapi aalu	Dhanusha
28.	Rato Bikase Naagi	Myagdi	68.	Thakali Red	-
29.	B-To Aalu	-	69.	Rato Chakre	-
30.	Dorje Sherpa	-	70.	Rtolamche	Panchhthar
31.	Bikas Red	-	71.	Sisne Lamo	-
32.	Seto Lamche	-	72.	Lalgulab	Jhapa
33.	Kalakhe Aalu	Morang	73.	Langthe	Sindhupalchowk
34.	Thaku Local	-	74.	Isthaniye Seto	-
35.	MS aalu	Panchhthar	75.	Buetex	-
36.	Sisne lamo Dalle	-	76.	Jumli Local	Jumla
37.	Tara aalu	-	77.	Kagbeni Local	Mustang
38.	Gajale	-	78.	Kagbeni 2	Mustang
39.	Langare	-	79.	Bardiya 1	Bardiya

SN	Cultivar	Collection site	SN	Cultivar	Collection site
40.	Rato aalu	Dhankuta	80.	Bardiya 2	Bardiya

Source: NPRP 2016.

Table 6. Orange-fleshed sweet potato varieties introduced from CIP, Peru 2010

SN	CIP #	Variety	Origin	SN	CIP #	Variety	Origin
1	400039	10-C-1	DOM	12	440099	TIS 9101	NGA
2	400917	Comal	ECU	13	440112	Centennial	USA
3	440001	Resisto	USA	14	440135	Travis	USA
4	440007	W-208	USA	15	440185	L 0-323	USA
5	440008	W-213	USA	16	440267	Hung Loc 4	VNM
6	440012	W-217	USA	17	440287	VSP 3	PHL
7	440014	W-219	USA	18	440328	AVRDC-CN 1840-284	TWN
8	440015	W-220	USA	19	440513	Koganesengan	JPN
9	440020	W-225	USA	20	441538	Tenian	USA
10	440021	W-226	USA	21	441624	L 4-13	USA
11	440047	Bugsbunny	PRI				

Source: NPRP 2015

Table 7. Most promising local germplasm collection of sweet potato, 2015/16

SN	Germplasm	Accession #	Collection site	Source
1	Dhankuta Red-1	KCU-10-01	Dhankuta	Farmer
2	Dhankuta Red-2	KCU-10-02	Dhankuta	Farmer
3	Sunsari Red-1	KCU-10-03	Sunsari	Farmer
4	Helen	BMS-12-01	-	Helen Keller
5	Bengali Red	KCU-12-01	India	Market
6	Sangachowk White	KCU-12-02	Sindhupalchok	Market
7	Lamatar White	TPG-12-01	Lalitpur	Farmer
8	Batakeshwor White	DC-12-01	Dhanusa	Farmer
9	Barhathwa White	KCU-12-03	Sarlahi	Farmer
10	Hansposa White	KCU-13-01	Sunsari	Farmer
11	Haibung White	BMS-13-01	Sindhupalchok	Farmer
12	Haibung Red	BMS-13-02	Sindhupalchok	Farmer
13	Fendikuna White	BMS-13-03	Lamjung	Farmer
14	Paundi White	BMS-13-05	Lamjung	Farmer
15	Majhigaun White	BMS-13-06	Lamjung	Farmer
16	Bensisahar Red	BMS-13-07	Lamjung	DADO
17	Parewatar White	BT-13-02	Dhading	Farmer
18	Kalidaha White	BT-13-03	Dhading	Farmer
19	Salang White	BT-13-04	Dhading	Farmer
20	Japanese Purple	BMS-13-10	HKI	Food Re. Division

Source: NPRP 2015.

Table 8. Maintenance of 54 taro accessions in Field Genebank, Khumaltar 2016/17

SN	Accession	Collection site	SN	Accession	Collection site
1	Taro-76	Nawalparasi	28	Taro-45	Nawalparasi
2	Taro-86	Nawalparasi	29	Taro-107	Nawalparasi
3	Taro-52	Nawalparasi	30	Taro-81	Nawalparasi
4	Taro-106	Nawalparasi	31	CO6921	Nawalparasi
5	Taro-80	Nawalparasi	32	Taro-44(B)	Nawalparasi
6	Taro-100	Nawalparasi	33	Taro-104	Nawalparasi
7	Taro-56	Nawalparasi	34	Taro-84	Nawalparasi
8	Taro-115	Nawalparasi	35	CO6918	Nawalparasi
9	Taro-87	Nawalparasi	36	CO6982	Nawalparasi
10	Taro-57	Nawalparasi	37	CO6981	Nawalparasi
11	Taro-329	Nawalparasi	38	MP-20	Malepatan
12	Taro-78	Nawalparasi	39	MP-22	Malepatan
13	Taro-99	Nawalparasi	40	MP-9 (Single)	Malepatan
14	Taro-102	Nawalparasi	41	MP-5	Malepatan
15	Taro-73	Nawalparasi	42	MP-1	Malepatan
16	Taro45	Nawalparasi	43	MP-4	Malepatan

SN	Accession	Collection site	SN	Accession	Collection site
17	Taro-108	Nawalparasi	44	MP-2 (Single)	Malepatan
18	Taro-46(A)	Nawalparasi	45	MP-21	Malepatan
19	Taro-55	Nawalparasi	46	MP-7	Malepatan
20	Taro-83	Nawalparasi	47	MP-16 (Single)	Malepatan
21	Taro-19	Nawalparasi	48	MP-17	Malepatan
22	Taro105	Nawalparasi	49	MP-12	Malepatan
23	Taro-85	Nawalparasi	50	MP-14	Malepatan
24	Taro-14	Nawalparasi	51	MP-6	Malepatan
25	Taro-44 (A)	Nawalparasi	52	MP-3	Malepatan
26	Taro-77	Nawalparasi	53	MP-23	Malepatan
27	Taro-46(B)	Nawalparasi	54	MP-8	Malepatan

Source: NAGRC 2015.

PUBLIC AND PRIVATE INSTITUTIONS FOR R&T CROPS CONSERVATION

Public organizations under Government of Nepal working in potato and sweet potatoes are NPRP, Biotechnology Division, NAGRC, Horticulture Research Division, Horticulture Research Stations (HRS), Different Regional Agriculture Research Stations (RARS) and Kandamul Vegetable Development Center (KVDC), Sindhuli under Department of Agriculture. Besides, National Potato Development Program, Khumaltar, Nucleus Seed Potato Center, Nigale and Potato Farm, Darma, Humla are under the Department of Agriculture, responsible for potato development in the country. Considering high nutritive value of sweet potato, some private organizations including non-government and international non-government organization (NGOs and INGOs) Hellen Keller Foundation, IDE-N and LI-BIRD are also involved in the collection and distribution of potato, sweet potato and taro for the farmers in rural areas. Tribhuvan University, Kathmandu University and Purbanchal University and their branch colleges are involved in research and development of these crops.

UTILIZATION OF R&T CROPS

NPRP holds the germplasm of potato and sweet potato and it is responsible for the introduction of new germplasm, collection of local germplasm, regeneration and multiplication, characterization and evaluation, maintenance, conservation and distribution of germplasm. NPRP is distributing the germplasm for the HRS, Research Stations, RARS, Government farms, Universities and private institutions for the research (particularly screening). NPRP should make the easy access to potato and sweet potato germplasm, its databases (if any) and strengthen their utilization for elite line development, marker-assisted selection (MAS), gene mapping and pre-breeding works. Likewise, genebank must distribute taro, yam, taro, cassava and ole germplasm as per the demand of public and private institutions to carry-out the applied and basic research on R&T crops. The local ecotypes of R&T crops can show variable phenology and low-to-moderate yield but might be highly nutritious. Local landraces have the certain implication in plant breeding since the traits contain the local landraces are more efficient in nutrient uptake and utilization as well as useful genes for adaption to abiotic stress such as water stress, salinity, high temperature and biotic stress (insect, pest and diseases). Therefore, useful genes existed in local ecotypes can be utilized in plant breeding work to develop the variety. Likewise, improved germplasm contain biotic and abotic resistance genes and bio-fortified with specific nutrients and can be utilized in variety development as well as development of the new functional foods for the sustainable production.

MAJOR CHALLENGES/ISSUES FOR R&T CROPS

Despite the several benefits of R&T crops, the genetic resources of these crops are threatened by the number of following challenges:

- Rapid expansion of mechanized and intensive agriculture is pushing massive introduction of exotic varieties
- With the increased human population, over-exploiting of wild plants for food, fuel or fodder and losses and degradation of agricultural and forest land is directly hampering the genetic resources of R&T crops
- R&T crops do not get much priority in the government research system
- Duplication in R&T crop research activities among research, development and education systems
- Poor marketing opportunities for traditional R&T crops
- Being R&T crops are bulky, they require high cost of transportation, processing and storage
- Costly in exploration, collection and multiplication and maintenance of R&T crops in in-vitro, at field and at community levels

- Characterization of R&T crops at molecular and functional compound level is costly
- Mechanization to minimize cost of production is costly
- No or less knowledge on value chain, unchanged food habits and diversify the processed products
- Weak linkages with national and international organizations cause difficulty in import export of genetic resources
- Poor technical know-how on agronomic and conservation practices

CONCLUSION AND WAY FORWARD

R&T crops are the significant component of the Nepalese food system. Due to their high starch content and calorie, these crops play a major role in food security of marginal farmers and the ethnic people. Local landraces of R&T crops are tolerant to biotic and abiotic stresses and have wide adaptability to diverse agro-climatic conditions. In contrast, exotic germplasm require high input but may have lower nutritional status as compared to local ones. With the modernization of agriculture in Nepal, exotic varieties are introduced which is gradually replacing the local germplasm of R&T crops. To minimize genetic and cultural erosion of R&T crops, their germplasm should be intensively collected, conserved at field genebank, in-vitro and DNA bank. The germplasm of R&T crops must be studied at their phenotypic, genotypic (molecular) and functional (bio-chemical) levels to identify the genes of interest. The cultivation techniques (agronomy, tuber physiology, propagation, storage and postharvest, etc) of R&T crops must be studied for enhancing the production and overall, their utilization should be promoted to improve the variety as well as livelihood of rural people. Indigenous knowledge residing in farm communities about R&T crops must be explored and documented. The industrial usages of R&T crops should also be explored and disseminated to rural communities. Government policies should give high priority in plans and policies for conservation and promotion of R&T crops thereby; public institutions mandated to R&T crops prioritize the research activities (exploration, collection, multiplication, characterization at morphological, molecular and functional compound levels and their maintenance at field, in-vitro and Community Field Genebank).

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Diversity and Utilization Status of Tropical and Sub-tropical Fruit Genetic Resources in Nepal

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ABSTRACT

Contribution of tropical and subtropical fruit and nut species is about 4% in GDP and 13% in AGDP. Despite significant contribution on the national economy, the country's investment in these fruits research is negligible. These major horticultural crop groups are characterized by remarkable levels of genetic diversity in both wild and cultivated species; yet much of their diversity is poorly studied, underutilized and conserved. Fruits and nuts are gaining attention in the nutrition arena for their role in combating the triple burden of malnutrition and low labor demanding agricultural enterprise. Furthermore, Nepal has yet to capitalize geographic and climatic comparative advantage of fruit based horticulture development and reduce dependency on fruit imports. The community managed fruit orchards, private orchards and field genebanks at different government horticulture farms are the current sites of in-situ conservation of fruits. These orchards and farms are conserving more than 200 accessions of at least 25 indigenous and exotic fruit species. Exotic species were introduced in Nepal in different periods but proper documentation of their characters and use is still lacking. Mango, citrus, jackfruit and banana are some of the few studied fruit crops in terms of their diversity in Nepal. Most of the diversity studies are based on phenotypic description except two studies on mango and acid lime using molecular markers. Richness of indigenous and wild fruit diversity is still not even explored, assessed and valued for sustainable use and conservation. These species include Indian gooseberries (amala), bayberry (kaphal), jambol (kalo jamun), yellow raspberry (ainselu), custard apple (sarifa), wood apple (bael), figs (timalo, khanayo), jackfruits, litchi, butter tree (chiuri) etc. Conservation of wild relatives along with systematic study using modern molecular tools needs huge investment and support from public sector which is lacking at present. The use of domesticated fruit in breeding and varietal development is long term process and few best trees from farmers' orchards and home gardens are investigated and registered to capitalize local fruit genetic resources. Recently two varieties of acid lime (Sunkagati-1, Sunkagati-2) have been released by the national system. A joint effort by all research and development partners on conservation and utilization of tropical and sub-tropical fruit species is needed for the sustainable growth and development of this sector. This paper aims to highlight methods, approaches and tools that have helped local communities to strengthen the conservation of wild and cultivated fruit species, to add value and improve the marketing of horticultural products and to enhance their contribution to improving food security and nutrition. Furthermore, suggestions have been made to strengthen research and development of tropical and sub-tropical fruit species.

Keywords: Conservation, genebanks, genetic diversities, sub-tropical fruits, tropical fruits, utilization, wild relatives

INTRODUCTION

Nepal is very rich in plant genetic resources which can be utilized for the domestication of new crops, raw materials for fruit tree breeding and use as rootstocks for propagating/ productive planting materials. The total fruit sector contributes 4.8 and 15.3% to Gross Domestic Product (GDP) and Agriculture Gross Domestic Product (AGDP) respectively in Nepalese economy where only tropical and subtropical fruit crops share nearly 4 and 13% to GDP and AGDP respectively (MoAD 15). Among tropical and sub-tropical fruits, Nepal is rich in diversity of citrus and mango fruit (goo.gl/PK2xiG). The other species like *Annona*, *Aegle*, *Castanopsis, Rubus, Actinida, Vitis,* etc. have also great importance and are still in wild state. Further, a status report by Nepal Agricultural Research Council (NARC 1995) states that there are wild relatives of banana, mango, strawberries, grapes and butter tree (*Diploknema butyracea*) are in Nepal (goo.gl/hOjdtl). The first introduction of fruit genetic resources in Nepal dates back to 1850 when Prime Minister Janga Bahadur Rana brought saplings of fruits from UK (Acharya and Atreya 2013). Later other Rana Prime Ministers also introduced exotic varieties of mango, litchi, persimmon, pomegranate, guava and fig into the palace orchard. Later tropical and sub-tropical fruit species were planted in four farms around Kathmandu valley (Kavre, Sindhupalchowk, Dhading and

Nuwakot). Systematic fruit development activities and research was initiated with the establishment of farms at Godawari, Chhauni and Balaju in 1964 in Kathmandu valley. From 1950-1990 different aid missions were in operation. These missions helped to establish fruit station/farms in various parts of the country and introduced many exotic cultivars of mango, litchi, banana, citrus etc. However, none of the programs helped to collect, conserve and utilize local collection of fruit resources. The fruit sector is possibly the least genetic material exchanged sector with other international research organizations from research prospective. Few of mandarin cultivars and rootstocks were introduced by Public Linkages Support Program (PLSP) from Australia into Central Horticulture Centre, Kirtipur but unfortunately planting of saplings in effluent water irrigated land was attributed to the failure of these cultivars in that farm. Genetic resources/germplasm are the building blocks of new varieties. These germplasm should be utilized in fruit industries by domestication of elite lines/varieties or as rootstocks.

Nepal's investment in fruit crop research is very low despite the strategic importance of these species in our lives and economy. These major horticultural crops group are characterized by remarkable levels of genetic diversity in both wild and cultivated species, yet much of their diversity is underutilized and poorly conserved. Fruits and nuts are gaining increasing attention in the nutrition arena for their role in combating the triple burden of malnutrition. Furthermore, Nepal has yet to capitalize geographic and climatic comparative advantage of fruit based horticulture development and reduce dependency on fruit import. This paper aims to review current research and development of fruit crops in Nepal and put forward few strategies of nutritionally dense and economically valued fruit crops for immediate benefits.

MAJOR IMPETUS TO TROPICAL AND SUB-TROPICAL FRUIT DEVELOPMENT

Prior to 1950, fruit growing was limited to homestead gardens. The formal horticulture development in Nepal was started early 1960s with establishment of horticulture farms in Nepal with the support of Indian Cooperation Mission (ICM). Since then many commercial cultivars of important fruits (mango, litchi, banana and pineapple) were introduced in Nepal. There were 192 cultivars of 42 fruit species brought under production in Nepal during that period (Kaini 1994). However, there were some cultivars of popular fruits selected and commercially cultivated using Nepali gene pool. For example, mandarin grown at present such as Banskhark Local, Parbat Local, Khoku Local; sweet orange cultivar Junar are Nepali land races, have unique pomological characters. Similarly, Japan assisted Janakpur Zone Agriculture Development Project (JADP) in 1973 launched Junar (sweet orange) development program in Sindhuli and Ramechhap and assisted to extent the production of Junar in these districts.

During the "Agriculture Year, 1975" there was a paradigm shift in fruit saplings production locally through private nurseries which were established all over the country. JICA supported Horticulture Development Project (HDP) was started in 1985 to develop fruit sub-sector in the central region of Nepal whereas Asian Development Bank (ADB) supported Hill Fruit Development Project (HFDP) was started in 1987 to develop citrus fruit in the eastern Mid Hill region of Nepal.

In 1995, twenty years' Agricultural Perspective Plan (APP) was formulated which emphasized on pocket package programs in mango and citrus fruit crops as a result Lime Mission, Citrus Rejuvenation and Area Expansion programs of mango, litchi and banana were implemented (Thapa et al 2017). After long effort Nepal has progressed significantly in developing fruit plant propagation techniques like shoot tip grafting in citrus, side veneer and stone grafting in mango as well as tissue culture technology has been successful in producing disease free saplings in banana and citrus.

CONSERVATION EFFORTS

The Convention on Biological Diversity (CBD) within its broader framework recognizes two ways of conserving genetic resources: in-situ, in the place of origin, and ex-situ, outside the place of origin (https://www.cbd.int/). In-situ conservation is often further divided into 'in-situ conservation' of genetic resources in their native habitats in the wild, and 'on-farm management' of genetic resources (or in-situ conservation of traditional varieties in farmers' fields) in agricultural systems.

The second State of the World's Plant Genetic Resources for Food and Agriculture (SoWPGRFA) report notes that over the last decade, promoting and supporting the on-farm management of genetic resources, whether in farmers' fields, home gardens, orchards or other cultivated areas of high diversity, has become firmly established as a key component of crop conservation strategies, as methodologies and approaches have been scientifically documented and their effects monitored (FAO 2010, Rao and Sthapit 2013). On-farm and in-situ conservation are considered important approaches to sustain the evolutionary process of creating new diversity, to conserve the associated knowledge about its traits and to sustain important ecosystem services connected to agricultural biodiversity. Depending only on ex situ conservation strategy leads to loss of genetic diversity. In Nepal, role of hobby orchardists and home gardeners in conservation and utilization of native and introduced horticultural crops and fruits are well recognized for their contribution in on farm conservation, however, best genetic resources available are neither explored nor characterized and used for wider scale benefits. Both the term and concept of 'custodian farmer' are relatively new in the field of in-situ and on-farm conservation of agricultural biodiversity (Sthapit et al 2016b). Working in Bolivia, India, Indonesia, Malaysia, Nepal and Thailand, researchers identified custodian of tropical fruit tree diversity who actively maintain, adapt and disseminate fruit tree biodiversity and related knowledge over time and space at home gardens, orchards and community levels and are recognized by their community members for their efforts (Sthapit et al 2013, 2015a, Gruberg et al 2013). Custodian farmers are often actively supported in their efforts by household members and family traditions. They are the champions of in-situ and on-farm conservation of agricultural biodiversity but the method is yet to be adopted by the Government of Nepal.

At the present, horticultural crops and fruit trees are conserved ex-situ at the farms and research stations of the government. Although the method is similar to field genebank, they were not systematically collected, characterized, evaluated and utilized by horticultural breeding programs. Field genebanks are used for plants species that produce seeds which cannot be dried and/or stored at low temperatures (recalcitrant seed). They are conserved as live plants in the field or in pots in greenhouses or shade houses. Field genebank is also used for plants that produce very few seeds, are vegetatively propagated and/or plants that require a long life cycle to generate breeding and/or planting materials (FAO 2013). Such horticultural genetic resources are maintained as a living collection in the field and is usually is expensive method of conservation. It also has many constraints in terms of requiring large areas of lands, large inputs of labour and time, the planting material is not readily available for distribution, problems with pest and diseases, vulnerability to adverse weather conditions, policy changes in land tenure, vandalism and thefts, to mention a few.

In the past with the establishment of government farms, fruit genetic resources were planted for the purpose of research and distribution to the farmers (**Table** 1). Beside this there was no any systematic way of conserving such genetic resources. The numbers of varieties/genotypes of tropical and sub-tropical fruit crops in Nepal are listed in **Table** 2 whereas fruit genetic resources both indigenous and exotic conserved in farm/centers as field gene bank are mentioned in **Table** 3. In recent days, NARC has given lead role in terms of research and conservation of fruit genetic resources in research stations whereas farms under DoA has prioritized in the production and distribution of quality seed and saplings. Thus collection, conservation and promotion of indigenous and exotic type of fruits have been started by the farm/stations under DoA and NARC. A few attempts for the systemic way of establishing field genebank have been carried out in different research farms of NARC. Many new species and/or varieties of fruits are being introduced by Nepali elites who have exposure with foreign countries and hobby in horticulture. Few examples to name are dragon fruit, guava, baer, amala, etc.

Table 1. List of government farms conserving tropical and sub-tropical fruit genetic resources

SN	Name of farms/station/centers	Address	Responsible organization
1.	National Citrus Research Program (NCRP)	Paripatle, Dhankuta	NARC
2.	Agricultural Research Station (ARS)	Pakhribas, Dhankuta	NARC
3.	Regional Agricultural Research Station (RARS)	Tarahara, Sunsari	NARC
4.	Regional Agricultural Research Station (RARS)	Parwanipur, Bara	NARC
5.	Regional Agricultural Research Station (RARS)	Khajura, Banke	NARC
6.	Agricultural Research Station (ARS)	Dashrathpur, Surkhet	NARC
7.	Horticulture Research Station (HRS)	Kimugaun, Dailekh	NARC
8.	Horticulture Research Station (HRS)	Malepatan, Kaski	NARC
9.	Central Horticulture Centre (CHC)	Kritipur, Kathmandu	DoA
10.	Tropical Horticulture Nursery Development Centre (THNDC)	Janakpur, Dhanusha	DoA
11.	Tuber Vegetable Development Center (TVDC)	Sindhuli	DoA
12.	Tropical Region Horticulture Centre (TRHC)	Nawalpur, Sarlahi	DoA
13.	Floriculture Development Centre (FDC)	Godawari, Lalitpur	DoA
14.	Sub-Tropical Horticulture Development Centre (STHDC)	Trishuli, Nuwakot	DoA
15.	Citrus Fruit Development Centre (CFDC)	Tansen, Palpa	DoA

SN	Name of farms/station/centers	Address	Responsible organization
16.	Agriculture and Forestry University (AFU)	Rampur, Chitwan	AFU
17.	ICIMOD Farm*	Godawari, Lalitpur	ICIMOD

Farms under non-governmental organization.

Table 2. List of commercially cultivated tropical and sub-tropical fruit species and number of cultivars/genotypes in Nepal

SN	English name	Nepali name	Scientific name	Number of cultivars/genotypes
1.	Acid lime	Kagati	Citrus aurantifolia (Christm.) Swingle	11
2.	Areca nut	Supari	Areca catechu L.	7
3.	Avocado	Ghewphal	Persea americana Mill.	5
4.	Banana	Kera	Musa paradisiaca L.	20
5.	Coconut	Nariwal	Cocos nucifera L.	3
6.	Grapes	Angoor	Vitis vinifera L.	7
7.	Guava	Amba, Belauti	Psidium guajava L.	11
8.	Indian Gooseberry	Amala	Emblica officinalis Gaertn. Syn. Phyllanthus emblica L.	4
9.	Jackfruit	Katahar	Artocarpus heterophyllus Lam.	7
10.	Jujube	Baer	Ziziphus mauritiana Lam.	4
11.	Kiwifruit	*Thekiphal*	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson	8
12.	Kumquat	Muntala	Fortunella japonica (Thunb.) Swingle	2
13.	Lemon	Nibuwa	Citrus limon (L.) Osbeck	6
14.	Litchi	Litchi	Litchi chinensis Sonn.	12
15.	Macadamia nut	Macadamia nut	Macadamia integrifolia Maiden & Betche	4
16.	Mandarin orange	Suntala	Citrus reticulata Blanco	11
17.	Mango	Aanp	Mangifera indica L.	30
18.	Mangosteen	Mangosteen	Garcinia mangostana L.	21
19.	Papaya	Mewa	Carica papaya L.	19
20.	Pineapple	Bhuinkatahar	Ananas comosus (L.) Merr.	5
21.	Pomegranate	Anar	Punica granatum L.	7
22.	Sapota	Sapatu	Achras sapota L.	2
23.	Sweet orange	Junar	Citrus sinensis (L.) Osbeck	8
24.	Trifoliate orange	Tin Pate Suntala	Poncirus trifoliata (L.) Raf.	5
25.	Wood Apple	Bael	Aegle marmelos (L.) Correa	5

Source: Gautam and Tiwari 2007, Gotame et al 2014, Kaini 1994.

Table 3. List of tropical and sub-tropical fruit cultivars and conserving farms/centers as field genebank

SN	Fruits	Cultivars/genotypes	Farms/centers	Number of saplings production	
				DoA farms	NARC farms
1.	Acid lime	Sunkagati-1, Sunkagati-2, NCRP-53, NCRP-107, Banarasi, Kagazi lime, Seedless lime, Eureka, Terhathum local	NCRP, Paripatle	-	4500
			RARS, Parwanipur	-	1500
			RARS, Khajura	-	300
			RARS, Tarahara	-	100
			HRS, Malepatan	-	200
			HRS, Dailekh	-	500
			RARS, Parwanipur	-	1500
			CHC, Kritipur	8000	-
			FDC, Godavari	1500	-
			STHDC, Trishuli	3600	-
			CFDC, Palpa	2500	-
2.	Areca nut	Motinagar, Shrimangala, Sumangala, Challia, Hazari, Asami, Singapore	RARS, Tarahara	-	100
			TRHC, Nawalpur	500	-
			TVDC, Sindhuli	100	-
			STHDC, Trishuli	200	-
3.	Avocado	Ettinger, Fuerte, Hass, Mexicola, Stewart, Reed, TopaTopa	ARS, Pakhribas	-	500
			HRS, Malepatan	-	150

SN	Fruits	Cultivars/genotypes	Farms/centers	Number of saplings production	
				DoA farms	NARC farms
			STHDC,Trishuli	1000	-
			TRHC, Nawalpur	500	-
			CHC, Kritipur	300	-
4.	Banana	Chini Champa, Dwarf Cavendish (Basrai Dwarf), William Hybrid, Malbhog (Poovan), Robusta (Harichhal), Dhusre, Mungre, Battisa, Athiya, Marche, Dhose, Hajari, Mirkote, Bankera, Australian Hybrid, Grand Naine, Manki, Bangali Malbhog, Fia	TRHC, Nawalpur	1000	-
			THNDC, Janakpur	250	-
			STHDC, Trishuli	500	-
			TVDC, Sindhuli	500	-
5.	Coconut	Kerala Dwarf, Singapuri, Hajari	RARS, Tarahara	-	-
			TRHC, Sarlahi	500	-
			THNDC, Janakpur	100	-
6.	Gooseberry	Banarasi, Kanchan, Krishna, Local	TRHC, Nawalpur	500	-
			THNDC, Janakpur	100	-
			TVDC, Sindhuli	100	-
7.	Grapes	Himrod, Muscat Belly A, Kyoho, Olympia, Steuben, Kambel Early, Thompson Seedless	CHC, Kirtipur	1000	-
			RARS, Khajura	-	300
8.	Guava	Allahabad Safeda, Chittidar, Seedless, Rampur Guava-1, Lucknow-49, Red fleshed, Chinese, Banarasi, Nasik, Saharanpur, Local	AFU, Rampur	-	-
			RARS, Nepalgunj	-	300
			RARS, Parwanipur	-	200
			HRS, Malepatan	-	100
			TRHC, Nawalpur	1000	-
			THNDC, Janakpur	100	-
			TVDC, Sindhuli	150	-
			STHDC, Trishuli	100	-
9.	Jackfruit	Sawane, Bhadaiya, Rudrakshi, Rohini, Asare, Shree Lankan, Local	RARS, Tarahara	-	800
			RARS, Parwanipur	-	500
			RARS, Khajura	-	100
			TRHC, Nawalpur	200	-
			THNDC, Janakpur	100	-
			STHDC, Trishuli	100	-
10.	Jujube	Umran, Gola, Banarasi, Local Round	TRHC, Nawalpur	200	-
11.	Kumquat	Japanese Round, Japanese Oblong	CHC, Kritipur	2500	-
			FDC, Godawari	1500	-
12.	Lemon	Eureka Round, Eureka Oblong, Lisbon, Amanatsu, Nepali Oblong, Pant Lemon-1	NCRP Dhankuta	-	1000
			RARS, Tarahara	-	100
			HRS, Dailekh	-	150
			CHC, Kritipur	400	-
			STHDC, Trishuli	200	-
13.	Litchi	Early Large Red, Early seedless, Shahi, Muzaffarpur, China, Rose scented, Bambai, Saharanpur, Brewster, MC Lean, Calcuttia, Late Seedless	AFU, Rampur	-	1000
			HRS, Malepatan	-	200
			RARS, Parwanipur	-	1000
			RARS, Tarahara	-	650
			RARS, Khajura	-	1000
			TRHC, Nawalpur	12000	-
			THNDC, Janakpur	1000	-
			STHDC, Trishuli	5400	-
			TVDC, Sindhuli	500	-
14.	Macadamia nut	Keauhou, Ikaika, Kakea, Keaau, Some accession of *M. tetraphylla* and *M. integrifolia*	HRS, Malepatan	-	400
			STHDC, Trishuli	3000	-
			TVDC Sindhuli	200	-
15.	Mandarin	Khoku Local, Yoshida Ponkan, Deco Ponkan, Murcott, Thai Tangarin, Clementine, Madam Venus, Kinnow, Okitsuwase, Miyagawawase, Imamura unshiu, Satsuma,	NCRP, Dhankuta	-	4000
			RARS, Lumle	-	6000
			HRS, Dailekh	-	1200
			CFDC, Palpa	11500	-
			CHC, Kritipur	4500	-

SN	Fruits	Cultivars/genotypes	Farms/centers	Number of saplings production	
				DoA farms	NARC farms
			FDC, Godawari	1500	-
16.	Mango	Bombay Green, Bombay Yellow, Jardalu, Krishnabhog, Gulabkhas, Gopalbhog, Maldah, Dasheri, Amrapali, Mallika, Aman Dashahari, Sukhatara, Sukul, Langra, Dokmai, Subarna Rekha, Samarbahistha, Alphanso, Ratna, Fazli, Chausa, Chausa, Abehyat, Neelam, Bhadaure, Calcuttia, Sipia, Safeda, Lakhanau, Totapuri	RARS, Khajura	-	500
			RARS, Tarahara	-	450
			RARS, Parwanipur	-	500
			TRHC, Nawalpur	20000	-
			THNDC, Janakpur	5000	-
			STHDC, Trishuli	2400	-
			TVDC, Sindhuli	700	-
17.	Mangosteen	Unidentified	RARS, Tarahara	-	-
			TRHC, Nawalpur	-	-
18.	Papaya	Honey Dew, Washington, Pusa Dwarf, Coimbatore-1, Pusa Majesty, Pusa Giant, Pusa Delicious, Solo, Selection-7, Nuwakot Local	THDC, Trishuli	1500	-
			TRHC, Nawalpur	500	-
			THNDC, Janakpur	150	-
			TVCDC, Sindhuli	150	-
19.	Pineapple	Giant Kew, Queen, Mauritius, Spanish, Local	TVCDC, Sindhuli	2000	-
			STHDC, Trishuli	1500	-
20.	Sapota	Baramase, Large Calcutta	RARS, Tarahara	-	-
			TRHC, Nawalpur	-	-
			THNDC, Janakpur	-	-
21.	Sweet orange	Sindhuli Local, Washington Navel, Valencia late, Malta Blood Red, Pineapple, Yoshida Navel	NCRP, Paripatle	-	1500
			CHC, Kritipur	3500	-
			FDC, Godawari	1500	-
			CFDC, Palpa	2000	-
22.	Wood Apple	Narendra Bael (NB)-5, NB-7, NB-9, NB-17, Rani Bael	RARS, Khajura	-	-
			TRHC, Nawalpur	2000	-
23.	Rootstock (Citrus)	Trifoliate Orange, Citrange (Carizzo), Citrange (C. sinensis X P. trifoliate), Rough lemon, Rangapur lime, Sour orange, Volkameriana (NCRP-70)	NCRP, Paripatle	-	25000
			HRS, Dailekh	-	1000
			CHC, Kritipur	30000	-
			CFDC, Palpa	13000	-
			FDC, Godawari	2500	-

NCRP, National Citrus Research Program; ARS, Agricultural Research Station; RARS, Regional Agricultural Research Station; HRS, Horticulture Research Station; THNDC, Tropical Horticulture Nursery Development Centre; TVDC, Tuber Vegetable Development Center; TRHC, Tropical Region Horticulture Centre; FDC, Floriculture Development Centre; STHDC, Sub-Tropical Horticulture Development Centre; CFDC, Citrus Fruit Development Centre; CHC, Central Horticulture Centre.

FRUIT DIVERSITY

Biodiversity International (then International Plant Genetic Resources Institute - IPGRI) has implemented regional project funded by Asian Development Bank (ADB) on 'Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia' which was implemented in ten Asian countries, namely, Bangladesh, China, India, Indonesia, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand and Vietnam (Bhagmal et al 2001). The project collected, characterized, evaluated, identified and documented elite fruit genetic resources of mango and citrus from Nepal (**Table** 4 and **Table** 5).

Mango

Mango is the most studied fruit crops in term of diversity in Nepal using phenotypic descriptors as well as molecular tools (Subedi et al 2004 and 2008) studied the eco-graphic and genetic diversity of mango collecting both 132 native and exotic accessions from seven districts (Siraha, Saptari, Dhading, Kavre, Parbat, Baglung and Dedeldhura) ranging from 90 m to 1400 masl. They found many native collections. Similarly, Budhathoki *et* al (2004) also collected 60 accessions of mango from Siraha and Saptari and diversity was studied based on phenotypic and organo-leptic characteristics. These accessions were later ex-situ conserved at RARS Tarahara for further studies. One of the collections is having off-season fruiting (flowering in January) character but fruit production at Tarahara is still unsuccessful. The use of such genetic resources of mango for commercial cultivation is still lacking.

Citrus

Various citrus species (acid lime, mandarin, pummelo) were the better genetic diversity studied fruits compared to other crops. History dates back to early 1980s when Hockey et al (1996) studied biodiversity of mandarin fruit collected from ten hilly districts (Kaski, Gulmi, Dhankutta, Tanahu, Dailekh, Palpa, Syanja, Ilam, Sankhuwasabha and Terhathum). They identified seven groups of local landraces and accessions from Gulmi and Dhankuta and were recommended to include in breeding program due to superior yield. Similarly, Pahari and Bimb (2004) studied the genetic diversity of nine populations of mandarin using four enzymes (peroxidase, malate dehydrogenase, shikimate dehydrogenase and malic enzyme. Malic enzyme revealed five distinct phenotypes among the studied population. Later on Paudyal et al (2011) evaluated 26 accessions of local mandarin collected from Khoku area of eastern Nepal which were planted at NCRP, Dhankuta based on yield and fruit quality for four years. From this study they recommended one elite accession (J 90). The saplings from same accession are under evaluation at farmer's field condition and in process of release and recommendation in coming days.

The collection of 32 lime accessions from Tarai and Mid Hill was initiated with an objective of finding superior off-season lime cultivars in 2002 from five districts (Terhathum, Jhapa, Morang, Sunsari, and Chitwan) (Paudyal and Shrestha 2004). These accessions were evaluated for tree and fruit characteristics. Later two accessions were identified that could be harvestable during July to November instead of October to January (normal time). Later, Shrestha et al (2012) performed genetic diversity study of 62 acid lime accessions collected from various altitudes of the eastern Nepal using simple sequence repeat (SSR) markers. This study found high level of genetic similarity and accessions were separated in five groups. Parallel to these studies a series of studies on phenotypic characters and phenology of these accessions were studied at National Citrus Research Program and it's out-reach sites in Morang and Sunsari districts based on above studies. Later two off-season lime cultivars (Sunkagati 1 and Sunkagati 2) selected from previous studies were recommended and released for cultivation in Tarai area. This is single evidence of commercial utilization of Nepalese fruit genetic resources.

Earlier in 2000, genetic diversity of 132 accessions of pummelo (*Citrus grandis* L. Osbeck) found in Tarai and Mid Hill areas were studied (Paudyal, 2000). The study revealed that there exist great genetic variability in fruit shape, fruit base and pulp color along with yield and quality parameters. There was recommendation of four superior accessions which could be cultivated below than 300 m in Tarai region instead of 700-1340 m elevation. There was similar kind of study conducted with 87 accessions of pummelo fruit collected from Sankhuwasabha and Bhojpur districts (Rijal 2002). These accessions were grouped into four with cluster analysis technique using phenotypic and fruit quality parameter. Later four accessions were reported as superior and maintained at fruit garden of Rampur agriculture Campus, Chitwan. Unfortunately, their use in breeding and further multiplication and distribution to farmers were not practiced.

Guava

A few studies were initiated to evaluate genetic diversity of Nepalese guava in early 2000 by two groups of researchers using Hill Agriculture Research Project (Bhurtyal et al 2004 and Shrestha 2005). The accessions collected from various parts of Mid Hill were evaluated for fruit characteristics and planted at different government farms but the output of this study was also not reached at farmer's level.

Banana

There are two documented evidences that Nepal got wild (Ban Kera) and cultivated banana species (Dhusre, Mungre, Battisa, across Tarai and Mid Hill (Gautam and Dhakal 1994, Gautam and Tiwari 2007). Some of cultivated genotypes (Dhusre and Mugre) were compared with exotic cultivars for commercial cultivation in Nawalparasi district by Gautam and Tiwari (2007). The yield of these genotypes were not comparable with commercial cultivars like Basrai Dwarf, William hybrid, Robusta, Poovan; however, they are reported to thrive well under cold and water stressed condition and could serve excellent gene source for crop genetic improvement.

Table 4. Country-wise details of accessions collected, characterized, documented, conserved and elite lines identified in six priority fruit tree species

Country	Existing accessions documented	Accessions data based in CD-ROM	New accessions collected	Accessions characterized	Accessions added to field gene banks	Elite lines identified
Bangladesh	857	159	206	196	199	26
China	833	833	129	326	129	28
India	404	552*	316	513*	316	30
Indonesia	110	47	127	107	52	17
Malaysia	165	108	100	140	45	06
Nepal	265	134	96	265	72	44
Philippines	419	519*	419	299	232	09
Sri Lanka	271	185	271	185	120	18
Thailand	982	982	279	799	279	03
Vietnam	661	548	241	529	241	09
Total	4967	4067	2184	3359	1685	190

**Includes additional accessions. Source: Bhagmal et al 2001.*

Table 5. Existing accessions documented for passport and characterization data and accessions in data bases compiled in CD-ROM for sharing

Country	Fruit crops						Total
	Mango	Citrus	Rambutan	Jackfruit	Litchi	Mangosteen	
Bangladesh	321	96 (89)	-	440 (70)	-	-	857 (159)
China	80 (82)	653 (651)	-	-	100 (100)	-	833 (833)
India	404 (151)	- (384)	-	-	- (17)	-	404 (552)
Indonesia	-	-	48 (21)	-	-	62 (26)	110 (47)
Malaysia	99 (66)	-	66 (42)	-	-	-	165 (108)
Nepal	130 (87)	135 (47)	-	-	-	-	265 (134)
Philippines	265 (356)	93 (101)	-	-	-	61 (62)	419 (519)
Sri Lanka	189 (124)	-	-	82 (61)	-	-	271 (185)
Thailand	780 (780)	-	202 (202)	-	-	-	982 (982)
Vietnam	100 (19)	476 (503)	-	-	85 (26)	-	661 (548)
Total	2368 (1665)	1453 (1775)	316 (265)	522 (131)	185 (143)	123 (88)	4967 (4067)

Figures in parentheses indicate the accessions in data bases in CD-ROM for sharing. Source: Bhagmal et al 2001.

COMMON CULTIVARS/GENOTYPES

The following are among widely grown tropical and sub-tropical fruits in Nepal listed by their cultivars, their origin and their traits.

(A) Acid lime (*Citrus aurantifolia* (Christm.) Swingle): Exotic cultivars collected – 9, Indigenous – 2

Cultivars/genotypes	Images	Origin/ Source	Traits
Terhathum Local		Nepal	Selected from Phakchamara, Terhathum; flowering starts from 3-4 years of seedling plantation, fruits are round, soft and thin skin, weight ranges 40-50 g, turns yellow when starts ripening, highly acidic (7-10%).
Sunkagati-1		Nepal	Fruiting at 3 years of planting, off-season flowering throughout the year, fruit skin is green in color when mature, number of segments in the fruit is 10-14, pulp color white, average fruit weight is 54 g.
Sunkagati-2	NA	Nepal	Off-season harvesting throughout the year, fruit color is green when mature, number of segments in the fruit is 10-14, pulp color

Cultivars/genotypes	Images	Origin/ Source	Traits
			white, average fruit weight is 53 g, acidity is high (7.1%) and strong juice aroma.

(B) Banana (*Musa paradisiaca* L.): Exotic cultivars collected – 20, Indigenous – 6

Cultivars/genotypes	Images	Origin/ source	Traits
Chinia Champa		Nepal	Pink pigmentation on the ventral side of the mid rib of young leaves, bears heavy bunch weighing 20-24 kg each having 150 to 300 fingers, cultivar available throughout the year, fruits are suitable for feeding to infants due to its taste and pulp quality.
Dwarf Cavendish (Basrai Dwarf)		India	Short statured variety; needs no staking of the plant; dark black brown blotches appear along the stem; crop duration 11 months, produces an average bunch weight of 20 kg with 8-10 hands, compactly arranged 142 to 160 fruits bunch.
Giant Plantain		India	Huge and tall growing banana cultivar, bunch has got 6-7 hands, with 12-14 fruits or fingers per hand, each hand weighs 2.25 to 2.75 kg, fruits are long and big, dark yellow in colour, weighing around 200g, pulp is light orange, very firm and sweet.
Malbhog		India	Very sweet and delicious variety always fetching premium price in the market, crop takes 13-15 months to come to harvest, weight about 15-18 kg per bunch, each bunch has got 8-10 hands, with 12-14 fingers per hand, each hand weighs 1.25 to 1.45 kg fruits are attractive yellow in color, pulp is creamy, firm and delicious.
Robusta (Harichhal)		India	Plants bear potential bunches weighing 25-30 kg each with good sized, slightly curved fruits, highly susceptible to leaf spot which limits its cultivation in highly humid tropical regions but is resistant to fusarium wilt.

(C) Guava (*Psidium guajava* L.): Exotic cultivars collected – 11, Indigenous – 1

Cultivars/genotypes	Images	Origin/ source	Traits
Allahabad Safeda		India	Tree is medium to tall, vigorous branching, heavy bearer, crown is broad and compact, medium sized fruit (180 gm), round shaped with smooth skin, relatively soft with less seeds, good keeping quality, very suitable for table and processing purposes.
Kanpur Guava 1 (KG-1)	NA	Thailand	Tree is medium height, vigorous branching, less bearer, large size fruit, good quality fruit, late maturing.

Cultivars/genotypes	Images	Origin/ source	Traits
Lucknow-49		India	Vigorous in growth, prolific bearer, fruits are large, roundish, ovate in shape, pulp white, very sweet and tasty, good keeping quality.
Red Fleshed		India	Trees are tall, vigorous branching, fruits roundish ovate in shape, saffron yellow colored, few red dots present on the surface, keeping quality poor to medium.
Seedless		India	Seedless fruit, round in shape, not suitable for commercial cultivation due to low yield.

(D) Mandarin (*Citrus reticulata* Blanco): Exotic cultivars collected – 11, Indigenous – 3

Cultivars/genotypes	Images	Origin/ source	Traits
Khoku Local		Nepal	Selected from Khoku of Dhankuta, skin easily pulls away from their flesh and their segments are easily separated, sweet and tasty with 13-14% TSS, good flavor, rough and light yellow skin color, fruit weight 100-120 g with 15-16 seeds.
Kinnow		Pakistan	Cross between King and Willow Leaf mandarin, good bearing habit, fruits are smaller in size (50-60 g), thin rind, segments 9-10, very juicy , seeds 12-24, highly acidic 2.8%, ripens winter to early spring: January through April, grown best in very hot regions.
Murcott			Cross between mandarin and sweet orange, heavy bearer, appropriate for high density planting, soft and thin fruit skin, sweet fruit with TSS of 14-15% and 2% acidity, late maturity, yellow-orange rind.
Ponkan		China	Very sweet and aromatic, somewhat dry, flesh and rind are deep orange, few seeds, ripens early: December and January.

Cultivars/genotypes	Images	Origin/ source	Traits
Fallglo			Cross between a mandarin and the 'Temple' tangor, juicy, tart and very seedy, reddish-orange, thin, smooth rind which peels easily, ripens early: October and November.
Gold Nugget			Cross between 'Wilking' and tangor, rich flavor, medium oblong to round shape with golden orange pebbly rind, flesh is orange and seedless, ripens mid to late season.
Unshiu		Japan	Moderately sweet, good flavor, seedless with loose skin, peels easily, medium sized fruits, rind and flesh are orange, ripens very early: November and December. Cultivars include 'Owari', 'Dobashi Beni', 'Okitsu Was', and 'Kimbrough'.

(E) Mango (*Mangifera indica* L.): Exotic cultivars collected – 30, Indigenous – 2

Cultivars/genotypes	Images	Origin/ source	Traits
Alphonso		India	Oblong shaped, very sweet with fibreless pulp, rich in vitamin A and C, mild flavor and its skin color varies from purple to yellow skin, superior in context to appearance and flavour, believe to be the "King of Mangoes", marked by a short season ranging between March to May, keeping quality good.
Amrapali		India	Cross between Dasheri and Neelam variety, dwarf, regular and prolific in bearing, small to medium fruits, fibreless, excellent in taste and plentiful pulp, ideally suited for high density planting, late season variety.
Bombay Green		India	Medium sized fruits with tough, thick skin, flesh firm and juicy, very sweet with pleasant aroma, medium size stone, medium bearer, early season variety.
Chausa		Pakistan	Medium sized oblong shaped mango, incredibly sweet pulp and bright yellow skin, admired for its extreme sweetness, smooth textured flesh with a good fragrance, It is harvested around July to August.

Cultivars/genotypes	**Images**	**Origin/ source**	**Traits**
Dok Mai		Thailand	A relative of the ordinary mango, also known as the “golden mango”, fruit has an attractive “S” shape, a creamy yellow skin and soft yellow flesh, sweet, juicy, fruit has a much flatter stone than the ordinary mango.
Dasheri		India	One of the oldest variety, medium sized fruit, skin smooth and medium thick, flesh yellow, firm with almost no fiber, very sweet taste of excellent quality, medium sized stone, mid-season maturity, heavy bearer.
Langra		India	Medium fibrous mango finds great popularity in Nepal, fruits greenish yellow with medium to big dark green dots, skin medium smooth, flesh firm to soft, very sweet with strong pleasant aroma, flattened stone, medium season variety.
Maldah		India	Medium but lager sized fruits than Bombay Green and Bombay Yellow, known for awesome taste and flavor with thin skin, flesh firm and juicy, mid-season variety.
Mallika		India	Cross between Neelam and Dasheri variety, moderately vigorous but dwarf with dense canopy, oblong with rounded base, large fruits (280-450 g), skin thick, strongly aromatic and sweet, woody stone, mid-season variety.
Neelam		India	Tiny in comparison to other varieties and have orange skin, noticeable with its distinctive lovely fragrance, woody stone, late variety, heavy bearer, high keeping quality, good for distant marketing.
Safeda		India	Medium-large fruit ripens to a golden-yellow, very juicy, slightly tangy with little fibre and a creamy texture, one of the earliest varieties of mangoes to hit the market, season ranges April to June, the largest volume mango cultivar in the world.
Totapari		India	Flesh not sweet like the other mango varieties, use for salads or with a tempering of salt and chilies, mostly used as processing purposes, season ranges between June to July.

(F) Pineapple (*Ananas comosus* (L.) Merr.): Exotic cultivars collected – 5, Indigenous – 1

Cultivars/genotypes	Images	Origin/ source	Traits
Giant Kew		India	Leaves are green, generally smooth with occasional spines at the tips, fruit cylindrical and large averaging 2.75 kg in weight, eyes broad and flat, flesh pale yellow, juicy, high sugar content but no acid, unusually sweet fruit.
Queen		Australia	Plant is dwarf with short, spiny, dark purplish-green leaves, fruit is conical, spiny with deep eyes, golden yellow in color and emit pleasant aroma and flavor when ripe, average weight of fruit varies from 600 – 800 g.

(G) Sweet orange (*Citrus sinensis* (L.) Osbeck): Exotic cultivars collected – 8, Indigenous – 2

Cultivars/genotypes	Images	Origin/ source	Traits
Nepali Junar		Nepal	Mid-season variety, selected from local junar, fruits are sweet with TSS 13-14% and 1% acidity, average weight of fruit 150-200 g.
Washington Naval		USA	Early variety, fruits are sweet with TSS 12-13% and acidity 1.7%, very few seeds and sometimes seedless, prone to high fruit drop.
Valencia Late		USA	Late variety, fruits are sweet with TSS 13-14% and acidity of 1.3%, average fruit weight 125-150 g, contains 5-6 seeds.
Pineapple			Mid-season variety, fruits are large in size of 150-200 g with seeds ranges 10-12, less sweet with TSS 9-10% and acidity of 1%, fruits have pineapple flavor.

UNEXPLOITED WILD FRUITS

There are many tropical and subtropical wild fruit relatives having more than one species, they are *Annona, Pummelo, Mangifera, Musa, Aegle* and *Rhus* (Satibayar) as reported by Gautam (2008). Recently, Upreti et al (2012) made an inventory of wild edible fruit crops of Nepal from Makawanpur, Tanahun, Dang, Bardia and

Kailali districts and recorded 44 wild fruit species. These wild fruits are neither conserved nor studied systematically. Some of these fruits include jambol (black jamun), bay berry (kafal), wild gooseberries and figs (Table 6). Some wild relatives of kiwi fruits are found in Nepal which is source of rootstock for imported kiwi sapling production in Nepal and their role in abiotic and biotic stress management has yet to be studied.

Table 6. List of unexploited tropical and sub-tropical wild fruits of Nepal

SN	English name	Nepali name	Scientific name	Uses
1.	Black plum/ Java plum /Jambol	Kalo Jamun	Eugenia jambolana Lam.	Edible fruit
2.	Bay berry	Kafal	Myrica esculenta Buch.-Ham. ex D. Don	Fresh edible fruit
3.	Wild gooseberries	Amala	Emblica officinalis Gaertn.	Fresh and processed products
4.	Fig	Nivaro, Anjir	Ficus carica L.	Rarely used as fresh and dry fruit
5.	Sugar apple (Annona)	Sarifa	Annona squamosa L.	Fresh and processed products
6.	Ficus	Khanayo	Ficus semicordata Buch.-Ham. ex Sm.	Edible fruit
7.	Barberry	Chutro	Berberis asiatica Roxb. ex DC.	Rarely used as fresh fruit
8.	Ceylon oak	Kusum	Schleichera oleosa (Lour.) Merr.	Oil extraction
9.	Bead plum	Hade bayar	Ziziphus incurva Roxb.	Fresh edible fruit
10.	Nepali Sumac	Sati bayar	Rhus parviflora Roxb.	Fresh edible fruit
11.	Zigyphus (wild)	Jangali bayar	Ziziphus mauritiana Lam.	Fresh edible fruit
12.	Grapefruit	Sankhatro	Citrus paradisi Macfad.	Processed products
13.	Citron	Bimiro	Citrus medica L.	Religious use
14.	Blue berries	Nilo Ainselu	Vaccinium uliginosum L.	Rarely used as fresh
15.	Yellow raspberry	Pahelo Ainselu	Rubus ellipticus Sm.	Fresh edible fruit
16.	Wild banana	Jangali Kera	Musa acuminata Colla	Rarely used as fresh fruit
17.	Pummelo	Bhogate	Citrus grandis (L.) Osbeck	Fresh edible fruit
18.	Butter tree	Chiuri	Bassia butyracea Roxb.	Fruit edible, seed oil extraction

Source: Upreti et al 2012.

FRUIT GENETIC RESOURCES CONSERVED IN PUBLIC, PRIVATE AND HOME GARDENS

Fruit genetic resources of many species are found conserved in many private orchards, home gardens and public areas in Nepal (Subedi et al 2005). For example, parks, public gardens, temple areas and schools. They are good example of in-situ and on-farm conservation but record of such resources and systematic studies for future utilization of such vast number of resources are lacking and proper attention need to be given by all research and development actors.

Home gardens and orchards of old Rana palace and custodian farmers are also reservoirs of fruit tree biodiversity (Kumar and Nair 2006, Pudasaini et al 2013). Sthapit et al (2015a) reported that both the term and concept of 'custodian farmer' are relatively new in the field of in-situ and on-farm conservation of fruit tree biodiversity. Custodian farmers are defined as those farmers who actively maintain, adapt and disseminate agricultural biodiversity and related knowledge over time and space at farm and community levels and are recognized by their community members for their efforts (Sthapit et al 2013). The important role that custodian farmers play in conservation, innovation and development is often underestimated, undervalued and unrecognized. One other low-cost, efficient strategy to strengthen community biodiversity management is to work with custodian farmers (Sthapit et al 2013) to identify elite materials, which are the best trees ('plus trees') available in the community, to characterize and evaluate them and further multiply them for community benefits. In five years, 95 elite varieties of *Mangifera*, 32 of Citrus, 5 of *Garcinia* and 2 of *Nephelium* were identified; characterized and documented using farmer fruit tree catalogues from South East Asian countries. Of these, a total of 75 farmer varieties of *Mangifera*, 16 of Citrus, 5 varieties of *Garcinia*, and 2 of *Nephelium* were registered by the respective competent authority of the government (Sthapit et al 2016a). These elite farmer materials are potentially valuable natural assets developed by farmer innovation that help income and livelihoods of farmers. It is a challenge to redress this situation and recognize the contribution by custodian farmers, which is exacerbated by their lack of links to mainstream research and development institutes or networks. Surprisingly, there has been no attempt by national plant genetic resources programs or conservation agencies to systematically identify or locate custodians of fruit tree diversity but there is greater scope for way forward.

UTILIZATION

In the context of predominant subsistence agriculture in the country, very limited fruit trees are generally maintained in home gardens. Because of low in number, utilization of intra species diversity is relatively high than that of inter species diversity. However, utilization of inter-specific diversity is experienced in big home gardens maintained by well off families of Tarai where diversity of mango is very prominent.

Despite long history of introduction and evaluation of genotypes in different agro-ecological regions, all the elite genotypes were not fully reached to the farmers' fields. What so ever genotypes gone to the community have not spread widely due to poor commercialization of fruit farming. The pace of commercialization of fruit farming is very slow because of long gestation period and high initial investment. Demand of diverse genotypes generates from the commercial growers for niche markets or supplies the commodity in extended period of time. In poor presence of commercial ventures, demand side of diversified fruit varieties is very weak. Moreover, public institutions are not offering options to the user for the utilization of the elite genotypes in larger scale. In this scenario, utilization of fruit genotypes primarily depends on the hand of supply side. The saplings produced in the public farms are distributed to the farmers through public sector extension system. Farmers to farmers exchange system are still prevalent but seedlings or seed is the main means. Hence, even utilization part of elite local genotypes is not happening properly.

Collection and consumption of wild species is common phenomenon in agrarian setting. But trading of wild species is coming up in many places. For example trading of bay berry in Dadeldhura – Dhangadi road is estimated to be Rs. 400 thousand per annum. A wine industry established in the eastern Hills is utilizing wild fruits (Himalayan raspberry and barberry) for wine making. Only exploitation without management will have negative effect in long term.

CONCLUSION AND WAY FORWARD

Nepal is rich in tropical and sub-tropical fruit plant genetic resources. These fruit germplasm are scattered across the country in different government farms under DoA and NARC stations and private farms. These germplasms available in public institutions and private farms should be characterized, evaluated, multiplied and selected for wider geographical recommendation based on yield performance, export quality and market niches from the single door. In-situ evaluation of these genotypes using a common protocol could be a worth at initial step for further utilization. Elite genotypes should be multiplied and mother plants conserved at public farms and should be supplied to private nurseries for commercial sapling production. For this, characterization, evaluation and utilization of tropical and sub-tropical fruits should be the priority program of MoAD and the GoN.

Despite long history of agriculture research in Nepal, horticulture research in the country is generally weak. Even within the horticultural sector, fruit sub-sector is the weakest one. In this context following issues should be considered for the use and conservation of genetic resources of tropical and sub-tropical fruits:

- **Exploration of diversity:** Diversity studies so far are carried out in major fruit crops like mango and minor crops like pummelo (in terms of popularity and area under cultivation it only comes after mandarin, sweet orange, lime and lemon). Almost all diversity studies are carried out from the external funds. Nepal needs to have a clear plan to carry out diversity studies either based on available diversity within the species or economic importance of the crops. It would be better to concentrate on more diversified crops having potential to promote as high value commercial crops. NARC as a leading apex body for fruit research should define lead center for each commodity and focus on variety improvement and other production technologies on national level.
- **In-situ conservation of fruits:** In-situ conservation of fruits is much easier than that of annual crops. Failure of *ex-situ* conservation of mango clearly proves that the conservation should be planned as per the agro-ecological suitability of the crops. Instead of collecting the genotypes in the public farm and station, more serious thought should be given for micro-climates as well.
- **Dedicated research team for fruit breeding:** Public (NARC and academia) sector investment on fruit research is extremely weak. The horticultural research in NARC is dominated by vegetable crops and fruit research within the system seems to be in low priority. On one hand, NARC has extremely few dedicated pomologists and, on the other hand there are challenges of retaining pomologists in their profession for longer term. To speed up the fruits research, NARC should have clear human resource planning with adequate manpower deployment. Further, Nepal never have sufficient plant breeders to do fruit research therefore identification of the elite tree land races from farmers' orchards is the

best strategy for the Nepalese conditions. There should be formation of one core team of research scientists at national level to develop research programs, direct activities to be undertaken and monitor and evaluate fruit research activities nationwide.

- **Regular explorations for mutation diversity:** Many commercial varieties of fruits are developed from bud mutation in other parts of the world. In addition to the regular diversity studies, regular exploration of diversity from mutation should also be looked on.
- **Diversity for use:** Nepal has introduced many varieties in order to increase the varietal diversity. Many of the introduced varieties were not properly studied and maintained. Despite introduction of large number of varieties, very few varieties are commercially multiplied and distributed in Nepal. Some success stories from introduction of exotic fruits such as, mango, litchi, banana, junar and kiwi are there, but potential of local fruit species (jambol, bay berry, pummelo) and few exotic fruits (avocado, berries) which are nutritional rich is yet to be explored. Likewise, the outcomes of diversity studies are not yet fully utilized for the economic advantages. Hence, there should be plan of continuum to link the finding of diversity studies for economic uses.
- **State's investment to increase fruits diversity:** Since there is no Consultative Group in International Agriculture Research (CGIAR) working on fruit crops, there is virtually no chance to get germplasms free of cost. Many economically important varieties are developed by private companies of the developed countries. Hence, state needs to be prepared to invest on buying and introduction of new genotypes of economic importance.
- **Use of sustainable alternative:** A simple home garden and orchard survey of fruit custodian farmers can identify the best genotypes of fruits for on-farm/in-situ characterization, scion/rootstocks to be established in community gene bank and/or the farms/stations for variety registration. Moreover, that also gives information on sapling multiplication and establishing new fruit diversity in productive orchards and nurseries for immediate benefits. These valued genetic resources could be characterized by morphological and molecular markers for high value differential and adaptive functional traits.

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Diversity and Prospect of Temperate Fruit Crop Development in Nepal

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ABSTRACT

Nepal is endowed with diverse agro-ecological climate. It has great diversity of genetic resources of fruit crops ranging from tropical to temperate species. Higher mountains and Hills have temperate climate which is not suitable for production of most of cereal food crops, whereas these areas are more potential for the production of temperate fruits. Cultivation of fruit crops in these regions could enhance food and nutritional security and livelihood support to the hill people and conserve ecology. Sustainable farming system is also possible with the fruit crops to increase the economy. Horticulture research stations and farms/centers located at different agro-ecological belts have played major role in germplasm collection, maintenance, evaluation and utilization of exotic and indigenous fruits in the country since 1952. Exotic varieties of temperate fruits have been introduced from India, Japan, Israel, and Canada etc. Promising varieties of apple, pear peach, plum, walnut, apricot, persimmon, kiwi, olive, almond and pomegranate have been introduced and evaluated in different research stations and government farms. Phonological studies of above mention fruits have been carried out and production technology has been standardized for commercial production. Hog plum is an indigenous fruit crop of Nepal grown in warm temperate region and has a great potentiality for commercialization. Its processed products have demand both in national and international markets. Similarly, sea buckthorn is a potential indigenous fruit grown in the higher altitude is being processed to concentrated thick sour syrup (*Chuck*) utilized for pickling and medicinal purpose. Indigenous wild species of *Malus, Pyrus, Prunus, Juglans, Diospyros* and *Olea* have been used as rootstocks in the production of grafted saplings of the temperate fruits such as apple, pear, peach, plum, apricot and almond, thin shelled walnut, persimmon, and olive. With the research and development efforts of the government the area, production and productivity of temperate fruits in the country has reached to 27124.8 ha, 128155.1 mt and 7.6mt/ha, respectively. Kiwi is one of the recently newly introduced fruit crop is getting popularity among the fruit growers of warm temperate regions. High density planting in apple has also been initiated by the use of clonal rootstock in spur variety of apple in Manang by private sector co-investment. Prime Minister Agriculture Modernization Project (PMAMP) has also declared Jumla district of Karnali zone as a super zone for apple and Bajura district of Seti zone for olive. Furthermore, there are many under exploited temperate fruit crops noticed in the higher Hills of Nepal, which have great potentiality for research, cultivation and processing.

Keywords: High density planting, hog plum, root stock, sea buckthorn, temperate fruit

INTRODUCTION

In the global perspective, Nepal lies in between 26°22' to 30°27' North latitude and falls under sub-tropical climate range. More over because of variation in topography and altitude from mean sea level it has different climate in different region. The country has three physiographic regions having mountains in the north, Hills in the middle, and the Tarai in the south (**Figure** 1). Approximately 86% of the area is occupied by mountains and Hills and remaining 14% in the Tarai. The farming system is practiced up to 4200 t of altitudes in the higher mountains (Nepal and Its Plants 2010, http://www.nepalflowers.com/blog/2010/11/nepal-andits-plants).

Northern parts of mountain region of Nepal has favorable climate for growing a large number of temperate fruits such as apple, pear, peach, plum, apricot, olive, walnut, strawberry, grapes, etc. Western and Mid western region are most favorable for temperate fruits. Warm temperate varieties of pear, peach are common both in Mid and High Hills throughout the country where as high chilling varieties of apple, pear, and peach, apricot are only grown in high mountain districts. Mustang is one of the best suitable districts for commercial apple production. Apple can be successfully grown in Karnali zone. Western mountain region gives more opportunity to grow temperate fruits commercially.

There are sixteen high mountain districts growing temperate fruits. Some Mid Hill districts also have warm temperate and temperate climate and provide opportunity to cultivate these crops. The major crops grown commercially are apple, pear, plum, peach, kiwifruit, grape, olive and strawberry. The area covered by temperate fruits is about 27125 ha (MoAD 2015). Apple is the major crop prioritized in eleven districts of Western Nepal while other crops are promoted from east to west of warm temperate to temperate areas ranging from 1500 to 3000 masl of altitudes.

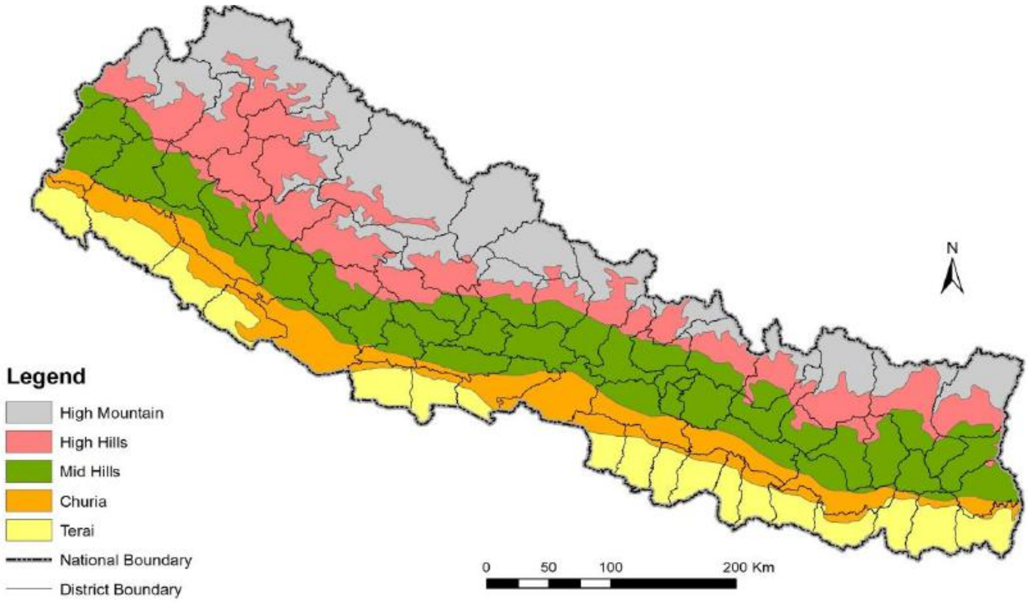

Figure 1. Physiographical zones of Nepal.

A Number of indigenous temperate fruits are famous in Nepal like crab apples, wild pears, Naspati, apricot, plums, peaches, and walnuts. Besides various indigenous species and varieties various improved cultivars have been introduced and adapted in different parts of country and recommended for commercialization. As a result exotic varieties of apple, pear, plum, grapes, peach, strawberry, kiwifruit are very common in commercial fields. The major objectives of this paper are:

- To prepare the present status of temperate fruit genetic resources in Nepal.
- To analyze the genetic resources management and its research gaps.
- To dig out the major problems of temperate fruit production and commercialization.
- To present the way forward to mitigate the major issues related to temperate fruit conservation and production in Nepal.

GOVERNMENT STRATEGIES AND PLAN FOR THE IMPROVEMENT OF TEMPERATE FRUIT

Horticulture Master Plan (1990 AD), Agriculture Perspective Plan (1995-2015AD), Agriculture Development Strategy (2015-2035 AD), Prime Minister Agriculture Modernization Project (2016-2026 AD), One Village One Product (2007 AD), One District One Product (2012 AD), Fruit Year (2018 AD), Fruit Decade (2016/17-2025/2026 AD) are major policies, plans and programs for fruit Development in Nepal.

Commercialization of agriculture was one of the major objectives of National Agricultural Policy 2061 and directly related with promotion of horticultural commodities. From ninth five years plan, the Government has taken a policy of developing commercial orchards of apple in suitable pocket areas of western and far-western development regions. Eleven districts: Manang, Mustang, Kalikot, Jumla, Humla, Mugu, Dolpa, Bajura, Bajhang and Darchula have been recognized as apple growing districts.

Donors' Projects in the past and present have supported in the development of fruit subsector towards farm station establishment and strengthening; fruit germplasm introduction, maintenance, characterization, evaluation and utilization and overall R& D to address commercialization of major fruits.

ADS aims to support 5 value chains through value chain development program and vegetable is one of them. Temperate fruits are not considered as the major value chain but it has provisioned to cover 15 more potential commodities in list where apple is one of them.

NARC is mandated for all research activities including horticulture and the Department of Agriculture (DoA) for all extension and development activities. There are many horticultural stations under DoA and horticulture research stations under NARC located in different agro-ecological regions of Nepal which are mandated to carry out both research and development activities. In temperate fruits, there is only one research station located at Rajikot, Jumla and eight horticulture stations (Phaplu, Solukhambu; BonchDolkha; Kirtipur, Kathmandu; Daman, Makawanpur; Jufal, Dolpa; Marpha, Mustang and Darma, Humla) Fruit development Directorate, Kirtipur has given clear guideline for germplasm collection, maintenance, characterization, evaluation and utilization.

Government of Nepal facilitated external supports from bilateral and multilateral donors to strengthen fruit research and development in the country. Some of the external supports in fruit research and development are as follows:

- United States Agency for International Development (USAID): First foreign funded project support and funded for Kakani Fruit Stationin 1952.
- Indian Cooperative Mission: In 1950, 13 horticulture farms/stations had been established in different agro-ecological zones of Nepal including temperate fruits farms/stations. Major works on the germplasm introduction from India was done during this period.
- Swiss Government Integrated Hill Development Project was implemented in Dolakha and Sindhupalchowk from 1975 to 1085.
- Food and Agriculture Organization of the United Nation (FAO) implemented Hill Agriculture Project during 1976 to 1979. In this period many germplasm of temperate fruits had been introduced and maintained in Kirtipur, Jumla and Mustang.
- Horticulture Development Project (JICA Phase I and II) started in 1985. During this project period germplasms of Japanese pear, grape, persimmon and chestnut were introduced. Demonstration and extension programs were demonstration around Kathmandu valley and its vicinity.
- High Value Agriculture Project in Hill and Mountain Areas (HVAP): Seven years' (2010/10 to 2017/18) IFAD funded project has supported for apple value chain based sub-projects in Jumla and Kalikot.
- High Mountain Agribusiness and Livelihood Improvement Project (HIMALI) (Oct 2011- Sept 2017): With the grant assistance of ADB, it has also supported apple value chain in high mountain areas of targeted districts. It has been initiated with introduction of high density planting of apple on commercial scale in Manang District.

GENETIC DIVERSITY OF TEMPERATE FRUITS

There are many cultivated and wild types of fruit crops in Nepal. Nepal is rich in bio-diversity of plan resources. About 6500 species of flowering plants exist in this country (Chalise et al 1993). In spite of many fruit species, such as *Annona, Phyllanthus, Aegle, Phoenix, Castanopsis, Morus, Pyrus, Prunus, Myrica, Berberis, Vitis, Rubus, Fragaria, Actinidia*, etc are growing wild in forest areas and very little documentation is made on these fruits (Kaini 1995). Many fruit species and their varieties of cultivated types have been introduced to Nepal from other countries during Rana Regimes as well as later years when fruit development activities began from last six decades.

Rich diversity occurs in *Malus, Pyrus, Prunus, Rubus and Ribes*. The high mountain areas of Mid western and western region have *Malus species. Prunus species such as Prunus napalensis, and Prunus cerasoides; Pyrus pyrifolia* are grown wild in Mid Hills areas of the country. Wild pomegranate (*Punica grantaum*) in High Hills and Mid Hills and wild olive (*Olea cuspidata*) is found growing along the Kanali river in Bajura, Mugu and Humla and Bheri River corridor of Dolpa.

Apple (*Malus pumila* Mill.)

Main temperate fruits grow in the Mid and High Hills, High Hills for high chilling varieties and Mid Hills for low chilling varieties. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Royal Delicious, Red Delicious, Rich-a-red Red delicious, golden delicious. Wild seedling of apple ie crab apple, EdiMayal and Japanese rootstock have been used for rootstock. Fruits are used fresh and for making processed products like jam, jelly, juice, wine and brandy, dried slices.

Table 1. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Apple	Syau	Malus pumila Mill., Malus baccata (L.) Borkh., Malus sikkimensis (Wenz.) Koehne ex C.K. Schneid Malus prunifolia	58 root stocks	2 3 M and MM series 1 Japanese	Cultivated low chill varieties in Mid Hills and high chills of Nepal and wild species are in High Hills of Western, Mid Western of Nepal

Collection and Maintenance

Farm/Stations	Varieties
1. Phaplu, Solukhumbu	1. Golden Delicious 2. Red Delicious, 3. Royal Delicious, 4. Richa-a-Red Delicious, 5. Grannysmith, 6. CO.UP, 7. Jonathan, 8. Anna, 9. Vered, 10. Star spur gold, 11. Fuji, 12. Red gravantein, 13. Honry Crisp, 14. Gala
2. Bonch, Dolakha	1. Anna, 2. Vared, 3. Star spur gold, 4. Fuji, 5. Red gravantein, 6. Honry crisp , 7. Gala Rootstock: 1. M9, 2. MM106, 3. MM111
3. Godavari, Lalitpur	NA
4. Kirtipur, Kathmandu	Rootstocks: Edimayal and *Malus prunifolia*
5. Daman, Makwanpur	1. Red delicious, 2. Royal Delicious, 3. Red Gold, 4. Fuji, 5. Mclontosh, 6. Summer Pippin, 7. Anna, 8. Vered 9. Gala, 10. Stark Spur, 11. Spurgold, 12. Red Graveisteen, 13. Honey Crisp Rootstock: 1. M7, 2. M9, 3. MM106, 4. MM109, 5. MM111
6. Juphal, Dolpa	Royal Delicious, Golden Delicious, Red Delicious
7. Marpha, Mustang	1. Royal Delicious, 2. Royal Delicious, 3. Rich-a-Red Delicious, 4. Golden Delicious, 5. Vance Delicious, 6. Fuji, 7. Red Fuji, 8. Red Gold, 9. Top Red, 10. Cox Orange Pippin, 11. Binauni, 12. Granny Smith, 13. M asadi, 14. Amri, 15. Aiken, 16. Kullu, 17. Green Gravestein, 18. Red Gravestein, 19. Liberty, 20. Pineapple, 21. Spintzenberg, 22. Scarlet Gala, 23. Bell Spur, 24. Bell Flower Milberg, 25. Origon Spur-2, 26. Co-Op-12-2, 27. Red Chief, 28. Star Crimson, 29. Red Spur, 30. Summer Pippin, 31. Fall Russet, 32. Bramleys, 33. Mutsu, 34. Bright and Earl, 35. Hello summer, 36. Melo Galas, 37. Tsugura, 38. Ushyu, 39. Saune, 40. Star Spur Gold, 41. Honey Crisp, Rootstock: 1. M-9, 2. MM-106, 3. MM-111 Crab apple: 8 types
8. Satbanjh, Baitadi	Delicious (1. Royal, 2. Red, 3. Golden), 4. Jonathan, 5. Red June, 6. McIntosh, 7. Cox's orange pippin, 8. King of pippin, 9. Top red, 10. Red gold, 11. Winter banana, 12. Kashmiri Ambri, 13. Stark all Bleze
9. Rajikot, Jumla	1. Red Delicious 2. Royal Delicious, 3. Golden Delicious, 4. Jonathan, 5. Mclontosh, 6. Sweet Ambri, 7. Ambri, 8. Cox orange Pippin, 9. Pakastani Masadi all these from India in 1969, 10. Ambrosia, 11. Blusine, 12. Susan, 13. Honey crisp, 14. Red Grevestine, 15. Jonagold, 16. Jubile, 17. Fuji, 18. Prestine, 19. Red Free, 20. Sinta, 21. Tsugaru, 22. Zestar, 23. Robinet, 24. Sunraise, 25. Jim, from Canada in 2011; 26. Vance delicious, 27. Red Chief I, 28. Red Chief II, 29. Red Gold, 30. Bright N Early, 31. Oregon Spur II, 32. Top Red, 33. Well Spur, 34. Star Crimson Delicious, 35. Red Spur, 36. Star Spur Gold from India in 2011 (all spur type), 37. Canada Cris, 38. Melrose, 39. Idared, 40. Boskoop from France 2016 (all spur type) Apple Rootstock: Edimayal (*Malus sikkimensis*)
Everything Organic Nursery (EVON), Patlekhet, Kavre	Fuji, Naomi
ARS Pakhribas	Anna, Veered

Source: HRS 2016, FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Pear: European (*Pyrus communis* L.)

***Pear Asian* (*Pyrus pyrifolia* (Burm.f.) Nakai)**

One of the major temperate fruits grew both in the Mid and High Hills. High Hills are suitable for high chilling European varieties and Mid Hills for low chilling Asian varieties. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Hosui, Kosui, Sinko, Bartlette and Pharping. Wild seedling of pear is used for rootstock. Fruits are used as fresh and for making processed products like juice, wine and brandy.

Table 2. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
European Pear Asian Pear	Naspati	Pyrus communis L. Pyrus pyrifolia (Burm.f.) Nakai	16		cultivated varieties in Mid and High Hills of Nepal and wild species in High Hills of western, Mid western High Hills of Nepal
	Mayal	Pyrus pashia Buch.-Ham. ex D.Don		2	
Wild Pear		Pyrus serotina Rehder			

Collection and maintenance

Farm/Stations	Varieties
1.Phaplu, Solukhumbu	1. Local Pharping, 2. Kosui, 3. Hosui, 4. Chujuro
2.Bonch, Dolakha	1. Pharping local, 2. Hosui, 3. Kosui
3.Godavari, Lalitpur	1. Kosui, 2. Hosui, 3. Bartlette, 4. Pharping
4.Kirtipur, Kathmandu	1. Kosui 2. Hosui 3. Chojuro 4. Sinko 5. Havana 6. Anju 7. Kikusui 8. Yakumo 9. Waseka 10. Patala 11. Golden Nijiseiki 12. Aatago 13. Nitaka 14. Bartlette 15. Okisankichi and 16. Pharping
5.Daman, Makwanpur	1. Pharping, 2. Hosui, 3. Kosui, 4. Sinko, 5. Nikisekki, 6. Choujuro, 7. Barlette Rootstock: 1. local Mayal 2. Bhote and small Mayal
6.Marpha, Mustang	1. Red Bartlette, 2. Pharping, Wild Pear: Mayal
7.Satbanjh, Baitadi	1. Bartlette, 2. Pharping, 3. Havana, 4. Kosui, 5. Hosui
8.Rajikot, Jumla	1. Havana and 2. Bartlette from Kirtipur in 1991
9. ARS Pakhribas	Bartlette, Chinese, Pharping
10.ICIMOD, Godawari	Suli, Xuili, Changxili, Hosui,
11. EVON, Kavre	Bosc, Comice, Danju, Hosui, RedBartlette, Seckels

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Peach (*Prunus persica* (L.) Batsch)

Peaches are grown both in the Mid and High Hills. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Orion, Peregrine and Elberta. Wild seedlings of peach have been used for rootstock. Fruits are used fresh and for making processed products like jam, wine and brandy.

Table 3. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Peach	Aaru	Prunus persica (L.) Batsch	9	1	Cultivated varieties in Mid Hills and High Hills of Nepal and wild species in High Hills of western, Midwestern High Hills of Nepal

Collection and Maintenance

Farm/Stations	Varieties
1. Phaplu, Solukhumbu	Peregrine, Orion
2. Bonch, Dolakha	Orion, Peregrine

Farm/Stations	Varieties
3. Godavari, Lalitpur	Orion ,Peregrine
4. Kirtipur, Kathmandu	1. Orion, 2. Armgold 3. Texas 4. Peregrine 5. Nectarin (*P. persicavar nectarina*-Panamint Local Peach for Rootstocks
5. Daman, Makwanpur	Peregrine, local peach
6. Juphal, Dolpa	
7. Marpha, Mustang	1. Early red 2. Armgold
8. Darma Humla	
9. Satbanjh, Baitadi	Peregrine, Orion, Elberta
10. Rajikot, Jumla	Peregrine from Kirtipur in 1991; Benedicte and Surprise from France in 2016
11 .EVON, Kavre	Desert Gold, June Pride

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994, HRS 2016.

Plum (*Prunus* spp.)

Plums are grown both in the Mid and High Hills. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Methely and Green gauze. Wild seedling of peaches has been used for rootstock. Fruits are used fresh and for making processed products like jam, juice, wine and brandy.

Table 4. Diversities and Distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Plum	Alubakhada	Prunus domestica L. Prunus salicina L.	8	1	cultivated varieties in Mid Hills and High Hills of Nepal and wild species in High Hills of western, Mid western High Hills of Nepal

Collection and Maintenance

Farm/Stations	Varieties
1.Phaplu, Solukhumbu	Perigreen, Santarosa, Meriposa
2.Bonch, Dolakha	Santarosa
3.Godavari, Lalitpur	Methley, Meriposa, Santarosa
4.Kirtipur, Kathmandu	1. Greengauze 2. Methey 3. Santarosa local plum (*Prunus domestica*)
5.Daman, Makawanpur	Peregrine
6.Marpha, Mustang	1. Spring time 2. Methley, 3. Santarosa
7.Darma, Humla	Methley, Greengauze, Santarosa
8.Satbanjh, Baitadi	Santarosa and Meriposa
9.Rajikot, Jumla	Methley from Kirtipur in 1991; Mirabelle and Stanley from France in 2016

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994, HRS 2016.

Almond (*Prunus dulcis* (Mill.) D.A.Webb)

Almonds are grown both in the Mid and High Hills. Production technology has been standardized and recommended for commercial production. Recommended most common variety is thin shelled. Wild peaches have been used for rootstock. Dry nuts are used.

Table 5. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Almond	Kagaji Badam	Prunus dulcis (Mill.) D.A.Webb	9	1	Cultivated varieties in Mid Hills and High Hills of Nepal and wild species in High Hills of western, Mid western High Hills ofNepal

Collection and Maintenance

Farm/Stations	Varieties
1. Marpha, Mustang	1. Thin shelled, 2. Hard shelled

2. Satbanjh, Baitadi	California paper shell, Sun IXL
3. Rajikot, Jumla	Taxes Spring, Non-Pareil
4. EVON Kavre	All In One, Garden Prince, Paper Shell, Thin Shell, IXL, Shalimar and Italian

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994, HRS 2016.

Apricot (*Prunus armeniaca* L.)

Apricot is one of the major temperate fruit grown both in the Mid and High Hills. High Hills are suitable for high chilling varieties and Mid Hills for low chilling varieties. A total of 11 accessions of apricot have been introduced from abroad; Sakarpara, Kaisha, Charmagaz, Tilton, Blenwhim from India in 1975, Hargand and Bergeron from France in 2016 (HRS 2016).

Production technology has been standardized and recommended for commercial production. Recommended most common variety is Sakarpara. Local apricot is also grown in the kitchen gardens of Kathmandu valet. Seedling of apricot and peach is used for rootstock. Fruits are used fresh and for making processed products like jam, jelly, wine and brandy, dried slices. Oil from kernels of Wild apricot is used for medicinal purpose.

Table 6. Diversities and distribution

English name	Common name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Apricot	Khurpani	Prunus armeniaca L.	11	1	Cultivated varieties in Mid Hills and High Hills of Nepal and wild species in High Hills of western, Mid western High Hills of Nepal

Collection and Maintenance

Farm/Stations	Varieties
1. Phaplu, Solukhumbu	NA
2. Bonch, Dolakha	NA
3. Godavari, Lalitpur	NA
4. Kirtipur, Kathmandu	Sakarpara and Ume
5. Daman, Makwanpur	NA
6. Juphal, Dolpa	NA
7. Marpha, Mustang	1. Kaisa, 2. Sakarpara Wild apricot: Chuli
8. Darma, Humla	Sakarpara
9. Satbanjh, Baitadi	Sakarpara, Kaisa, Charmagaj
9. Rajikot, Jumla	Sakarpara,Tilton, Blenwhim (all from India in 1975) Hargand, Bergeron (from France in 2016)
10.ICIMOD, Godavari	Chaubatia Madhu (Indian), Erzhuanzhi (Chinese), Lanzhoudajiexin (Chinese), Meixin (Chinese), Safaida Special(Indian), Sakarpara, Xinli (Chinese)

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994, HRS 2016.

Walnut (*Juglans regia* L.)

Walnut is one of the major temperate fruit grown in the Mid Hills and High Hills. Five varieties have been introduced from India in 1975. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Kashmiri thin shell, Ashley, Hartley, Franquette. Wild seedling of hard shelled walnut is used for rootstock. Fruits are used as dry nuts.

Table 7. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Walnut	Okhar	Juglans regia L.	5	Rootstock:2	Cultivated varieties in Mid Hills and High Hills of Nepal and wild species in High Hills of western, Mid western High Hills of Nepal

Collection and Maintenance

Farm/Stations	Varieties
1. Phaplu, Solukhumbu	Kashmiri Thin shell
2. Bonch, Dolakha	Kashmiri Thin shell
3. Godavari, Lalitpur	NA
4. Kirtipur, Kathmandu	Kashmiri Thin shell, Hartley , Ashley, and Franquette
5. Daman, Makwanpur	Kashmiri Thin shell
6. Juphal, Dolpa	1. Kashmiri Thin shelled, 2. Hard shelled
7. Marpha, Mustang	1. Kashmiri Thin shelled, 2. Hard shelled
8. Darma, Humla	1. Kashmiri Thin shelled, 2. Hard shelled
9. Satbanjh, Baitadi	Kashmiri Thin shell, Hard shell
10. Rajikot, Jumla	Payne, Hartley, Ashley (All from India in 1975) Local: Rootstock: North California Black, Local hard Shell

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994, HRS 2016.

Persimmon (*Diospyros kaki* L.f.)

Persimmon is grown in the Mid Hills. Ten varieties of persimmon have been introduced from Japan. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Jiro and Fuyuu (non-astringent type); Hiratanenasi and Hachiya (astringent type). Fruits are used fresh and dried slices.

Table 8. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Persimmon	Haluwabed	Diospyros kaki L.f.	10	Rootstock:1	Cultivated varieties and wild species in Mid Hills

Collection and Maintenance

Farm/Stations	Varieties
1. Bonch, Dolakha	Fuyu
2. Godavari, Lalitpur	Jiro, Fuyu
3. Kirtipur, kathmandu	Fuyu, Mayakawawase Fuyuu, Jiro, Zinjimaru, Ubeni, Mompe, Hanagoso, Hachiya, Soruga, Atago local persimmon for rootstock (*Diospyros* spp.)
4. Daman, Makwanpur	Hanagosi, Fuyu, Jiro
5. Satbanjh, Baitadi	Jiro, Fuyuu, Zingimaru

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Grape (*Vitis* spp.)

Grapes are found growing from Tarai to High Hills of the country. Wild grapes diversity can be seen in Mid and High Hills. Twenty exotic varieties have been introduced from abroad, mostly from Japan, a few from India. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Kyoho, Steuben, Himrod seedless, Black Olympia.

Table 9. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Grape	Angur	Vitis venifera L., Vitis labrusca L.	21		Wild grapes are in Mid and High Hills of the country

Collection and Maintenance

Farm/Stations	Varieties
1. Kirtipur, Kathmandu	Himrod, Pearllet, Steuben, Kyoho, Olympia, olympia red, Cambell Early, Buffalo, Deware, Ezuka Kyoho, Muscat Belly A, Late Rizamat, Gorby, Pione selection, Ohtsubu Niagara, Shien, Banana, Shupu-1 and Shupu-2
2. Marpha, Mustang	1. Himrod, 2. Stuben, 3. Egyptian, 4. Olympia
3. Satbanjh, Baitadi	1. Pearlet

4. ARS, Nepalgunj	Beauty Seedless, Delaware, Kyoho, Muscat Baily A, Olympia, Perlette, Thomson Seedless, Steuben, Tanored
5. EVON, Kavre	Concurd, French, Himrod Seedless, Kyoho, Red Olympia, Steuben

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Pecanut (*Carya illinoinsis* (Wangenh.) K.Koch)

Pecan is exotic fruit in Nepal. Six varieties have been introduced and maintained. Production technology has been standardized and recommended for commercial production. Recommended most common varieties are Mahan, Witchita.

Table 10. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Pecanut	Chuchche Okhar	Carya illinoinensis (Wangenh.) K.Koch	3	×	Mid Hills of Nepal in very limited areas

Collection and Maintenance

Farm/Stations	Varieties
1. Kirtipur, Kathmandu	Mahan, Chowta, Mohawk, Witchita
2. Satbanjh, Baitadi	Money maker, Desirable
3. EVON, Kavre (www.everythingorganic.org)	Mahan, Mohawk

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Hazelnut (*Corylus avellana* L.)

Seven exotic varieties of hazelnut Tonda Gentile, Dette Langhe, Cob Not, White Skinned, Red Skimmed, Corluna and Amellana were introduced and maintained in the horticulture stations Humla, Dolpa and Bonch. Not so much work done this nut crop and no recommendation of commercial practices have been done so far. Not much work has been done in this fruit and commercial production is also not recommended.

Table 11. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives
Hazelnut	Hande Badam	Corylus avellana L.		

Collection and Maintenance

Farm/Stations	Varieties
1. Bonch, Dolakha	Corluna, Amellana
2. Juphal, Dolpa	Tonda Gentile, Dette Langhe
3. Darma, Humla	Tonda Gentile, Dette Langhe

Chestnut (*Castanea* spp.)

Wild chest nuts are found growing in the Mid Hills. A total of 5 accessions of varieties Chinese, Japanese: Tshukuba, Ishujuki, Ibuki, Tanjawa and Yamanewase have been introduced from Japan and maintained in different horticulture farms/ research stations. Production technology has been standardized and recommended for commercial production. All varieties are under recommendation for cultivation. No work has been done on wild Dhale and Masure Katus.

Table 12. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Japanese Chestnut	Japani Katus	Castanea crenata Siebold & Zucc.	4		Wild and cultivated chestnut in Mid Hills of the country
Chinese Chestnut	Chinese Katus	Castanea mollissima Blume	1		
	Dhale Katus Masure Katus	Castonopsis indica Roxb. Castonopis tribuloides Sm.		1 1	

Collection and Maintenance

Farm/Stations	Varieties
1. Bonch, Dolakha	Chinese and Japanese
2. Kirtipur, Kathmandu	Chinese, Japanese:Tshukuba, Ishujuki, Ibuki, Tanjawa, Yamanewase
3. Daman, Makwanpur	Ishujuki, Ibuki, Tanjawa, Yamanewase
4. Darma, Humla	Japanese and Chinese
5. Satbanjh, Baitadi	Ishijuchi, Tanzawa
6. ICIMOD, Godawari	Liangxiangbanli (Chinese), Japanese Chestnut
7. ARS, Paripatle, Dhankuta	Japanese Chestnut

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Kiwi (*Actinidia chinensis* Planch.)

A total of 6 accessions of varieties Hayward, Alison, Monty, Bruno, Soyou (Red Kiwi), Motsuwa have been introduced from Japan and maintained different horticulture farms/ research station. Production technology has been standardized and recommended for commercial production.

Table 13. Diversities and Distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Chinese gooseberry	Theki Fal	Actinidia chinensis Planch.	6	×	

Collection and maintenance

Farm/Stations	Varieties
1. Phaplu, Solukhumbu	Hayward, Alison, Monty, Motsuwa, Abbot
2. Bonch, Dolakha	Hayward, Alison, Monty, Bruno, Abbot
3. Kirtipur, Kathmandu	Hayward, Alison, Bruno, Motsuwa, Abbot, Tomori
4. Daman, Makwanpur	Hatward, Alison, Monty, Bruno, Red Kiwi, Motsuwa
5. ARS, Pakhribas	Abbott, Alison, Bruno, Hayward, Monty, Soyou (Red Kiwi)

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Nepalese Hog Plum (*Choerospondias axillaris* Roxb.)

Indigenous to Nepal and is found growing in the Mid Hills especially in the hilly areas of Kathmandu valley. This indigenous fruit crop has been collected and maintained at Government farm at Godavari. Production technology has been standardized to some extent and recommended for commercial production. No detail characterization has been done and there is variation in the germplasms' characters.

Table 14. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Nepalese Hog Plum	Lapsi	Choerospondias axillaris Roxb.	1		wild relatives are in Mid Hills of the country

Collection and maintenance

Farm/Stations	Varieties
1. Bonch, Dolakha	Local
2. Godavari, Lalitpur	Local

Sweet Cherry (*Prunus avium* L.)

Local wild sour cherry is found growing in the Mid Hills of Nepal which has been used as avenue trees in bio-aesthetic planning of urban areas. Production technology has not been standardized and not recommended for commercial production.

Table 15. Diversities and Distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Cherry	Painyun	Prunus avium (L.) L.	2	1	wild relatives are in Mid Hills of the country

Collection and maintenance

Farm/Stations	Varieties
1. Rajikot, Jumla	Big Van and Burlat from France in 2016
2. EVON, Kavre	Bing, Montamery, Ranier

Pomegranate (*Punica granatum* L.)

Wild pomegranate is found growing in Mid Hills. Four varieties Ganesh, Kandhari, Mridula, Sinduria have been introduced from India and are under testing of their performance in Central Horticulture Centre, Kirtipur. These varieties are under cultivation for commercial purpose as well. The characterization and evaluation has not been done under Nepalese condition.

Table16. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Pomegranate	Anar	Punica granatum L.	4	1	Wild relatives in Mid Hills of the country

Collection and Maintenance

Farm/Stations	Varieties
1. Godavari, Lalitpur	NA
2. Kirtipur, Kathmandu	1.Ganesh, 2. Kandhari, 3. Mridula, 4. Sinduria
3. Darma, Humla	Kandhari
4. Root Crops Development Centre, Sindhuli	Kandahri
5. Subtroical Horticulture Centre, Trishuli, Nuwakot	Sindhuria, local collection

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Fig (*Ficus carica* L.)

Wild figs are found growing in Mid Hills. Four varieties have been introduced from Japan. Production technology has not been standardized and not recommended for commercial production.

Table 17. Diversities and Distribution

Nepalese name	English name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Anjir	Fig	Ficus carica L.	4		Wild relatives in Mid Hill

Collection and maintenance

Farm/Stations	Varieties
1. Kirtipur, Kathmandu	Kirtipur: Masui, Dolphin, White Geneva, Brown Turkey
2. ICIMOD, Godavari	Masui Dolphin, White Genoa
3. EVON, Kavre	Voilet D, Bordeaux

Source: FDD 2017, Shrestha 1998, Kaini 1995, NARC 1994.

Olive (*Olea* spp.)

Wild olive (*Olea cuspidata* Wall. & G. Don*)* is found growing in Dolpa (Parang, ThuliBheri, Dunai, upper Bheri, Tallon, ParakyaLogne and Karnali; in Rukum: Gotamkot; in Humla:Darma and Simikot; in Bajura : Kaligad, Kolti, Boldhik from 1100m to 2192 m; from 1000m to 3000m in Mugu, Kalikot, Jajarkot, Jumla; Wild olive *Olea grandiflora* Wall.ex G.Don from 1530 to 1566 m in Bajhang Chainpur, Manakot, Baru Ganga.

37 Exotic varieties were introduced from different countries like Israel, Syria (2006), Japan, Italy (2006 AD) and India and maintained in Kolti, Bajura, Kirtipur horticulture station and some varieties in Himalayan Plantation Pvt.Ltd., Chitlang, Makawanpur.

Ripe olive fruits are pressed for edible oil. The oil is used for cooking, salad dressing, food preparation, massage, and for the manufacture of cosmetics, pharmaceuticals, etc. Matured fruits are also eaten after being processed and preserved in vinegar or salt solution. The extract from leaves, bark and fruits has medicinal properties. Its wood is used for carving to furnish houses, to prepare vessels and tools for the kitchen as well as for the field purposes and has excellent firewood. Leaves are given to the animals as fodder; oil cakes are fed to livestock or are used as manure and are again excellent firewood. Production technology has been standardized to some extent.

Table 18. Diversities and distribution

English name	Nepali name	Scientific name	No of cultivars in the country	No of wild relatives	Distribution
Olive	Jaitun	Olea europaea L.	37		Wild relatives (Olea cuspidata Wall. & G. Don and Olea *grandiflora* Wall.ex G.Don) are found growing along the corridor of Karnali river of Humla, Mugu and Bajura; and along Bheri river corridor of Dolpa
		Olea cuspidate Wall. & G. Don Olea grandiflora Wall.ex G.Don		2	

Collection and Maintenance

Farm/Stations	Varieties
1. Godavari, Lalitpur	1. Sorani 2. Zaiti and 3. Kaisi from Syria in1998
2. Kirtipur, Kathmandu	1. Picae, 2. Manzamilla, 3. Toffahi, 4. Hamed, 5. Lakka 6. Mission 7. cipriccino, 8. cassanese, 9. Marina, 10. Nocellare, 11. Rosciola, 12. Femminelle, 13. Leccino, 14. Frantio, 15. Taggiasca, 16. Morailo, 17. Coratina, 18. Ascolana, 19. Bourbon, 20. Rasara, 21. Pendolino, 22. Valle Corsana, 23. Leoncino, 24. Frattese, 25. Itrana, 26. Carbonella, 27. Maurino, 28. Piantone, 29. Rajo, 30. Canino, 31. Anahairi, 32. Caroica, 33. Bosana, 34 Corana, 35. Local
3. Jan Prabhat Uchcha Ma. Bi, Kolti, Bajura	1. Cipriccino, 2. Cassanese, 3. Marina, 4. Nocellara, 5. Rosciola, 6. Femminelle, 7. Leccino, 8. Frantoio, 9. Taggiasca, 10. Morailo, 11. Coratina, 12. Ascolana, 13. Bourbon, 14. Rasara, 15. Pendolino, 16. Valle Corsana, 17. Leoncino, 18. Frattese, 19. Itrana, 20. Carbonella, 21. Maurino, 22. Piantone, 23. Rajo, 24. Canino, 25. Anahairi, 26. Caroica, 27. Bosana, 28. Corana, 29. Gentile de Anghiari, 30. Local introduced in 2006 A. D.
4. Juphal, Dolpa	Sorani, 2. Zaiti, and 3. Kaisi from Syria in1998
5. Marpha, Mustang	1. Nobeli, 2. Sorani, 3. Zaiti, and 4. Kaisi from Syria in1998
6. Himalayan Plant-ation Pvt. Ltd. Chitlang, Makwanpur	NA

Source: Dhakal and Bartoulucci 1998.

Seabuckthorn (*Hippophae salicifolia* D.Don)

High altitude berry shrub well adapted in dry valleys of High mountain areas specially in Mustang and Dolpa. The small bush produces small berry that is sour and astringent. It has good medicinal value high in Vitamin C content. Processed products are used as juice and squash etc. Wild germplasm has been collected in temperate Horticulture Centre, Marpha, Mustang. Their characterization evaluation needs to be done.

Black berry (*Rubus* spp.)

In Nepali, it is called Kalo Aiselu. Four exotic varieties namely Amarand Logan berry, Mestry, Ollalie and Sunshine have been collected and maintained by EVON, Kavre.

Blackcurrant (*Ribes nigrum* L.)

One variety Benconan has been collected and maintained by EVON Kavre.

Blue berry (*Vaccinium* spp.)

One variety Petriate has been collected and maintained by EVON Kavre.

Nepalese Rasp berry (*Rubus nepalensis* hort.)

Widely found growing Nepalese rasp berry in the Hills and mountain of Nepal. Not so much attention has been given. Wild collection is done for processed products making like jams and wine. It has medicinal value. Exotic rasp berry varieties Red and Gold have been collected in Everything Organic Nursery (EVON) (www.everythingorganic.org), Patlekhet, Kavre.

STATUS OF TEMPERATE FRUIT PRODUCTION IN TERMS OF AREA AND PRODUCTION AND EXPORT IMPORT

Table 19 shows that apple is leading crop in temperate fruit followed by pear in terms of area and production. The productivity of fruits are at low level particularly in case of apple and pear which are comparatively lower than the abroad. Export import data clearly shows the significant trade difference in export to import which indicates to put great efforts to meet this big gap addressing the market demand through upscaling of production, productivity and product diversification programs.

Table 19. Area, production and productivity

Fruit	Area (ha)	Productive area (ha)	Production (t)	Productivity (t/ha)
Apple	11165.9	5599.7	43502.1	7.1
Walnut	4396.5	3386	34151.9	10.1
Pears	2426.3	1944.3	13318.6	6.9
Peach	1770.2	1413.1	10508.3	7.3
Plum	1980.2	1502.6	10488.2	7
Hogplum	451.8	311	2401.3	7.7
Persimmon	403	294.3	2735.1	9.3
Apricot	596.1	461.1	2842.6	6.2
Pomegranate	283	52.2	368.1	7
Total	27124.8	16849.5	128155.1	7.6

Source: MoAD 2015.

Table 20. Export in 2014/15

Commodity	Country	Export quantity (kg)	Amount in NRs
Apple Fresh	India	16670	278000
Pear and Quinces	India	39944	430000
Fresh Grape	India	1100	39000
Fresh Apricot	China	3450	239500
Cherries	China	10927	295673
Peaches including nectarine	Imdia	3000	48000
Plums and Sloes	India	350	5600
Strawberries	India	766	54200
Dried Apricots	China	3529	748514
Dried apple	China	375	26550
Total		80111	**2165037**

Source: MoAD 2015.

Table 21. Import in 2014/15

Commodity	Country	Import quantity (kg)	Amount in NRs
Almond in shell and shelled	China, India, USA	316226	188186196
Walnut in shell and shelled	China, India	219335	23299383
Chestnut in shell and shelled	India, China, USA	728	136668
Pestachios, inshell and shelled	China, India	16433	8662064
Figs	India, UAE	29175	5193569
Fresh Grape	India	11143112	597513733
Grapes Dried	China, Thailand, India	316152	43542521
Apple Fresh	China, India, USA, New Zealand	46970288	1982955170
Pear	China, India	184589	6579140
Peaches including nectarine	China, India	15063	759567
Fresh Apricot	India	77542	8043960
Sour Cherry	India	1712	48040
Cherries	Thailand, India	1435	93603
Plums and Sloes	Thailand, India	40868	755051
Strawberries	Thailand, India	105	10414
Kiwi Fruit	India	2955	49800
Rasp berries, blackberries, mulberries	India	30	8880
Dry Apricots	India	4757	699356
Prunes	Thailand, India	274	193960
Dried Apple	China	195	41822
Total		59340974	286677897

Source: MoAD 2015.

OPPORTUNITIES AND THREAT FOR THE PROMOTION OF TEMPERATE FRUIT PRODUCTION

Huge opportunities exists in the country for the promotion of the temperate fruits, these are:

- Commercial scale orchards of temperate fruits in Hills and mountains are very few and land is available for the expansion of temperate fruit for cultivation
- At present scenario the expanding south-north road networking has given a great possibility for the possibility of expansion of temperate fruit production and fruit-based industries in those ecological belts
- Comparative advantages of temperate fruits are far better than other cereal crops under cultivation in Hills and mountains
- Existence of Horticulture Farms/ Research/Stations for R&D and technical support

Despite of these potentials and opportunities following threats cannot be ignored:

- Climate change and adverse climatic conditions like sudden temperature rise and fall; long time dry condition, hail storms
- Spread of insects pests and diseases
- Fast rate of deforestation due to link roads to village areas, uncontrolled animal grazing and unorganized rural settlement, the threat of eroding local germplasm has been increased

PROSPECTS OF GERMPLASM CONSERVATION

International and national policies and convention have emphasized on the genetic resource conservation which has opened a good prospects towards conservation of genetic resources. The government farms and research stations have already done great efforts in their collection, maintenance, evaluation and utilization in different time periods. The establishment of National Genetic Resource Centre (Genebank) and Non-government organizations like LIBIRD, CEAPRED have also initiated such type of conservation of diversity and utilization through home gardening and biodiversity program which has created awareness among the farmers.

MAJOR GAPS

Gap in Knowledge and Information

Knowledge and information on genetic diversity of temperate fruit is poor in terms of their exploration, inventory, documentation and sharing of the information to the relevant institutions.

Gap in Institutions and Human Resource Capacity

There are number of horticulture farms, research stations and agricultural campuses, their capacity in terms of land availability, laboratory facility, reference materials and documentation is poor. With respect to the human resources, it is very poor in terms of their visioning and technical capacity to undertake biodiversity conservation activities.

Gap in Prioritization of Biodiversity Conservation Program of Temperate Fruits

Priority has not been accorded as per present time, needs to address the food security, stress of climate change and income generation of people with a view of sustainable development.

Gap in Coordination and Facilitation

Coordination and facilitation is very weak among the different institutions involved directly or indirectly in genetic resource management. In case of temperate fruits, there are 9 farms stations under department of agriculture and only one research station under NARC. No or very weak coordination and facilitation exist among them.

CONCLUSION

The importance of the indigenous and exotic diversity of temperate fruit has been realized for the sustainable development as well as for commercial production. The establishment of government farm stations and research stations; national genetic resource center and their functional activities have shown the impact on recommendation for commercial temperate fruit production and production areas expansion and productivity increment. Commercialization of temperate fruits is very much limited in terms of crops and their varieties and scale of production is very small to address the demand of the country. The trade balance is very negative showing more dependency on the import of temperate fruits. Market oriented production for fresh and processed market through product diversification is very much needed to address the import substitution of temperate fruits. Problem of improved technology and technological service support is also not adequate keeping in view all these, more germplasm of temperate fruits need to be identified for collection particularly for high yield, quality, resistance to diseases and pests, tolerance to climate change stress. Those collected should be systematically characterized, evaluated and utilized as per their full potential without delay.

WAY FORWARD

Knowledge and Information

Exploration and preparing inventory and documentation should be done together with sharing of the information to the relevant institutions.

Institutions and Human Resource Capacity

Horticulture farms and research stations should be strengthened to enhance their capacity in terms of allocating proper field genebank (land area and tree number); at least fruit laboratory facility and facilitation for reference materials collection and documentation. Human resource should be trained to handle properly the activities related germplasm collection, maintenance record keeping, documentation and reporting. Techno-guide for the human resources should be availed and time to time technical backstopping should be provided them with incentive package for their motivation.

Prioritization of Biodiversity Conservation Program of Temperate Fruits

Priority has to be given for the biodiversity conservation focused program. Program should be in whole sole package and with coordinated program budget. Indigenous species should be given equal importance as the exotic ones in the program. Need based research programs should be designed and conducted for variety development and registration/release; technology generation and technology refinement on cultural practices, postharvest management and value addition to capture the potential of the germplasm/variety developed looking their level of utilization at present level. In-situ conservation and survey activity should also be conducted in collaboration with forest institutes, conservation parks and local governments/communities

Coordination and Facilitation

Common understanding among the actors related to genetic resource management institutes and their institution heads should be made. Coordination program at least establishing focal person, joint monitoring of the program and sharing workshop should be made to establish good coordination and facilitation.

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Annex 1. Description of some varietal characters

SN	Fruit crop	Variety and varietal characters
1	Apple	**Red Delicious**: Trees are vigorous; fruits are oblong to conical; calyx end prominently lobed and red stripped over yellow; dark red color; flavor is sweet and mild; firm texture; maturity mid to late; biennial bearing and self unfruitful.
		Royal Delicious: Trees are vigorous; fruits are oblong to conical and darl; red striped; firm texture, mid season, and self unfruitful.
		Rich-a-red Delicious: Trees are vigorous; fruits are oblong to conical with prominent lobes, red blush over texture.
		Golden Delicious: One of the most popular varieties in the world; developed in Virginia, USA in 1914; trees are vigorous; roundish oblong fruit; greenish yellow to golden yellow in color; regular size and color; very sweet; excellent for both culinary and dessert purpose than other varieties because of the moisture loss through fruit epidermis which does not have a heavy waxy coating; late season maturity; a good pollinator.
		Red Gold: Trees are medium in vigor; fruits are round to slightly oblong; medium in size; dark to dull red in color; early to mid season maturity; very good pollinizer.
		McIntosh: Trees are very vigorous; hardy; annual bearing but very susceptible to apple scab; sometimes fruit matures too early with poor color and poor flesh quality; fruit is crisp and juicy with excellent flavor; tendency to fruit drop prior to full maturity.
		Jonathan: Trees are vigorous, precocious, hardy and productive but very susceptible to fireblight and powdery mildew; fruit is bright red, medium to small in size; flesh is firm with a tart flavor; excellent quality.
		Anna: Originated in Israel; trees are medium in vigor; low- chilling variety (CH 150-200 hours); fruits are relatively large with a light greenish-yellow skin; slight red blush; oblong to conical with smooth calyx end; fairly sweet and sour in taste early season maturity and self-fruitful but better production if pollinated by Dorsett Golden; ready for harvest from mid June to mid July with average yield of 11.7 kg per tree; suitable for 1500-2000 masl (warm temperate) conditions of Nepal.
		Veered: Originated in Israel; trees are medium in vigor; low- chilling variety (CH 150-200 hours); fruits are relatively large with a light greenish-yellow skin; slight red blush; oblong to conical with smooth calyx end; fairly sweet and sour in taste early season maturity and self-fruitful but better production if pollinated by Dorsett Golden; ready for harvest from mid June to mid July with average yield of 11.7 kg per tree; suitable for 1500-2000 masl (warm temperate) conditions of Nepal.
		Crispin (Mutsu) : Developed in Japan in 1930s; a cross between Golden Delicious x Indo; vigorous and reliable tree; maturing after Golden Delicious; fruit is very large, round, yellow fruit with crunchy flesh; good juice and tartness; stores well; flesh is firm and of excellent quality; being a triploid do not act as a pollinizer for other varieties; resistant to powdery mildew but susceptible to scab, blister spot, bitter pit; CH-600 hours.
		Red Fuji: Early ripening; blush and stripe pattern over 80% to 95% of surface of the fruits; tree is identical to standard Fuji.
		Gala: A complex cross between 'Golden Delicious' and 'Golden Delicious' x 'Cox's Orange Pippin' (New Zealand, 1970s); trees are vigorous; semi spur type; precocious and regular bearer; dessert type; fruits are medium in size and oval to globose in shape; red striping on golden skin which gives the fruit a red-orange color; flesh is crisp, aromatic with excellent quality; nice blend of sweetness and tartness; rich in flavor; fine-textured; yellow-white flesh; early harvest; shows some self-fertile but should be pollinated with other varieties with similar chilling requirements; susceptible to fire blight and moderately susceptible to other common apple diseases; ripens about 140-160 days from bloom and requires at least 550-600 CH units.
		Fuji: Developed in Japan by crossing Ralls Janet x Red Delicious; somewhat bushy tree; medium to high vigor and develops good spurs; requires 140-160 days from bloom to harvest; high quality apple; medium sized fruit; yellow-green skin with orange to red stripes; crisp; juicy; white flesh; mid in maturity; susceptible to bitter pit rot and red mites.
		Red Fuji: Early ripening; blush and stripe pattern over 80% to 95% of surface of the fruits; tree is identical to standard Fuji.
		King of Pippin: Developed in UK; suitable for more northerly areas with higher rainfall.
		Grannysmith: Originated in Australia in 1868; highly productive; trees are moderately vigorous; fruit is green, large, firm and of excellent quality; roundish globose to slightly conical in shape; calyx end smooth; bright green in color and sometimes slight yellow tinge appears upon the green blush; a very late variety; pollinizer to other varieties.
2	Pear	**Hosui**: Originated at the National Horticulture Research Station,Tsukuba, Japan after complex cross (Kikusui x Yakumo) x Yakumo in 1954; selected in 1963; medium to large tree; vigorous growth habit; fruits are large (300 - 350 g), globose to oblate shape; skin russeted; golden to goldbrown; enlarged

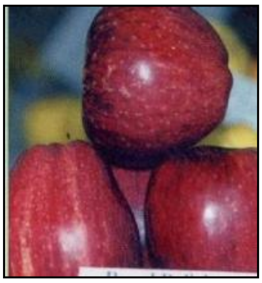
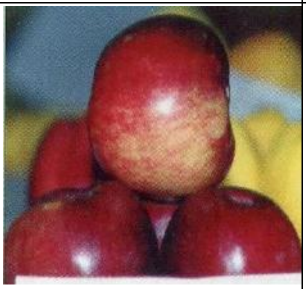
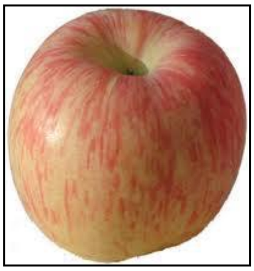
		lenticels; one of the most flavourfull of the Asian pears; flesh off white; sweet; mild; crisp; juicy; finer texture and higher fruit quality than Chojuro; productive; resistant to *Alternaria* black spot; CH-400 hours.
		Chojuro: Originated in Kawasaki, Japan in 1895; chance seedling of *Pyrus pyrifolia;* medium vigour; spreading trees; fruits are medium in size, oblate shape; skin thick; russeted; green to orange-brown; flesh white; mildly sweet and bland; firm; coarse; distinctive aroma; high sugar content; high productivity and resistance to black spot *(Alternaria kikuchianu*); mid season; self-fertile.
		Kosui: Originated at the Natl. Hort. Res. Sta., Tsukuba, Japan in 1941 and released in 1959; cross between Kikusui × Wasekozo; medium size trees with vigorous growth habit; high-quality fruits; early ripening (2 weeks before Hosui and Chojuro); fruit medium size; skin mostly russeted ; yellow to golden brown; crispy; juicy; very sweet; resistant to black spot; moderately resistant to scab.
		Sinko: Excellent quality fruit; juicy; sweet flavor and very crispy; late season; needs pollinizer.
		Kikisui: Tree medium size; slightly drooping limbs and dense; fruit medium to large, somewhat lopsided; yellowish-green; flesh is sweet and mild; firm and juicy; mid season; self fertile.
		Nijisseiki: A mutation of Nijisseiki; resistant to black spot disease; developed at Institute of Radiation Breeding at the National Institute of Agro-biological Resources, Japan from gamma-irradiated buds of Nijisseiki; similar in habit, flowering season and fruit characteristics to Nijisseiki except fruit ripens a few days later and resistant to Japanese pear pathotype *of Alternaria alternate* but not as resistant as Chojuro
		Pharping: Local pear; round in shape; medium to large in size; skin dark brown with prominent lenticels; flesh hard (6-8kg/cm2), juicy and sweet(11^0-13^0brix), gritty; self fruitful; ripens on October and is a late variety, keeping quality better.
		Bartlette: The leading pear variety both commercially and for home garden; trees are vigorous; compact upright growth habit; fruits are large, smooth, attractive, golden-yellow, slightly blushed with red, oblong to obtuse pyriform with a prominent neck making the fruit bell shaped; an outstanding canning variety; flesh is tender and juicy, buttery and of excellent dessert quality; does not cross pollinize with Seckel; mid season maturity; needs pollinizer.
		Red Barlette: Trees are medium in vigor; large fruits; dark red maroon in colour over light green yellow ground; mid season maturity.
3	Persimmon	**Fuyu**: Most popular non-astringent variety; flesh is sweet; fruit is smaller than Hachiya.
		Motsumatowaswe Fuyu: Flat, orange fruit; fairly large; very good quality; very good production on a vigorous spreading tree; non-astringent.
		Hiratanenashi: Flat, seedless and very sweet; top quality; vigorous spreading tree; astringent.
		Hachiya: Popular market variety; very large with orange-red skin with sweet, astringent until soft.
4	Peach	**Orion**: Early variety, small to medium in size; globose in shape; skin 75% dull ,dark-red on light green ground color; flesh light green, firm, clingstone, juicy and sweet in taste; self fruitful ; low chilling cultivar; ripening on first week of May.
		Springtime: Early variety medium in size; round in shape; skin red blush on yellowish ground colour; flesh whitish, firm, semi free stone juicy & sweet; self fruitful; low chilling cultivar; ripening on mid May.
		Peregrine: Late variety; the fruit large in size; round in shape; skin brilliant crimson; flesh juicy, sweet and fine flavored; a high chilling cultivar and ripens in mid July.
		Elberta: Late variety; the fruits are large; free stone; deep golden yellow color; yellow flesh; famous for its outstanding shipping qualities; an excellent pollinizer; mid season; self-fertile.
5	Plum	**Methley**: Trees are medium to vigorous; fruits are small to medium in size with roundish heart shape; reddish purple maroon skin with dark red flesh; good pollinizer; very early season maturity; self-fruitful and readily pollinate other plums; CH-250 hours.
		Green Gauze: Small to medium sized fruits; greenish-yellow plum; very sweet for eating, canning, freezing or making jam or preserves; mid season; self -fertile; low chilling requirement.
		Santarosa: One of the largest and most beautiful of the Japanese plums; trees are large, vigorous and upright growth habit; fruits are large in size, round to oblong conic shape with a slight beak like tapering at the base; purplish plum with amber colored flesh; good pollinizer and early to mid season maturity; self-fertile; low chilling requirement.
6	Apricot	**Tilton**: Fine-flavored; excellent canning apricot; fruits are medium to small in size; golden-yellow with dark red blush color; resistant to brown rot and sunburn; ripens mid to late; self fertile; good pollinizer.
		Kaisha: Trees are vigorous and spreading; medium sized fruit with roundish flattened shape and prominent suture; skin pale lemon yellow with red blush; free stone; early season maturity.
		Blenheim: Fruits are medium size; oval; deep yellow; an outstanding variety for eating as well as very good for canning; pollinizer; low chilling requirement; early to mid season.
		Sakarpara: Fruits are sweet with pleasant aroma; medium in size; round in shape; skin is glossy; creamish yellow with rosy blush; pulp soft; light yellow in color; sweet and less acidic and pleasant

		flavor.
7	Almond	**IXL**: Trees are spreading and intermediate in vigor; mid season blooming but mid to late season maturity; nuts are medium; bold, brown in color; medium kernel; soft shelled.
		Thin Shell: Non-Pareil: Trees are moderately vigorous; upright to spreading; mid blooming; early maturity; nuts are medium, flat shape, smooth surface, bold and light brown in color; thin and soft shell; easily blanched; smooth kernel; high suture opening.
		Neplus Ultra: Originated in France in 1879; used for pollination of Non Pareil; early bloom; blooms 5-7 days before Non Pareil but mid season maturity and harvest 14 days after Non Pareil; trees are vigorous and spreading, somewhat willowy growth habit; nuts are medium to large sized, flattened, bold and light brown in cooler; moderate bearing habit; sometimes showing precocious bearing on long, previous season's shoots followed by heavy spur production.
		Shalimar Texas (Mission): Have a rich flavor; kernels are small, wide and often plump; kernel skin is normally darker than Non Pareil and wrinkled; shell is hard and good shell integrity; no suture opening; short wide shape; dark brown; deeply wrinkled surface.
8	Pecanut	**Mahan**: Nut: oblong, with acute apex and base; nut often asymmetric, appearing 'pinched' in middle due to flattening of abaxial and adaxial surfaces; flattened in cross section; 32 nuts/lb, 58% kernel; kernels with deep secondary dorsal grooves and basal cleft, often poorly filled to base, woody in texture. Mid- to late-season pollen shed, with early to mid season receptivity. Very precocious and prolific, with a strong tendency to overbear as a mature tree. Ripens late, about 12 days after 'Stuart'. Very susceptible to scab.
		Mohawk: Released in 1965. Nut: oblong with obtuse apex and base; slightly flattened in cross section; shell rough, dark striped; 32 nuts/lb, 59% kernel; kernels golden to light brown in color with narrow dorsal grooves when well-filled. Protogynous, with mid season pollen shed and early to mid season pistillate receptivity. Very precocious and prolific with a tendency to alternate bear on mature trees. Freeze susceptible, especially after large crop. Ripens mid season, about 9 days before 'Stuart'. Susceptible to scab.
		Wichita: Released in 1959. Nut: oblong, with acute to acuminate, asymmetric apex and rounded apiculate base; round in cross section; 43 nuts/lb, 62% kernel; kernels golden to light brown in color with narrow dorsal grooves and a wide, shallow basal cleft. Protogynous, with mid season pollen shed and early to mid season receptivity. Precocious and prolific. Ripens in mid season, with 'Western', 4 to 20 days before 'Stuart', depending on location. Tree moderately upright, vigorous, often with a late flush of growth. Very susceptible to scab.
		Desirable: Nut elliptic with obtuse apex and obtuse to rounded base; round in cross section; shell rough, with elevated suture; 38 nuts/lb, 54% kernel; kernels golden in color, with wide dorsal grooves. Protandrous, with abundant early pollen shed and mid- to late- season pistillate receptivity. Bears in about 6 years and makes consistent, moderate production of high quality nuts, due in part to self-thinning fruit drop that reduces the number of nuts per cluster. Ripens in late mid season, shortly after 'Stuart'. Susceptible to scab.
		Stuart: Nut: oblong elliptic with obtuse apex and rounded base; round in cross section; dark stripes on shell; 51 nuts/lb, 49% kernel; kernels golden to light brown in color with wide, shallow dorsal grooves, deep secondary dorsal grooves and a pronounced basal cleft. Protogynous with late pollen shed and mid season pistillate receptivity. Resistant to scab. Susceptible to downy spot, black pecan aphids, and yellow aphids. Late to begin growth in spring.
9	Walnut	**Franquette**: Vigorous large tree; Terminal bearing, fair yield; nut weight 11g.kenelweight 5.5 g and kernel percent 50 % ; Medium-thin shell with good seal; Good quality, light & extra light color; late harvest, primarily used as pollenizer for Chandler & Hartley.
		Hartley: Large tree; Terminal bearing, moderate yield; distinct triangular shape nut, nut weight 14.3g.kernel weight 6.5 g and kernel percent 45 % ;often no pollinizer used.
		Ashley: Moderate, upright tree, precocious ; lateral bearing, moderate yield; nut weight 12.9g kenelweight 6.4g and kernel percent 50% ; good quality, and light color and easy removal; early harvest, very susceptible to blight pollinizer Hartley.
10	Pomegra nate	**Ganesh**: A selection from open pollinated seedlings of Alandi; a prolific bearer; fruit very large, pinkish yellow to reddish yellow rind; pinkish aril; turn whitish during warmer months; soft seeded variety.
		Mridula: A cross between Ganesh x Gulshah Rose Pink; arils are blood red in color and rind is red; soft seeded variety; has all the characters of the Ganesh except the arils are dark red in color; average fruit weight is 250-300 g.
		Kandhari: Fruits are large; rind deep red; fleshy testa; blood red or deep pink; seeds hard; slightly acidic juice.
		Bedana: Fruits medium to large in size; fleshy testa; blood red or deep pink with sweet; slightly acidic seeds and are very hard.
11	Kiwi	**Abbot**: Early season (blossom and maturity); pistillate; mediumsize fruits (45-60 g); skin covered with

		dense hairs; slightly tapering at distal end in comparison to peduncle attachment; light green outer pericarp and locule; no reddish color in locule; transverse elliptic shape of core in cross section; white core; elliptical fruit shape; oblate shape in cross section; stylar end rounded; strong slope of shoulder at stalk end; no pointed protrusion; calyx ring medium; medium hairs in skin; brown hairs and light green skin.
		Allision: Both male and female flowers are present; good pollinizer; profuse bearer; heavy fruiting; maturity period is similar to Hayward (round); light green outer pericarp and locule; no reddish color in locule; circular and oblate shape of core in cross section; white core; oblong fruit; oblate shape in cross section; rounded stylar end; truncate shoulder at stalk end; no pointed protrusion; medium calyx ring; brown hairs with light green skin colour; fruits are slightly longer and broader than Abbot; slightly tapering at both ends; average fruit weight is 70g.
		Bruno: Good fruit bearing tress; purely pistillate; green fleshed; oblong shape and medium sized (63.9 ±12.4 g); high keeping quality (about 3 months in room temperature); matures in 2nd week of Kartik (first week of November) at Mid Hill conditions of Nepal; earliest in maturity among green fleshed varieties; fruits have brown hairs on the skin; light green outer pericarp and locule; no reddish color in locule; oblate shape of core in cross section; white core; oblong and obovate fruit shape; transverse elliptical in cross section; round stylar end; weakly sloping shoulder at stalk end; no pointed protrusion; strong calyx ring; skin hairy and densely present; brown hairs with light green skin; low chilling requirement.
		Hayward: Purely pistillate variety; large fruit; superior in flavor; light green outer pericarp and locule; no reddish color in locule; oblate and transverse elliptic core in cross section; white core; oblong and ovovate fruit shape; ovate and transverse elliptic shape in cross section; flat stylar end; weekly sloping shoulder at stalk end; no pointed protrusion; medium calyx ring; dense and brown hairs on light green skin; very good keeping quality.
		Monty: Light green outer pericarp and locule; no reddish colour in locule; oblate core in cross section; white core; oblong fruit shape; oblate and transverse elliptic fruit cross section; rounded stylar end; truncate shape of shoulder at stalk end; no pointed protrusion; medium calyx ring; medium brown hairs on skin with greenish brown skin; late in flowering but short maturity period; purely pistillate variety; prolific bearing habit.
		Soyou (Red Kiwi): Color of outer pericarp is cream; red locule; medium intensity of reddish color in locule; transverse elliptical core in cross section; white core; oblong and circular fruit shape; oblate in cross section; weakly depressed stylar end; truncate shoulder at stalk end; no pointed protrusion; medium calyx ring; no hair on light green skin. Soyou is red fleshed early variety maturing from third week of Bhadra and can fetch better price during Dashain and Tihar (Dipawali) festivals. It requires less chilling hours and does not have hairs on the fruit skin. Fruits are small in size (39.3 ±9.6g). It can be stored in room temperature for about one month.
12	Grape	**Himrod Seedless**: It is a cross of Thompson seedless x Ontari (European × American); Vine medium, berry small, berry 3g, color white, bunch weight 250gm, brix 16^0, suitable for telephone or Kniffin system; harvesting time is May.
		Kyoho: Vine large, vigorous, berry obovate large, black, bunch weight 500g, berry weight 12g, Brix 16^0, suitable for Bower system; harvesting time July.
		Steuben: Vine medium; berry small, color black, berry weight 3g; bunch weight 300g;Brix 18^0, suitable for pole & Telephone system; harvesting time June.
		Delaware: Vine medium, berry very small, berry weight 2g,color purple,bunch weight 200g;brix 18^0,suitable for pole or telephone system; harvesting time June.
		Pione Selection: Vine medium, berry large, berry 42g,color bright red bunch weight 400g; brix 20^0, suitable for flat system; harvesting time beginning of August.
13	Olive	**Leccino**: Large tree with drooping type of branches; regular bearer and good for oil and pickling.
		Frantoio: Good for oil production; tree growth medium and drooping type of branches; regular bearer and fruit yield is high good; self pollinated variety.
		Coratina: Good for oil production; tree growth medium and spreading type of branches; regular bearer and fruit and oil yield is high.
		Pendolino: It is an early variety and bears fruit early; branches dense and drooping type and growth is medium; regular bearer and fruit yield is high but oil yield is low; it is a pollinizer variety.
		Pecual: It is a early variety and bears fruit early in third year; spreading type of tree and growth is medium; regular bearer and fruit yield is high.
		Bosana: It is a late variety; spreading type of tree and growth is medium; late in bearing ; shows alternate bearing; can tolerate drought to some extent and can tolerate leaf spot disease; yield of fruit and oil is good.

Annex 2. Some temperate fruit species and cultivars

Apple

 Red Delicious	 Royal Delicious	 Richard Deliciou	 Golden Delicious
 Mclontosh	 Fuji	 Red Gold	 Anna
 Cox Orange Pippin	 Red Chief	 Vance Delicious	 Red Spur
 Edimayal: Flowering	 Edimayal: fruiting	 Edimayal Seeds	

Pear

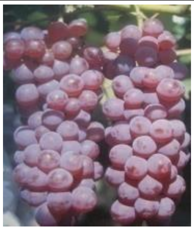
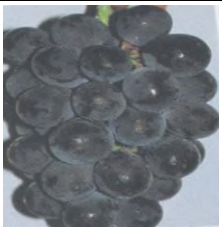
 Pharping	 Local Green	 Hosui	 Kosui

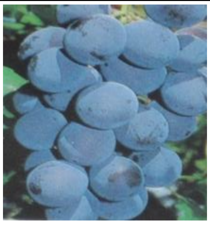
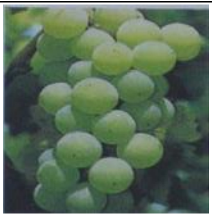
 Chojuro	 Shinko	 Waseko	 Golden Nijiseiki
 Yakumo	 Kikisui	 Okusankichi	 Atago
 Bartlette	 Red Bartlette	 Havana	 Anju

Persimmon

 Jiro	 Fuyu	 Maekawa Jiro	 Mastumotowase Fuyu
 Zinjimaru	 Hiratanenasi	 Local	 Ubeni

Grape

 Himrod Seedless	 Buffalo	 Delaware	 Kyoho

 Banana	 Seon	 Cambell Early	 Muscat Bailey A
 Peon Selection	 Black Olympia	 Ostubu Nayagara	

Olive

 Bosana	 Ascolana	 Coratina
 Pendolini	 Frantioi	 Leccino

Kiwi

 Mastuwa	 Bruno	 Allison

 Hayward	 Soyou (Red kiwi)	 Abbott

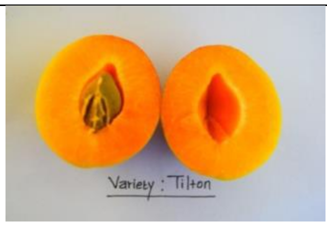
Pomegramate

 Mridula	 Kandhari	 Bedana

Other Temperate Fruits

 Sweet Cherry	 Fig	 Rasp Berry
 Blue Berry	 Blackcurrant	 Black Berry

 Walnut	 Pecanut	 Almond	 Hazelnut

 Rasp Berry	 Apricot:Tilton	 Apricot: Bleinhim	 wild Apricot: Flowering
 Wild Apricot Fruit	 Wild Apricot Fruit: Ripe	 Peach	 Plum: Methley

Diversity and Utilization Status of Spice Crops in Nepal

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ABSTRACT

Spices are natural products of plant origin, used primarily for flavoring, seasoning or adding pungency and flavor to foods and beverages. Of the 109 spices listed by the International Standard Organization (ISO), India grows 52 spices and in Nepal near 21 spices are under naturally grown in-situ*,* back yard or in commercial cultivated conditions. In Nepal, spices are grown in 81807 ha (1.7%) of the total cropped area (4,699,479 ha). Of the major spices, ginger is grown in 21451 ha (26.2%) followed by onion (25.3%), large cardamom (15.2%), chilies (11.2%), turmeric (9.6%), garlic (8.7%) and coriander (2.2%). By monitory export value cardamom and ginger are the most important exportable spices that have been significantly contributing to national AGDP. Nepal is the third largest ginger producer in the world with the productivity of 12t/ha. There are many location specific ginger cultivars with high diversity in rhizome size (small, bold and extra bold), essential oil (0.9-2.2%), oleoresin (2.57-6.21%) and fiber content (4.4–8.5%). Two varieties of ginger 'Kapurkot Aduwa-1' and 'Kapurkot Aduwa-2' developed through selection breeding are released. Ginger cultivars, representing 25 major ginger producing districts, have been conserved at the Ginger Research Program (GRP), Kapurkot, Salyan in collaboration with National Agricultural Genetic Resources Center (NAGRC), Khumaltar, that could be utilized for further genetic improvement. Rhizome rot disease is the major biotic constraint in production. Several cultivars of large cardamom ie Ramshai, Dambarshai, Golshai, Saune, Chibeshai, Kantishai and Jirmale (local) are commercially grown under Mid Hills conditions ranging from 700 to 1600 masl. Average productivity of these genotypes is low (410 kg/ha) because of biotic factors particularly diseases, soil moisture stress and poor crop management. Despite of being a spice crop, in Nepal onion (*Allium cepa* L.) is considered as vegetable crop. Onion is grown commercially in 20,712 ha. There are three sub species *Allium ampeloprasum* L. (*Chhyapi*), *Allium cepa var. aggregatum* G.Don (shallot) and *Allium hypsistum* Stearn (*Jimbu*) which are still conserved under in-situ conditions at Mid and High Hill. There is high genetic diversity in chillies known in Nepali as *Jire Khursani, Bhende Khursani* and *Akabare Khursani*. Of them Akabare (round fruit shape) is famous for its high quality capsaicin and medicinal value, widely cultivated in eastern and central Hills. Research on turmeric has been initiated and single variety 'Kapurkot Haledo-1' released for commercial cultivation. Several local cultivars of turmeric has been maintained and being evaluated at GRP Salyan. *Zanthoxylem* (*Timur*) and cinnamon (*Dalchini*) at Mid Hill, saffron (K*esar*) and asafetida (*Hing*) at High Hill are the important Nepalese indigenous spices require conservation and utilization for commercial cultivation. This paper briefly highlights on the conservation and utilization status of the major spices of Nepal that are under in-situ or in cultivation.

Keywords: Akabare, cardamom, chilly, essential oil, ginger, jimbu, oleoresin, spices, timur

INTRODUCTION

International Standard Organizations (ISO) has defined spices as "Any of the aromatic vegetable products used in cooking, seasoning and preserving the foods". In a simple definition "Spices are natural products of plant origin, used primarily for flavoring, seasoning or adding pungency and flavor to foods and beverages (Ferrel 1985). Dry parts of aromatic plants such as root (sweet flag), bark (cinnamon), rhizome (ginger/turmeric), leaf (mint), berry (black pepper), flower bud (clove), stigma (saffron), fruit (Nutmeg), seed (cumin) and resinous exudates (asafetida) are the representative examples and have been considered as spices in the international spice trade. Majority of spices are grown in tropical to sub-tropical but some spices (saffron, black cumin and *Jimmu*) are grown in temperate climates. Hence almost all countries produce one or more spices and herbs. Of the 109 spices listed by the ISO, India grows 52 spices (Ravindran 2006) and about 30 spices are used in Nepal (Sharma 2013). Nepalese people use many indigenous and imported spices on daily basis or at week intervals or at special social functions.

It was Captain Vasko de Gama, the first discover and spreader of spices from India to other countries (2003a). Spices are used in various forms and ways, pickles (peppers, garlic, ginger, chilies), as preservatives (clove, black pepper, mustard seeds/powder), coloring (turmeric, chilly, saffron), spice oils (ginger oils) for the preparation of soft drinks and the oleoresins obtained from black pepper, ginger, capsicum, turmeric, fenugreek and cardamom are used for pungency, flavor and aroma in meat and food processing industries.

The intrinsic quality of spices and herbs varies with variety, location, time and stages of harvest, processing methods, etc. The main flavoring effect in many spices is pungency.

Several valuable pigments are found in spices. These pigments are extracted and used as natural colorants in the food industry. Some of the spices, which yield color pigments, are turmeric, paprika and saffron. In paprika carotenoids such as beta-carotene, capsantin, capsorubin and lutein provide reddish orange, dark red, purple red and red color respectively. Orange yellow color in turmeric is due to curcumin. Crocin in saffron makes its color yellowish orange.

Spices have innumerable medicinal properties (Singh 2003a) and are used in substantial quantity in pharmaceutical industries for various medicinal preparations in Ayurbeda, Unani, Sidha and Homeopathic systems of medicine (Pruthi 2006). Cardamom contains 2.7 to 3.6% volatile oil and oleoresin 6 to 7%. Essential oil possesses medicinal properties like carminative, stomachache, diuretic and cardiac stimulant, etc. Dried ginger contents 2-4% oil and 6-9% oleoresin and many antibiotic and antifungal properties. It is the main constituent in most of the Aaurvedic medicines (Sharma and Shrestha 2002). About thirty spices have been used in Nepal. Some of them are imported from India and overseas countries and most of them are cultivated or available under in-situ conditions of Nepal.

RESEARCH AND DEVELOPMENT ACTORS

There are two farms working with Cardamom in Nepal. Cardamom Development Center, Fikkal, Ilam under DoA, that works in promotion of healthy seedlings and Agriculture Research Station (ARS), Pakhribas, Dhankuta under NARC that basically mandated for research and development of large cardamom, identifying problems and constraints in production and processing. It is also responsible to develop technology for high productivity by minimizing biotic and abiotic constraints and develop good drying and processing technologies in the country. Spice Crops Development Center at Panchkhal, Kavrepalanchok district take care other spices for germplasm collection, maintenance and to develop production technologies. At the center level for policy and program planning on spices National Spice Crops Development Program (NSCDP) is also functioning at Khumaltar under Department of Agriculture. There is separate National Ginger Research Programme (NGRP) at Kapurkot, Salyan under Nepal Agricultural Research Council (NARC). Agriculture Development Offices in each district are also implementing ginger and cardamom related income generation activities. Ginger and Large Cardamom spices are the identified potential export sectors in the Nepal Trade Integration Strategy (MoC 2016).

Apart from Govt. organizations, several Govt. lead projects as High Value Agriculture Project (HVAP), Raising Incomes of Small and Medium Farmers Project (RISMFP) and High Mountain Agri-business and Livelihood Improvement (HIMALI) Project are also supporting farmers to increase their income through the production of ginger, turmeric and saffron at Mid Western and Far Western region of Nepal. Based on Govt. priority INGOs like Samarth-NMDP, Mercy Corps, UNNATI-Inclusive Growth Program are also supporting ginger crop production activities to uplift the farmer's livelihoods.

AREA PRODUCTION AND PRODUCTIVITY STATUS OF SPICES

Spice crops are the low volume high value crops. Volume wise, we use very low amount of spices in our daily foods which provides high calories and health care. Despite of high calorie and medicinal value cultivation of spices is very limited to 81807 ha (1.7%) of the total cropped area (4699479 ha) in the country (**Table** 1). Consumption of spices is increasing with population and improvement of livelihoods and well being of the people. Nepal imports worth of NRs 1,41,89,22,174 and also exports few spices mainly cardamom and ginger (TEPC 2008). Export value of spices is not consistent over the years because of fluctuation in demand of global spice trade.

Table 1. Share of cultivation area and production of spices to the total cropped area in the country during 2014/15

Crops	Area (ha)	Production (t)	Productivity (kg/ha)	% area of total crops
Food crops	3377036	9266240	2.74	72.0
Pulses	326400	353500	1.08	7.0
Vegetables	463974	6166372	13.27	9.9
Fruits crops	110802	992703	8.96	2.4
Spice crops	81807	736489	7.98	1.7
Cash crops	310128	3287523	10.65	6.6

Tea and Coffee	21652	21858	1.30	0.5
Total	4699479	20864857		100

Source: MoAD 2015a

SPICES UNDER IN-SITU, BACK YARD AND COMMERCIAL CULTIVATION

Nepal has the highly diversified agro-climates within the short aerial distance. Different micro climates are available to grow several species of spices. 21 spices crops are domesticated but few of them are being grown commercially and few are confined to kitchen garden or surviving under in-situ conditions (**Table** 2). Unlike cereals and pulses, different plant parts are used as spices.

Table 2. List of spices under in-situ, back yard or in commercial cultivation in Nepal

SN	English name	Nepali name	Scientific name	Plant parts used
1.	Bishop's weed	Jwano	Trachyspermum ammi (L.) Sprague	Seeds
2.	Black cumin	Himali Jeera	Bunium persicum (Boiss.) B.Fedtsch.	Seeds
3.	Black pepper	Marich	Piper nigrum L.	Fruit
4.	Caraway	Himali sonf	Carum carvi L.	Seeds
5.	Cardamom (L)	Alainchi	Amomum subulatum Roxb.	Fruits and seeds
6.	Chilly	Khursani	Capsicum frutescens L.	Fruits
7.	Cinnamon	Dalchini	Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Leaves and barks
8.	Coriander	Dhaniya	Coriandrum sativum L.	Leaves and seeds
9.	Cumin	Jeera	Cuminum cyminum L.	Seeds
10.	Fennel	Sonf	Foeniculum vulgare Mill.	Seeds
11.	Fenugreek	Methi	Trigonella foenum-graecum L.	Seeds
12.	Garlic	Lasun	Allium sativum L.	Bulbs
13.	Ginger	Aduwa	Zingiber officinale Roscoe	Rhizomes
14.	Jimbu	Jimbu	Allium hypsistum Stearn	Leaves
15.	Leek	Chhyapi	Allium ampeloprasum var. porrum (L.) J.Gay	Leaves and bulbs
16.	Mint	Pudina	Mentha spicata L.	Leaves
17.	Nepal pepper	Timur	Zanthoxylum armatum DC.	Fruit
18.	Onion	Pyaj	Allium cepa L.	Bulbs
19.	Saffron	Kesar	Crocus sativus L.	Stigma
20.	Shallot	Chyaapi	Allium cepa var. aggregatum G.Don	Leaf and bulbs
21.	Turmeric	Besar	Curcuma longa L.	Rhizomes

SPICES OF COMMERCIAL PRODUCTION

Of the twenty one spices, eight spice crops are grown commercially ranging 60 to 21451 ha. Ginger occupies highest area and production followed by onion and cardamom and least by funnel. Area under the group chilly (capsicum, Akabare and chilly long) occupies 4^{th} larger area (10,256 ha) after ginger, onion and cardamom.

Table 3. Area, production and productivity of spices

Spices	Area (ha)	Production (t)	Productivity (fresh yield t/ha)
Ginger	21451	257735	12.02
Onion	20712	248584	12.00
Cardamom	12458	5166	0.41
Chilly (long)	8239	74902	9.00
Turmeric	7877	71812	9.12
Garlic	7119	44723	6.28
Coriander	1874	17114	9.00
Chilly (Capsicum)	1114	11516	10.00
Chilly (Akabare)	903	4510	5.00
Fennel	60	427	7.00
Total	81807	736489	7.98

Source: MoAD 2015a

GENETIC DIVERSITY OF NEPALESE SPICES

Ginger (*Zingiber officinale* Roscoe)

Among the major spices grown in the country, ginger which belongs to the family Zingiberaceae deserves an important place as it is a source of foreign exchange. The family Zingiberaceae consists of 47 genera and about 400 species. The genus *Zingiber* consists of 80-90 species, among these *Zingiber zerumbet* (L.) Roscoe ex Sm.

and *Zingiber cassumunar* Roxb. are wild medicinal species and *Zingiber officinale* Roscoe is the cultivated (Mohanty and Panda 1994). We can also find several species of wild ginger similar to cultivated ginger in the Mid Hill of Nepal used for medicinal purpose, some of them are known as 'Bye Aduwa'.

From its existence to date, 90 cultivars were collected from the ginger growing areas, characterized and evaluated for their yield performance at Ginger Research Program (GRP), Kapurkot, Salyan. Collection of local germplasm initiated since its existence and continued for evaluation and improvement through clonal selection (GRP 2000, 2016). These collections are being maintained at the research station. Two varieties have been released as Kapurkot Aduwa-1 and Kapurkot Aduwa-2. Both varieties are of bold size with considerable amount of oil, oleoresin and fiber content, acceptable to international markets.

In 2016, developing Nepal ginger profile, in addition to GRP's collection, 30 representative cultivar samples from 25 ginger potential districts, were collected and evaluated for their physical character (rhizome girth, rhizome expansion, inter node length and appearance) for identification and commercial quality characters (oil, oleoresin and crude fiber content). Chemical parameters were analyzed at accredited lab of Indian Spices Board, Calicut (Adhikari 2016).

Physical Characteristics of Nepalese Local Cultivars

In general, rhizomes were found in four size small (<2.5 cm), medium (2.5-3.0 cm), bold (3-3.5 cm) and extra bold (>3.5 cm). Cultivars from Oyrajung (Terhathum) and Bhadrakali (Sindhuli) were found extra bold. Cultivars of Deumai (Ilam), Fidim (Panchthar), Haldekalika (Nuwakot), Mannakapadi (Doti), Asigram (Dadeldhura), Malneta (Salyan) and Dhanabang-GRP (Salyan) were found bold size rhizomes. Rests of the cultivars were medium and in small size. Three cultivars of Pakhribas (Dhankutta), Namtar (Makwanpur) and Bhadrakali (Sindhuli) were found wide expansion of rhizomes (>30 cm). There was variation in internodes length that may also helpful in cultivar identification (**Table** 4).

Table 4. Physical characteristics of indigenous ginger cultivars collected in 2016

Acct#	District and VDC	Rhizome girth, cm	Rhizome expansion, cm	Internodes length, mm	Skin appearance
ZI 1601	Jhapa, Prithivinagar	2.21	22.8	6.4	buff skin
ZI 1602	Jhapa, Bahundangi	2.37	24.8	6.9	buff skin
ZI 1603	Ilam, Barbote	2.58	24.8	8.5	brown skin
ZI 1604	Ilam, Deumai	3.36	24.8	7.4	Bright & glazy
ZI 1605	Panchthar, Pouwasata	2.18	14.8	8.8	Bright & glazy
ZI 1606	Panchar, Fidim	2.77	20	9.1	brown skin
ZI 1607	Panchar, Fidim	3.15	27.6	12.6	Bright & glazy
ZI 1608	Dhankutta, Pakhribas	2.72	30.8	8	Bright & glazy
ZI 1609	Terhathum, Oyargung	3.77	24.8	11	Bright & glazy
ZI 1610	Morang, Letang	2.78	25.2	5.8	buff skin
ZI 1611	Dhading, Jivanpur	2.23	26	6.2	buff skin
ZI 1612	Dhading, Kebalpur	2.44	25.6	7.4	Bright & glazy
ZI 1613	Nuwakot, Haldekalika	3.15	24.8	10.8	Bright & glazy
ZI 1614	Makwanpur, Namtar	2.74	29.2	8.5	Bright & glazy
ZI 1615	Makwanpur, Hetauda	2.3	20	7.1	Bright & glazy
ZI 1616	Nawalparasi, Jaubari	2.32	25.2	7.1	buff skin
ZI 1617	Nawalparasi, Bhendabari	2.39	29.2	7.6	buff skin
ZI 1618	Palpa, Barangdi	2.26	25	7.3	Bright & glazy
ZI 1619	Syangja, Chilaunebas	2.19	20.8	7.1	buff skin
ZI 1620	Dang, Kabhre	2.58	18.4	6.9	brown skin
ZI 1621	Surkhet, Harre	2.38	23.2	6	brown skin
ZI 1622	Kailali, Sahajpur	2.48	22	10	brown skin
ZI 1623	Doti, Mannakapadi	3.24	25	12.2	brown skin
ZI 1624	Dadeldhura, Asigram	3.09	22.8	8.8	brown skin
ZI 1625	Doti, Barchhain	2.29	23	8.3	brown skin
ZI 1626	Salyan, Malneta	3.21	26	7.9	brown skin
ZI 1627	Dhanbang, GRP	3.08	26.8	8.4	brown skin
ZI 1628	Dhanbang, GRP	2.19	21.8	6.9	brown skin
ZI 1629	Dailekh, Narayan NP	2.77	20	9.3	brown skin
ZI 1630	Sindhuli, Bhadrakali	3.52	32.8	10	Bright & glazy

Quality Characteristics of Nepalese Local Cultivars

Drying recovery in cultivars was found highly variable (10.3-26.4 %w/w), fiber content (4.4-8.5 %w/w), oil content (0.9-2.20 %v/w) and oleoresin content (2.57-6.21 %w/w). Highest drying recovery was found in the cultivar collected from Chilaunebas, Syangja (26.4%) followed by Jibanpur, Dhading (24.8%) and Prithivinagar, Jhapa (23.4%). Cultivar from Oyarjung, Terhathum (ZI 1609) had a lowest (10.3%) drying recovery (**Table** 5).

Crude fiber (CF) is another important quality parameter, none of the cultivars were found less than 4% CF, which indicates all the Nepalese cultivars were Nase (fibrous) type. However, under Nepalese conditions cultivars were categorized as less fibrous (Bose) (<5% CF), fibrous (4.0-7.0% CF) and highly fibrous (>7.0% CF). Under this categorization, of the 30 cultivars 7 were found highly fibrous (ZI 1604, ZI 1607, ZI 1608, ZI 1609, ZI 1622, ZI 1623, ZI 1624 and ZI 1629).

Content of essential oil which is volatile in nature is one of the determining quality factors in the global spice trade. Regarding oil content, among the 30 cultivars, 11 cultivars are found below the international standard (<1.5%). Oleoresin is real spice taste having oil and resins that gives aroma and pungency. Cultivars having oleoresin ranging from 4.0-6.0% are medium and containing more than 6% are high oleoresin type cultivar. Only two cultivars ZI 1621 (Harre, Surkhet) and ZI 1624 (Asigram, Dadeldhura) were of high oleoresin containing type (**Table** 5)

Table 5. Quality characteristics of Nepalese ginger cultivars

Acc#	District and VDC	Drying recovery, %/wt	Crude fiber, %/wt	Essential oil, % v/wt	Oleoresin, %/wt
ZI 1601	Jhapa,Prithivi nagar	23.4	4.67	1.30	3.99
ZI 1602	Jhapa, Bahundang	17.6	5.93	1.70	5.05
ZI 1603	Ilam, Barbote	15.0	7.00	1.70	4.97
ZI 1604	Ilam, Deumai	13.7	8.10	1.50	4.44
ZI 1605	Panchathar, Pouwasata	15.0	6.34	0.90	2.57
ZI 1606	Panchathar, Fidim	17.1	4.54	1.50	3.39
ZI 1607	Panchathar, Fidim	11.0	7.67	2.10	5.56
ZI 1608	Dhankutta, Pakhribas	12.8	7.09	1.50	5.51
ZI 1609	Terhathum	10.3	7.85	1.70	4.86
ZI 1610	Morang, Letang	15.0	6.75	2.10	4.98
ZI 1611	Dhading, Jibanpur	24.8	4.50	1.10	3.24
ZI 1612	Dhading, Kebalpur	18.9	4.46	1.20	4.16
ZI 1613	Nuwakot, Haldekalika	18.3	4.84	1.20	4.32
ZI 1614	Makawanpur, Namatar	17.1	4.44	1.40	3.69
ZI 1615	Makawanpur, Hetauda	13.6	6.41	1.90	5.95
ZI 1616	Nawalparasi, Jaubari	21.4	4.56	1.60	4.69
ZI 1617	Nawalparasi, Bhendabari	21.1	5.54	2.20	4.46
ZI 1618	Palpa, Barangdi	21.4	4.72	1.80	4.92
ZI 1619	Sayngja, Chilaunebas	26.4	5.26	1.80	5.17
ZI 1620	Dang, Kabhre	20.0	6.76	1.80	4.02
ZI 1621	Surkhet, Harre	17.5	5.26	2.00	6.21
ZI 1622	Kailali, Sahajpur	14.4	8.46	1.50	5.47
ZI 1623	Doti, Mannakapadi	16.8	7.44	1.10	5.28
ZI 1624	Dadeldhura, Aasigram	17.5	7.66	1.90	6.19
ZI 1625	Doti, Barchhain	21.9	5.22	1.00	2.62
ZI 1626	Salyan, Malneta	22.1	6.44	1.80	5.46
ZI 1627	Salyan, Kapurkot, GRP	21.1	6.49	1.60	3.66
ZI 1628	Salyan, Kapurkot,GRP	21.1	6.06	1.30	3.27
ZI 1629	Dailekh, Narayan NP	16.4	8.50	1.20	4.76
ZI 1630	Sindhuli, Bhadrakali	23.4	6.50	1.10	3.79

In collaboration with Genebank, all the cultivars of accession numbers have been maintained under field conditions at GRP Kapurkot, for further utilization in developing the new varieties using different breeding methods. Of the 70 ginger producing districts Salyan, Ilam, Terhathum, Makwanpur, Dhading, Nawalparasi, Palpa, Syangja are the major ginger producing districts. Despite of many constraints, Nepal ranks 5th in area and 3rd in production and 8th in productivity of ginger in the world (http://www.fao.org/faostat/en/#data/QC). It grows well in warm and humid climate and is cultivated from sea level to an altitude of 1500 m above sea level. It can also be grown both under rain fed and irrigated conditions. In Nepal, ginger is cultivated in 21,451 ha and total production 257,735 MT with the average productivity of 12.02 t/ha (MoAD 2015a). The major causes of low productivity are rhizome rot disease, unavailability of quality disease-free planting material. Ilam, Nawalparasi, Palpa, Salyan are the lead ginger producing districts. Some constraints are:

- Rhizome rot caused by *Pythium aphanidermatum* and *Fusarium* spp. is the main bottleneck of production causing substantial yield loss of 30 percent (Sharma and Shrestha 2002), however it may cause crop losses up to 100%.
- Disease free planting materials are not adequately available.
- Seed certification system is not adopted and no institutions are formally involved in quality seed production.
- Nepali cultivars have low oil and oleoresin and high fiber content.
- Weak adoption of sanitary and phytosanitary (SPS) measures that is hindering the international trade.

Large Cardamom (*Amomum subulatum* Roxb.)

Large cardamom (Family: Zingibereceae) is mainly grown in the sub-Himalayan region of India and Nepal between an elevation of 600 to 2000 masl where annual rainfall is between 1,500 to 2,500 mm and the temperature varies from 8°C to 20°C (Dhital and KC 2012). Other species of *Amomum* (*Amomum ligulatum* R.M.Sm., *Amomum kingii* Baker, *Amomum aromaticum* Roxb., *Amomum corynostachyum* Wall.) can also be found as wild in eastern Hills (Adhikari and Aryal 2016 BS). It is a shade loving perennial spice crop, which was introduced from Sikkim in 1865. After the establishment of Cardamom Development Center at Fikkal in 1975 cultivation extended to 42 hill districts (NSCDP 2008) covering 12458 ha. Productivity of this crop in Nepal is relatively low ranging from 400 to 800 kg/ha. The cultivation area is being extended towards western region of Nepal. As area is expanding, not all cardamom cultivation area are having good soil fertility, proper shading, irrigation and unavailability of disease free planting materials that have led to poor yield. However, 73% of total national production still comes from four districts (Taplejung, Panchthar, Ilam and Sankhuwasabha (MoAD 2015b). Out of 16 cultivars of large cardamom grown in the world, Ramshai and Golshai cultivars are popular in Nepal. However Saune, Ramala, Chibeshai, Dammarshai, Bharlangae, Jirmale/Salakpure have been cultivated sparsely at the altitude of 600 to 1500 m extended from eastern to the western Mid Hills (**Table** 6). Recently a new cultivar 'Jirmale' is being tested in farmer's field at Ilam (MoAD 2015b). Propagation is done through seeds and suckers. Micro propagation for rapid multiplication of high yielding clones, vegetative buds from disease free high yielding mother plants are collected and disease free plantlets are produced through the tissue culture technique. Large cardamom contains 2-3% essential oil and possesses medicinal properties.

Table 6. Characteristics of different cultivars of cardamom

Name of cultivars	Characters
1. Ramshai	• Pink pseudo stems • Short inflorescence • 3-4 inflorescence/clump • Fruits (capsules) medium and oblong • Suitable altitude above 1500 m • Harvesting at November.
2. Golshai	• Flower yellowish • Performed better at 1200-1500 m • Plants shorter than Ramshai • Fruits are larger and weighty than Ramshai • Susceptible to Chhirkey and Foorkey disease • Harvesting at October.
3. Dambarshai	• Performs better at the altitude 700-1200 m • Short plant, less bushy • Pseudo stem color light pink • Large size capsule and number of seeds in a capsule high • Comparatively gives higher flavor • Fetches better price • Harvesting starts from last week of September • Oldest cultivar in the region.
4. Saune	• Leaves are short and flat • Leaf color dark green • Stems are green to light pink • Capsules are bold and brown

Name of cultivars	Characters
	• Thin capsule coat with high number of seeds/capsule • Performs better at 1200-1600 m altitudes • Matures in Shrawan (July-Aug).
5. Ramala	• Prefers in altitudes more than 1500 m • Less number of inflorescence 10-11 capsules/ clump • 65-70 seeds/capsule.
6. Chibeshai	• Capsules with tail • Performs better at 700-1000m altitudes • Stems are short with light green color • Less tillers/clump, small capsules in large numbers • Seeds/capsule is also less • Matures in last week of August.
7. Bharlange	• Suitable at diversified environmental conditions • Leaves are dark green • Plant height 2.8 m • 60-150 pseudo stems/ clump • Stems are pink as of Ramshai • Bears capsules maximum 0f 20/inflorescence • Forms 50-65 seeds/capsule • Starts harvesting from 1st week of October.
8. Jirmale/ Salakpure	• Leaf and stem are green • Bushy and short plant • Flowers are white • 22-37 capsules/ clump • 50-56 seeds/capsule • Tolerant to drought • Performs better at the altitudes of 700-1000 m.

Constraints in Production and Processing

- The major problem to this crop is the widespread occurrence of the viral diseases such as Streak mosaic (Chhirke) caused by 'Mosaic streak virus and stunt mosaic (Furke) caused by 'Bushy dwarf virus' (Subba and Ghimire 2009).
- Indiscriminate planting of available land races from unknown source without considering climate and altitudes is one of the major issues of poor yield.
- Disease resistant variety is not readily available to Nepalese farmers.
- Poor post-harvest handling and unscientific processing are the major problems in cardamom. Conventional drying using firewood makes the cardamom inferior because of smoky appearance and reduced oil content.
- In sufficient availability of disease free planting materials.

Turmeric (*Curcuma longa* L.)

Turmeric is a rhizomatous herbaceous perennial plant belonging to the ginger family Zingiberaceae, which is native to tropical South Asia (http://www.spices.res.in/pdf/package/turmeric.pdf). Irrespective of well being, rich or poor turmeric is the most essential spice used substantially by Nepalese people. Fresh rhizomes are known as '*Haledo*' whereas powder form is called '*Besar*'. The genus *Curcuma* includes many other economically important species eg *Curcuma amada* Roxb. (mango ginger), *Curcuma angustifolia* Roxb. (narrow-leaved turmeric), *Curcuma aromatica* Salisb. (wild turmeric) and *Curcuma zedoaria* Roxb. (zedoary). Mango ginger is closely related to turmeric but the rhizomes are very similar to ginger but gives taste and flavor like a raw mango. They are used most suitable in making pickles. Turmeric rhizomes contain curcuminoids 2 to 6% (Pruthi 2006), which gives yellow pigments and comprises three types of curcumins.

Collection of local cultivars of turmeric started from 1998 and getting continue collection reached collection numbers 87 to date from turmeric growing potential areas of the country. In 2014, through selection breeding one variety 'Kapurkot Haledo-1' containing moderate level of curcumin and rhizome yield, has been released (GRP 2015). Twenty five local turmeric germplasm with the accession numbers as TI9801 (First two letters= turmeric indigenous, first two digit; 98=year of collection and last two digits; 01= number of collection) have been maintained at Kapurkot, Salyan. Sarlahi, Nawalparasi, Palpa, Salyan and Bardiya are the major turmeric producing districts. However, turmeric is grown in Tarai, inner Tarai and Mid Hill areas covering 7877 ha with the productivity of 9.12 t/ha. It is also a shade-loving crop and can be grown as intercropped with orchard and suitable for agro-forestry systems.

Constraints in Production and Processing

- Rhizome rot (*Pythium graminicolum*), leaf blotch (*Taphrina maculance*) and leaf spots (*Colletotrichum capsici*) are the major biotic problems causing significant yield losses.
- Dried rhizomes and their powder are the commercial forms. Research on drying of fresh turmeric is lacking. Freshly harvested rhizomes either boiled or slices made and dried under sun deteriorate its quality particularly of essential oil and oleoresin.

Chilly (*Capsicum frutescens* L.)

Chilly is an annual herb, which is also called hot pepper, red pepper, cayenne pepper, capsicum, etc. Chilly imparts pungency and color to the dishes. Biting pungency is attributed by 'capsaicin' whereas; 'capsanthin' attributes red pigment (Singh 2003b). It is also a rich source of vitamin A, C and E, and assists in digestion and also prevents heart diseases by dilating blood vessels.

There is high genetic diversity in the genus *Capsicum.* Several types of chilly regarding shape, size, biting pungency and capsaicin content are under cultivation but some are confined to backyard and some are under commercial cultivation. Out of five cultivated species resulted from long domestication only two cultivated to large extent are *Capsicum annuum* L. and *Capsicum frutescens* L. (Verma and Joshi 2003). Most common types of chilly cultivars under cultivation in Nepal are Bhende, Akabare, Jire and Hattisunde. Jire khursani (erected small fruits) and Akabare (round red fruit) are the indigenous to Nepal. Akabare khursani is the most popular and widely cultivated in eastern region. Akabare is one of the most pungent spices containing best quality 'Capsasin' and has great market value. Its oleoresin has special medicinal value, best of its kind in the world. Paprika oleoresin is an oil-soluble extract from the fruits of *Capsicum annuum* or *Capsicum frutescens*, and is primarily used as a coloring and flavoring in food products.

Cylindrical long red chilly are commercially being grown in Mid and Far Western Tarai. Area under all types of chilly is 10,256 ha with the average productivity of fresh fruit 8.0 t/ha. However, *Akabare* alone is cultivated in 903 ha and common red chilly in 8239 ha. Two varieties 'California wonder' and 'Jwala' released and 15 hybrids of registered. Among the OP varieties Jwala, Suryamukhi, NP 46, Pant C1, Jyanmara and in hybrids NS 1701, NS 1101, Karma 747 and Karma 777 are the popular.

Chilly is propagated by seeds. It requires warm and humid climates for best growth and dry weather during the maturation of fruits and can be grown throughout the year from sea level to 2100 masl. Almost all Tarai and Mid Hill districts grow chilly but commercial producers are Ilam, Morang, Jhapa, Sunsari, Rautahat, Banke, Bardiya, Kailali and Kanchanpur.

Constraints in production and processing

- Thrips, mites, aphids and pod borers are the major insect pests
- Fruit rot, die-back, bacterial wilt, powdery mildew and mosaic are the major diseases
- Weather during harvesting and drying is the major bottle neck in processing and storing

Onion (*Allium cepa* L.)

Onion is the member of family: Amaryllideae and sub family: Alloideae. It is one of the most important and popular vegetable grown successfully in Nepal. Onion contains vitamins 'B' and 'C' and traces of iron and calcium and has manifold medicinal value. A significant amount of onion is being imported from China, India and Thailand. Few years back, government of Nepal has launched 'Onion mission' with the objectives of its promotion for increasing production and substitute import.

Onions are grown in 20712 ha and produced 248584 t. With the development of technologies onion could be harvested twice May-June for normal crop and Oct-Nov for off season using set plantation. Agrifound Dark Red was found most suitable for set plantation. Productivity of onion is low 12 t/ha due to biotic and abiotic stresses during the crop growth stages.

Popular OP varieties are Red Creole, Agri-found dark red, Nasik red and N-53. Few hybrids Superex, TI-172, Cass, Venus and winter silver are also using by commercial onion growers (Pandey and Joshi 2016). Local cultivar named as "Baitadi Sthaniya Pyaj" highly adopted and preferred at Doti, Dadeldhura and Baitadi district has been improved and proposed for registration. Bulbs are very large 250-300 g size with light pink appearance. Because of having very low pungency, this cultivar is highly preferred for salad. Likewise 'Nuwakot Local Pyaj' grown at Nuwakot and few areas of Dhading is also popular and its seed is produced and maintained by farmers themselves.

Constraints in production and processing

- Purple blotch disease, Thrips, Tip burning and Seed production

Jimmu (*Allium hypsistum* Stearn)

Jimbu is an herb belonging to the family Amaryllidaceae and genus *Allium* which is naturally grown in high altitude areas of Nepal. Two species are common, *Allium hypsistum* Stearn and *Allium przewalskianum* Regel (www.forestrynepal.org/publications). In Mustang and Manang districts of Nepal, it is used to flavor vegetables, pickles and meat. In the rest of Nepal it is most commonly used to flavor Dal. The dried leaves are fried in ghee to develop their flavor. It is a seasonal herb, harvested between June and September and dried for future use. *Allium hypsistum* is a Nepalese species of wild onion in the Amaryllideae family. It is one of two species referred to as Jimbu in Nepal, used in Nepalese cuisine (Nepal 2006). *Allium przewalskianum* is an Asian species of wild onion in the Amaryllideae family. It is also widely distributed in mountain areas in the Himalayas (India, Nepal, Pakistan Tibet and China). It has narrow bulbs up to 10 mm across. Plant is up to 40 cm tall. Leaves are tubular, about the same length as the plant. Umbel is densely crowded with many red or dark purple flowers. Research work has not been started on both types of Jimbu on their commercial cultivation.

Leek (*Allium ampeloprasum* var. *porrum* (L.) Hayek)

Leek is a hardy, vigorous, biennial plant also known as Sano chhyapi resembling onion like flavor. It is widely used in the high altitudes of Nepal. Its origin is the Mediterranean area. It is cool weather (temperatures between 13° C and 25° C) and can tolerate minus temperature without any ill effects (Joshi 2003). Its thick and succulent stems are used in autumn and winter as a substitute for green onions. The edible part of the plant is a bundle of leaf sheaths that is sometimes erroneously called a stem or stalk.

Shallot (*Allium cepa* var. *Aggregatum* G.Don)

Shallot is the botanical variety (Aggregatum) of *Allium cepa* L. It has a milder taste and odor than onions, so shallots are more commonly eaten raw. Onions and shallot are both bulb vegetables in the same family that originated from central Asia. They are both used as ingredients to flavor dishes and can be eaten on their own. Shallots can be distinguished from the common onion by their appearance. Shallots are smaller and have longer, slimmer bulbs than the common onion. Both vegetables have a similar taste but shallots are less pungent. It has high anti-oxidant, good for blood pressure and cholesterol. It contains higher calories, carbohydrate, and protein than onion.

Garlic (*Allium sativum* L.)

Garlic is a member of family: Amaryllidaceae and sub family: Alloideae. In Nepal, it is cultivated from Tarai to the high altitudes. The variety of garlic cultivated at high altitudes is generally called 'Bhote Lasun'. It has tall plants and large leaves, resemble with Chinese garlic. Research has been initiated, local germplasm have been collected and being evaluated at the agriculture research stations Malepatan and Surkhet. 'Tarai lasun' and 'Bhote lasun' are common in Nepal. Thirty two local and exotic garlic germplasm have been conserved at Genebank Khumaltar. No varieties are released nor registered so far. Bhote lasun and Tarai lasun types may be different species of *Allium.* The white-skinned bulb or corm is subdivided into several 'cloves'. Garlic contains sulphur compounds, most important chemical responsible for its taste is allicin (diallyl disulphide oxide).

Constraints in production and processing

- Unavailability of high yielding varieties, Tip burning complex and Infestation of thrips insect

Coriander (*Coriandrum sativum* L.)

Coriander requires cool climate during the growth stage and warm dry climate at maturity. Two open pollinated varieties (Lotus and Suravi) and three hybrid varieties have been registered after the adaptation testing. 'Pant haritama' an Indian variety is under testing at Kapurkot and Dailekh. This crop matures from 110 to 140 days. Tarai and Inner Tarai are the best-suited areas for its cultivation. It can be intercropped with sugarcane as catch crop before the full growth of sugarcane. Coriander is grown in 1870 ha with the productivity of 9.0 t/ha.

Constraints in production and processing

- Aphids, cutworms are the major pests in turmeric; Fusarium wilt, stem galls and powdery mildews are the major diseases

Culinary and Medicinal Use:

Fresh green leaves of coriander (Dhaniya) are used in dressing all types of vegetables whereas coriander powder is used in flavoring vegetables and meat items. It is also extremely useful for multiple health purposes. It is an excellent appetizer, helps in proper secretion of enzymes and digestive juices in the stomach, stimulates digestion, peristaltic motion and prevents flatulence (http://www.gyanunlimited.com). It is a good source of dietary fiber and relieves intestinal gas, beneficial for constipations, piles and stomach pain. It is helpful for cough, removes bad smell from mouth and an excellent antiseptic. It removes phlegm, reduces fever and offers a feeling of coolness.

Fenugreek (*Trigonella foenum-graecum* L.)

Fenugreek is the member of family: Fabaceae. It is used as a condiment for flavoring the foods and vegetables. It requires cool climate during vegetative growth while warm dry weather during maturity and can withstand frost. It is propagated through seeds. Sowing of seeds can be done directly on well-prepared land at a seed rate of 10-15 kg/ha. Prior to sowing, the seeds are soaked in water for 6-8 hrs to hasten germination, shade dried and shown in the field. It is most important seed spice used in every day vegetable preparation. Sprouted seeds provide high nutritious value. It is being grown in Tarai and Mid Hill during winter.

Culinary and Medicinal Use

- Seeds of fenugreek are tiny, bitter, dicotyledons. On roasting, they exhibit strongly aromatic and pungent flavor.
- Traditionally, fenugreeks have been found use to cure digestive problems and to improve breast milk secretion in the nursing mothers.
- Fenugreek seeds are a rich source of minerals, vitamins, and phytonutrients. 100 g seeds carry 323 calories. The seeds compose ample amounts of soluble dietary fiber. Soaking them in water softens their outer coat and turns it slimy. 100 g of seeds provide 24.6 g - 65% of dietary fiber (http://www.nutrition-and-you.com).
- Fenugreek seeds contain amino acid 4-hydroxy isoleucine, and act as facilitator action on insulin secretion and helps in regulating blood sugar levels. Therefore fenugreek seeds are recommended food ingredients in the diabetic diet.
- Fenugreek is an excellent source of minerals like copper, potassium, calcium, iron, selenium, zinc, manganese, and magnesium. Potassium helps to control heart rate and blood pressure by countering action on sodium.

Cumin (*Cuminum cyminum* L.)

Cumin is the member of family: Apiaceae. It is widely cultivated in sub-tropical climate. It is an annual herb, generally it takes about 110-115 days for maturity and can yield 600- 700 kg/ha. Cumin is mainly used in flavoring foods. It is also used in Ayurvedic medicines. Cumin is a tropical plant. It can be cultivated in all types of soils but well drained sandy loam and medium soils are suitable for the crop. It requires dry weather at seed setting and maturity stage. The major problems encountered were diseases particularly powdery mildew and fusarium wilt and the wet weather during flowering and seed setting stage. Commercial cultivation of cumin is possible if planting time is adjusted to have dry weather during the seed formation stage.

Culinary and Medicinal Use

- Cumin is generally roasted gently before adding in a recipe. In order to keep its fragrance and flavor intact, it is generally ground just before preparing dishes.
- It is widely used as a spice and employed in cooking as a condiment and flavoring base used for preparing as Jeera fried rice, Jeera fried dal, Aalu-jeera, chicken, fishes and mutton curies and so on.

Cumin seeds contain many phytochemicals that are known to have antioxidant, carminative and anti-flatulent properties. The seeds are an excellent source of dietary fiber. It contains health benefiting essential oils such as cuminaldehyde, which also responsible for its flavor and aroma (http://www.nutrition-and-you.com).

- It is an excellent source of minerals like iron, copper, calcium, potassium, manganese, selenium, zinc and magnesium.
- It also contains very good amounts of B-complex vitamins such as thiamin, vitamin B-6, niacin, riboflavin, and other vital anti-oxidant vitamins like vitamin E, vitamin A, and vitamin C.

Caraway (*Carum carvi* L.)

Caraway, also known as meridian fennel and Persian cumin. It is a biennial plant in the family Apiaceae, native to western Asia, Europe, and North Africa. Caraway is also known as Himali soop in Nepal. During 2006-2009, it was explored and demonstrated its cultivation through the National Agricultural Research Fund (NARDF) at Jumla, Humla and Dolpa district (www.nfi.org.np).

Black cumin (*Bunium persicum* (Boiss.) B.Fedtsch.)

Black cumin is the member of family Apiaceae. It is also known as Himali Jeera in Nepal. Ripen seeds of black cumin are reported to contain an essential oil (up to 7%) rich in monoterpene aldehydes, the main components are cumin aldehydes. Kashmir is the only region in India, where this cumin is produced. Indigenous Himali Jeera is found in Karnali region and is being domesticated in Jumla, Dolpa and Humla districts (www.nfi.org.np).

Bishop's weed (*Trachyspermum ammi* (L.) Sprague)

Bishop's weed is the member of the family: Apiaceae. It is also called *Jwano* in Nepali and Ajwain in Hindi. It was originated in India and Pakistan. Both the leaves and the seeds of the plant are consumed. It is an annual herb grown as winter crop in Tarai and Mid Hill of Nepal.

Culinary and Medicinal Use

- The fruits are commonly roasted or fried in Brassica oil or ghee to get its flavor and aroma in Nepali cuisine. It is used to flavor lentil dishes.
- Jwano is used as traditional Ayurvedic medicine, primarily for stomach disorders such as indigestion and flatulence. It has antispasmodic and carminative properties. In general the crushed fruits are applied externally as a poultice against inflammation.

Fennel (*Foeniculum vulgare* Mill.)

Fennel is a flowering plant species in the Apiaceae family. It is a hardy, perennial herb with yellow flowers and feathery leaves. It is indigenous to the shores of the Mediterranean but has become widely naturalized in many parts of the world, especially on dry soils near the sea-coast and on riverbanks. It is a highly aromatic. Fennel is cultivated in small scale limited to kitchen gardens. It is winter crop grown in Tarai and Mid Hill conditions.

Culinary and Medicinal Use

- Roasted seeds mixed with sugar crystals are used as mouth refresher after meals.
- It is commonly used in flavoring Haluwa, Pulau several other food preparations.

Saffron (*Crocus sativus* L.)

Saffron is the member of Iridaceae family. It is a spice derived from the flower stigma of *Crocus sativus*, commonly known as the "saffron crocus". Saffron grows to 20–30 cm and bears up to four flowers, each with three vivid crimson stigmas, which are the distal end of a carpel. The styles and stigmas, called threads, are collected and dried to be used mainly as a seasoning and coloring agent in food. Saffron is the most costly spices by weight in the world's spice markets. It is native to Southwest Asia and was probably first cultivated in or near Greece. Saffron's taste/fragrance result from the chemicals picrocrocin and safranal. It also contains a carotenoid pigment, crocin, which imparts a rich golden-yellow to dye dishes and textiles. Iran now accounts for approximately 90% of the world production of saffron.

Saffron is basically grown in dry temperate region altitude ranging from 2500 to 3000 m. It can withstand cold winters, tolerating frosts as low as −10 °C and short periods of snow cover. It is perennial propagated through corms. However, Chaudhary (2004) reported that cultivation of saffron under protected condition initiated at Rajikot (Jumla), Daman (Makwanpur) and Godavari (Lalitpur). Approximately 150 flowers are needed for one gram of dried saffron. There is high potential of saffron production in the high altitudes of Nepal. Horticulture Research Station Rajikot, Jumla has initiated its research to develop packages of practices for its commercial production at Karnali region. 260,000 flowers/ha were harvested from the third year crop under Jumla condition and net profit was estimated NRs 19,54,000/ha (Chaudhary and Pandey 2004). Few farmers groups of Jumla and Humla have started growing this crop but not yet attained commercial production. However HIMALI project has implemented a sub-project on Saffron in Jumla for its production in farmer's field.

Constraints in Production and Processing

- Requires dry temperate climates and can tolerate few days frost before flowering.
- Nematodes, leaf rusts, and corm rot are the common threats.
- Bright sun shine during the growth and flowering period is necessary.
- Harvesting of stigma is tedious and laborious.

Culinary and Medicinal Use

Saffron is as colorant, to make the all kinds of foods natural herbal color instead of synthetic chemicals. Saffron is largely cultivated and harvested by hand. Saffron is used for asthma, cough, whooping cough, and to loosen phlegm (as an expectorant).

Mint (*Mentha spicata* L.)

Mint is the member of family Lamiaceae and sub family Nepetoideae. *Mentha* genus are widely distributed and can be found in many environments, most grow best in wet environments and moist soils. There are 21 species reported but of them only *Mentha spicata* L. and *Mentha arvensis* L. are common in Nepal. *Mentha spicata* L. grows 10–120 cm tall and can spread over an indeterminate area. It thrives near bank of irrigation channels, lakes, rivers, and cool moist spots in partial shade. It can be grown all year round. They are fast-growing, extending through a network of runners. Due to their speedy growth, one plant could be sufficient with little care for home use. Harvesting of mint leaves can be done at any time. *Mint arvensis* is being commercially grown and oil is extracted locally using stem distillation mini plants in Banke and Bardiya districts and the oil is exported to India.

Culinary and Medicinal Use

- The green leaves of *Menth spicata* are the real spices commonly used in preparing squash, pickles and Chatanies.
- In ayurveda, pudina is considered as appetizer and useful in gastric troubles.
- Traditionally used as to treat flatulence, digestive problems, gall bladder problems and coughs.
- Menthol oil when rubbed into the skin relives aches and pains.
- Mint extracts and menthol-related chemicals are used in food, drinks, cough medicines, creams.
- Menthol is widely used in dental care as a topical antibacterial agent, effective against streptococci and lactobacilli.
- Mint is also commonly used in pharmaceutical and oral preparations like toothpastes, dental creams and beverages.

Cinnamon (*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.)

Cinnamon falls under the botanical family Lauraceae. Cinnamon is native of Sri Lanka and is the oldest known spice in the world. However, *Cinnamomum tamala* has been found as wild in Indonesia, India and Nepal (Rema and Leela 2008). The genus cinnamon comprises about 250 species (Pruthi 2006), few of them are economically important. *Cinnamomum cassia* (L.) J.Presl (Chinese cinnamon), *Cinnamomum burmanni* (Nees & T.Nees) Blume (Indonesian cassia), *Cinnamomum loureiroi* Nees (Vietnam cassia) and *Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm. (Indian cassia). Research on cinnamon has not been initiated for its cultivation and processing. The cinnamon species existing in the Nepalese forest not authentically identified. Farmers group of Palpa has started commercial production and extraction of oils from cinnamon leaves.

Cinnamon can tolerate wide range of soil and climatic conditions and can be grown from sea level to an elevation of 1000 masl with an annual rainfall of 2000-25000 mm (Anandaraj et al 2005). Cuttings, air layering and seedlings are used for propagation. In Nepal 'Tejpat' and 'Dalchini' (*Cinnamon tamala*) have been used as spices since long time and are available in the forest of Mid Hills. Some of the forest nurseries have started seedlings and saplings production and started cultivation. Nepalese cinnamon bark is thick and does not have aroma and pungency as that of Indonesian and Malaysian. No scientific cultivation, harvesting, drying and processing yet started. Essential oils (2.7%) from leaves and 8% oleoresin from inner bark could be obtained by distilling dried leaves and solvent extraction of bark respectively (Anandaraj et al 2005).

Culinary and Medicinal Use

- Dalchini power is one of the important ingredients of "Garam masala" used basically in chicken, mutton and fish dishes. It is also used in flavoring tea along with ginger.
- Dalchini powder acts like a baking powder, it helps the sel-roti to swell and it keeps the bread stuck together so it doesn't disintegrate when it is deep fried. It is said that "no Sel-roti without Dalchini" (http://thespicejournal.com).
- Cinnamon has traditionally been used to treat toothache and fight bad breath. It improves cognitive function as well as memory, helps in removing impurities from the blood, and is often recommended for pimples.
- It helps to stop bleeding, and facilitates the healing process and effective for indigestion, nausea, vomiting, upset stomach, diarrhea and flatulence.
- Cinnamon helps in cold, flu, influenza, sore throat and also used in the treatment of flatulence, piles, amenorrhea, diarrhea, toothache, amoebiasis, heart diseases, fever, cough, cold, headache and many others (http://www.medicalhealthguide.com).

Black pepper (*Piper nigrum L.*)

Black pepper belongs to the family Piperaceae. It is obtained from the perennial climbing vine, *Piper nigrum* L., which is indigenous to the tropical forests of Western Ghats of South India (http://www.spices.res.in). India accounts for 54% of the total area under pepper in the world but its share of production is only 26.6 %. It is a climbing evergreen plant and grows to a height of 10 m or more. The vines and branches show the appearance of bush. The fruit is a single seeded berry, which has a thin, soft pericarp surrounding the seed. It takes approximately six months to mature after flowering. It was introduced more than 20 years back from India to Nepal and started its research and demonstration at Regional Agricultural Research Station, Tarahara. Few farmers at Jhapa have started cultivation as intercrop with areca nut.

Nepal pepper (*Zanthoxylum armatum* DC.)

Nepal pepper (Timur) is member of family Rutaceae and sub family: Toddalioideae. It is a branched, erect shrub or a small tree, 6 m tall or more, with dense foliage. Every year, thousands of tons of its fruits are collected in the Mid Hill of Nepal and traded with India. This spice naturally occurs in forests and on open sites at altitudes between 1000 and 2100 m (Den Hertog and Wiersum 2000). It can also be propagated vegetatively from branch cuttings or seeds. It is tolerant to drought and can be grown successfully in low fertile marginal land. This can fetch lucrative price without any significant investment. Due to its carminative, stomachache, and anti-helmenthic properties; the fruits, seeds and bark are extensively used in indigenous medicines and best aromatic and flavored spice used specially in tomato pickles (fresh) and all kinds of fermented pickles in Nepalese tradition. The oil obtained by steam distillation of the fresh plant and fruits shows anti-fungal activity and can be used in crop disease management. Timur grows well in the barren lands and forests (community, leaseholds, and private), and is regarded as a prioritized commodity for export with its potential of trading in raw and processed form for Indian markets and producing oil for European markets. About 850 to 1,100 MT of timur is collected annually in Nepal and traded with with India, which is the principal buyer, purchases about 80 per cent in raw form of Timur (HVAP 2011)

Constraints in Production and Processing

- Lack of proper knowledge on harvesting, grading and value addition.
- Inadequate technical skills for processing, Lack of harvesting tools and processing.
- Difficult to establish nurseries because of low germination of seeds.

CHALLENGES

- Negligible spices research and development farms working on many spices with limited manpower.
- Nepal does not have improved high yielding varieties, scientific cultivation practices and far away from processing technologies. Whatever technology we have that has long way to reach to the growers and processors.

- Unwashed (dirty) fresh ginger reducing its SPS and gets quarantine problem; instead of that traders have to face many non tariff barriers during the trading process.
- Since Nepal became a member of WTO, without quality-processed product spices and meet SPS criteria cannot enter into international spice markets.
- Nepali spice products unable to meet the minimum standard of American Spice Trade Association (ASTA) and European Spice Association (ESA), to enter into European countries with respect to cleanliness and quality.
- Lack of proper knowledge on harvesting, grading and local value addition, and inadequate capacity of farmers to acquire required technical and business plan preparation skills.
- Low access to international spice market and its information.
- Large cardamom fetches good price but it has to compete with Sikkim and Darjiling products. Because of smoky appearance and low oil content hindering the high price.
- Inadequate storage facilities to farmers, traders, and processor to wait for better price of spices.

OPPORTUNITIES

- Nepal has diversified climate from tropical to temperate, where almost all spices can be grown successfully.
- Growers will get more returns from spice crops per unit area, time and inputs invested than cereals and other crops.
- Seed spices like coriander, fenugreek, cumin, fennel, Bishop's weed can be grown commercially in Tarai and Mid Hill.
- In the recent years, all over the world, there is a growing trend in the use of various spices in culinary preparations due to changing food habits of the present generation.
- As per its importance in employment generation, earning foreign currency and potential in balancing international trade not getting due priorities.
- There is high possibility of doubling the price of cardamom and ginger through value addition in drying, cleaning and marketing by attractive packaging.

WAY FORWARD

- Wild, domesticated and introduced spices should be conserved and registered along with their DNA finger printing.
- All these spices should be promoted for commercial production that could help in minimizing the trade imbalance and increase income and employment opportunities in the country.
- The growing demands for organic crop products have led to the development of international trade for organic spices. Europe is the world leading market for organically produced spices. Spice export is always a significant part of total agricultural export of the country.
- Cinnamon (Dalchini) and Zanthoxylem (Timur) should be promoted through adopting improved package of practices in the community forests that will help to reduce soil erosion and increases income of the community through Silvi-horti system.
- Temperate climate in the high mountain regions has provided special opportunities to grow saffron, Jimmu and Himali Jeera.
- For the promotion of all these spices, a 'Spice Board' needs to be formed and spices should get due priority for research and development in the country.
- Special courses for spices production should be included in the curriculum of agricultural universities.
- All the Nepali spices mentioned above need to be dealt by one organization rather than keeping under two ministries MoAD and Ministry of forest and Soil Conservation.
- Spices varieties, which have high production potential and better export demand, have to be identified for promotion of quality planting materials in large scale, adopting the latest technologies.
- Rejuvenation of unproductive fallow land for the scientific cultivation of suitable spice crops should be given high priority.
- There is urgent need of establishing oils and oleoresin extraction industries in the country. Ample raw materials (ginger, turmeric, chilly, cardamom, Timur and cinnamon) are now available for the oil and

oleoresin extraction. Because of low volume, Nepal can directly penetrate into European and American spice trade by air.

- Among seed spices cumin, coriander, fennel in Tarai and valleys; tree spices Zanthoxylem (timur) and Cinnamon (Dalchini) in Mid Hill and Saffron in High Hills should be promoted for commercial production.
- There is need of exploring value added spice products in the International market under our own Nepali trade mark.

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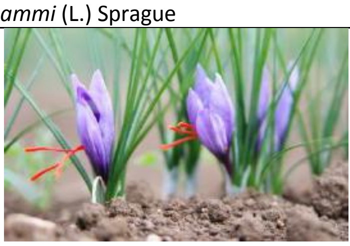
Annex 1. Some species of spices

 Ginger: *Zingiber officinale* Roscoe	 Ginger: *Zingiber officinale* Roscoe	 Cardamom: *Amomum subulatum* Roxb.
 Cardamom: *Amomum subulatum* Roxb.	 Shallot/ Chyaapi: *Allium cepa* var. *aggregatum* G.Don	 Fenugreek: *Trigonella foenum-graecum* L.
 Cumin/ Jeera: *Cuminum cyminum* L.	 Cumin/ Jeera: *Cuminum cyminum* L.	 Black cumin: *Bunium persicum* (Boiss.) B.Fedtsch.
 Bishop's weed/ Jwano: *Trachyspermum ammi* (L.) Sprague	 Fennel/ Sonf: *Foeniculum vulgare* Mill.	 Fennel/ Sonf: *Foeniculum vulgare* Mill.
 Saffron/ Kesar: *Crocus sativus* L.	 Cinnamon: *Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	 Cinnamon/Dalchini: *Cinnamomum cassia* (L.) J.Presl

 Black pepper: *Piper nigrum* L.	 Black pepper: *Piper nigrum* L.	 Nepal pepper: *Zanthoxylum armatum* DC.

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Diversity and Utilization Status of Sugar, Beverage and Narcotic, and Fiber Crops in Nepal

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ABSTRACT

Sugarcane, coffee, tea, tobacco, cotton and jute are the important cash crops of Nepal. Sugarcane is the most important sugar and bioenergy crop in the world that is cultivated for its stalks which accumulate sucrose. While coffee, tea and tobacco are the important beverage crops. Jute and cotton are also other important fiber crops of Nepal. Till now, there are 6 sugarcane, 2 coffee, 1 tea, 2 jute and 3 cotton species reported in Nepal. National Seed Board has released four sugarcane varieties for different domains. Similarly, two jute varieties and only one variety each of cotton and tobacco have been released. In case of germplasms, 98 sugarcane hybrids *Saccharum* complex have been maintained at NSRP, Jeetpur. A total of 166 accessions (88 of *Corchorus olitorius* L. and 78 of *Corchorus capsularis* L. have been conserved at JRP, Itahari. Germplasm of *Hibiscus cannabinus* L. has been lost which has been collected during a mission conducted by International Jute Organization (IJO). In case of beverage crops 24 genotypes of coffee (*Coffea arabica* L.) are coneserved at Horticulture Research Station, Malepatan, along with Coffee Research Program, Baletaksar, Gulmi. One genotype of *Coffea robusta* L.Linden is conserved at Coffee Development Center (CDC), Aapchaur, Gulmi. Seventeen genotypes of tea (*Camellia sinensis* (L.) Kuntze) are conserved at ARS, Pakhribas. There are many other landraces and exotic germplasm of sugarcane, tea, coffee, tobacco, cotton and jute that are needed to be explored and utilized for further improvement of these crops. So we need to step forward to collect, conserve and utilize those germplasm that are valuable resources for genetic improvement in future.

Key words: Beverage crops, cash crops, fiber crops, germplasm

INTRODUCTION

Nepal is rich in agro-climatic condition ranging from warm subtropical in the plains to temperate in the mountain region. Diverse agro-ecological conditions, varied topography within a relatively small geographical area had created a most intense diversity in Nepal. A long history of cultivation has resulted in the selection of a large number of landraces of various crops in course of evolution. Due to the lack of proper conservation strategies, such genetic resources are not maintained well. Genetic erosion is the increasing problem of Nepal with increase in supply of improved modern varieties without any provision of collection and conservation of those valuable local resources. It is very essential to increase productivity of the crops to meet increasing demands of increasing population. This can be achieved only through crop improvement and their proper management in different environments. Crop improvement depends upon continuous availability of diverse plant genetic resources (PGR). Thus their availability and use will definitely ensure the development of suitable diverse genotypes which can give higher and more stable yield and tolerant to biotic and abiotic stresses.

The old landraces of sugarcane and jute found in the Tarai is mostly replaced by the hybrids while threatened in the hills. The various germplasm of coffee and tea may have been lost in due course of time. The various genotypes exotic or indigenous are not preserved for utilization in crop improvement as they are valuable genetic sources for crop improvement in future. A large degree of genetic erosion is evident in major botanical species including sugarcane, coffee, tea and jute. The improved sugarcane genotypes are replacing valuable old landraces which are the major source for the future breeding programs. The plant genetic resources are the key ingredient for successful agricultural development so we need to move forward for creating the inventory of the landraces and improved genotypes and utilize. Those genotypes can be used for improvement of varieties to tackle the increasing challenges of climate change these days.

Sugarcane is a tall perennial true grass of the genus *Saccharum*, tribe Andropogoneae and family Poaceae (Graminae) which is native to the warm temperate to tropical regions of South Asia and Melanesia. This genus has six species viz *Saccharum officinarum* L., *Saccharum barberi* Jeswiet, *Saccharum sinense* Roxb., *Saccharum spontaneum* L., *Saccharum robustum* E.W.Branes & Jeswiet ex Grassl, and *Saccharum edule* Hassk. (Artschwager and Brandes 1958, Daniels and Roach 1987), two of which are wild (*Saccharum spontaneum* L. and *Saccharum robustum* E.W.Branes & Jeswiet ex Grassl) and the others are domesticated. *Saccharum officinarum* L. was the first named and is the primary species for production of sugar.

Jute is an important fiber crop. Commercial jute fiber is obtained from two cultivated species namely *Corchorus capsularis* L. and *Corchorus olitorius* L. The genus *Chorchorus* contains about 40 species which are distributed throughout the tropical regions of the world. Cotton (*Gossypium* spp.) is another important fiber crop, *Gossypium* genus which comprises about 50 species (Brubaker et al 1999).

Tea (*Camellia sinensis* (L.) Kuntze) is an important beverage which has high export value outside the country. It has been grown in wide range of climatic condition in the eastern part of Nepal ranges from 150 to 2200 masl. It is a perennial crop and takes more than 5 years for its full phase of production.

ORIGIN AND DISTRIBUTION

The centre of diversity of *Saccharum officinarum* L. is thought to be in New Guinea. The wild sugarcanes, *Saccharum spontaneum* L. and *Saccharum robustum* E.W.Branes & Jeswiet ex Grassl are found to be restricted to southern Asia and the islands in the Indian and Pacific Oceans adjacent to southeastern Asia. The range of *Saccharum spontaneum* L. seems to be much greater than that of, *Saccharum robustum* E.W.Branes & Jeswiet ex Grassl, extending from Turcomania and Afghanistan on the west to Melanesia and Taiwan on the east. Wild sugarcane of that species has been reported even from some of the small southern Pacific islands. The other wild progenitor of sugarcane, *Saccharum robustum* E.W.Branes & Jeswiet ex Grassl, is limited to New Guinea adjacent islands and Celebes known so far (Daniels and Roach 1987).

Arabica coffee has its primary centre of origin in highlands of south west Ethiopia and the Boma Plateau of Sudan. Tea (*Camellia sinensis* (L.) Kuntze) has been believed to be originated in South East Asia and China. Tobacco was believed to be originated in America and Island of Pacific. In case of jute, greatest diversity is found in Africa so the probable center of origin of *Corchorus olitorius* L. is Africa. Origin of *Corchorus capsularis* L. is believed to be in the Indo Burma region, as wild types of this species have been found in this region. Some scientists say that East Africa is the centre of origin of both white (*Corchorus capsularis* L. and black jute (*Corchorus olitorius* L.). Cotton was believed to be originated in India and Central Asiatic region including Central and South America. *Gossypium arboreum* L., *Gossypium nanking* Meyen was originated in India while *Gossypium herbaceum* L. was originated in Central Asiatic region. *Gossypium hirsutum* L. and *Gossypium purpurascens* Poir. and *Gossypium barbadense* L. was originated in South America (Wendel and Albert 1992, Seelanan et al 1997, Percy and Wendel 1990).

STATUS OF GERMPLASM

The present status of germplasm of cash crops in Nepal is presented in **Table** 1. Altogether 331 germplasm have been collected and conserved. Shrestha (1994) had reported the collection of 3 of Cotton, 215 of Jute, 7 of Sugarcane and 1 Tobacco germplasm in Nepal. National Sugarcane Research Program (NSRP) has collected 98 genotypes of sugarcane which are maintained at Jitpur (**Table** 2). There are around 20 landraces found in Mid Hill region of Nepal (**Table** 3). Most of those landraces are still not collected and conserved.

Similarly, Jute Research Program has collected altogether 180 germplasm of jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) from Mid Hill and Tarai of central and eastern development region of Nepal with the help of International Jute Organization (IJO). Among them, 78 *Corchorus capsularis* L. and 88 *Corchorus olitorius* L. germplasm are preserved at JRP, Itahari (**Table** 4 and 5). During the same mission, thirty germplasm of *Hibiscus cannabinus* L. (Java Jute) have also been collected.

In case of coffee, there are 24 germplasm conserved at Horticulture Research Station, Malepatan and Coffee Research Station, Baletakshar (**Table** 6). Few of them are local landraces.

A total of 23 coffee (*Coffea arabica* L.) has been collected from the different farms, stations and farmers' field and are conserved and maintained at the Horticulture Research Station, Malepatan, Pokhara (**Table** 6). Characterization of collected varieties of coffee is going on.

There are many cultivars of tea for the preparation of CTC and orthodox tea. About 17 genotypes of tea are collected and conserved at Agricultural Research Station (ARS), Pakhribas, Dhankuta (Table 7). There are many cultivars of tea for the preparation of CTC and orthodox tea. But the quality made tea is an average level. About 17 genotypes of tea were collected and maintenance in the ARS, Pakhribas, Dhankuta.

Two germplasm of cotton (Tamcot SP-37 and H-777) have been found in Nepal. In case of tobacco, 3 accessions (Burley-21, HDBRG and Belachapi-1) have been found till date. Burley and HDBRG are major growing tobacco genotypes popular among the farmers in Nepal. A private company Surya Nepal Private Limited has distributed these germplasm among the farmers for commercial cultivation.

Table 1. Status of germplasm of cash crops in Nepal

English name	Nepali name	Scientific name	Number of Accessions
Sugarcane	उखु	Saccharum complex	98
		Saccharum officinarum L.	20
		Saccharum barberi Jeswiet	
		Saccharum sinense Roxb.	
Coffee	कफी	Coffea arabica L.	24
		Coffee robusta L.Linden	1
Tea	चिया	Camellia sinensis (L.) Kuntze	17
Tobacco	सुर्ती	Nicotiana tabacum L.	3
Jute	जुट	Corchorus capsularis L.	78
		Corchorus olitorius L.	88
		Hibiscus cannabinus L.	-
Cotton	कपास	Gossypium arboreum L.	2
		Total	331

Table 2. Sugarcane genotypes maintained in field genebank, NSRP

SN	Genotype	SN	Genotype	SN	Genotype
1.	BO-91	34.	Co-98014	67.	CoSe-92440
2.	BO-99	35.	Co-98020	68.	CoSe-93232
3.	BO-110	36.	Co-98027	69.	CoSe-93234
4.	BO-113	37.	Co-98028	70.	CoSe-93235
5.	Jeetpur - 1	38.	Co-98029	71.	CoSe-93237
6.	BO-124	39.	CoH-119	72.	CoSe-94027
7.	BO-128	40.	CoJ-64	73.	CoSe-94429
8.	BO-130	41.	CoJ-85	74.	CoSe-94431
9.	BO-131	42.	CoJ-88	75.	CoSe-95255
10.	BO-132	43.	CoLk-94184	76.	Jeetpur-3
11.	BO-133	44.	CoP-9103	77.	CoSe-95427
12.	BO-134	45.	CoP-9105	78.	CoSe-95436
13.	BO-135	46.	CoP-92186	79.	CoSe-9601
14.	BO-136	47.	CoP-93182	80.	CoSe-96234
15.	BO-137	48.	CoP-94163	81.	CoSe-96238
16.	BO-138	49.	CoP-95181	82.	CoSe-96275
17.	BO-139	50.	CoP-96181	83.	CoSe-96436
18.	BO-141	51.	CoP-97181	84.	CoSe-97232
19.	BO-146	52.	CoS-767	85.	CoSe-97263
20.	BO-147	53.	CoS-8432	86.	CoSe-98231
21.	BO-150	54.	CoS-8436	87.	CoSe-98235
22.	BO-174	55.	CoS-88230	88.	CoSe-98259
23.	Co-0118	56.	CoS-96268	89.	CoSe-98426
24.	Co-0142	57.	CoS-96275	90.	CoSe-99233
25.	Co-0232	58.	CoSe-01235	91.	CoH -152
26.	Co-0233	59.	CoSe-01434	92.	CoH-160
27.	Co-0238	60.	CoSe-03234	93.	CoP- 2061
28.	Co-0239	61.	CoSe-88039	94.	CoS-08272
29.	Co-07250	62.	CoSe-92231	95.	CoS-88216
30.	Co-94024	63.	CoSe-92234	96.	CoSe -91259
31.	Co-97016	64.	Jeetpur- 4	97.	UP -0097

SN	Genotype	SN	Genotype	SN	Genotype
32.	Co-97020	65.	CoSe-92426	98.	UP -0098
33.	Co-97268	66.	CoSe-92430		

Source: NSRP 2016.

Table 3. Sugarcane landraces found in various districts of Nepal

SN	Genotype	Districts	SN	Genotype	Districts
1.	Dhode Ukhu	Khotang, Udaypur, Dhading	11.	Phulne Ukhu	Baitadi
2.	Gewora	Udaypur, Kaski	12.	Rasgulla 1	Gulmi
3.	Gulmi 4	Gulmi	13.	Rasgulla 2	Gulmi
4.	Gulmi 5	Gulmi	14.	Rato Gewora	Khotang, Dhankuta
5.	Gulmi 6	Gulmi	15.	Rato Koser	Udaypur
6.	Gulmi 7	Gulmi	16.	Seto Dhode	Udaypur
7.	Kaalo Gewora	Khotang, Dhading	17.	Seto Koser	Udaypur
8.	Kathe	Baitadi	18.	Ukhudi	Udaypur
9.	Maratha 1	Mahottari	19.	Phusre	Dhading
10.	Maratha 2	Dhading	20.	Kaski Local	Kaski

Table 4. Germplasm of black jute (*Corchorus olitorius* L.) at JRP, Itahari

SN	Genotype	SN	Genotype
1.	JRO-632	45.	X/022
2.	JRO-7835	46.	BL/067
3.	JRO-524	47.	YPY/026
4.	Itahari-2	48.	BL/133
5.	JRO 66	49.	SRP-1035
6.	JRO-128	50.	SRB/061 R
7.	JRC-7447	51.	BL/020 R
8.	JRO-878	52.	KEN/BL/039
9.	SRP-7016	53.	ILM/YPY/O91
10.	SRB-020(G)	54.	BL/105 G
11.	SM-1018	55.	PACH/YPY/O58
12.	SRB-061	56.	DS/046
13.	BL-020	57.	SUR/SRB/034
14.	X/107	58.	X/1020
15.	RB/063	59.	Y/1072
16.	KEN/DS/035	60.	KEN/SM/018
17.	BL/035(G)	61.	DS/046
18.	X/082 (G)	62.	Y/072
19.	ILM/YPY/067	63.	SRB/117 R
20.	BL/047 R	64.	X/072
21.	JRO 8432	65.	X/077
22.	BL/1 WR	66.	JRP/ACC 123
23.	SRB/024	67.	SM/007
24.	SM/024	68.	BL/121
25.	BL/054	69.	DS/040
26.	NY/018 G	70.	BL/068 G
27.	SRB/021	71.	JRO 534 (BJRI)
28.	BL/035 R	72.	SRB/026
29.	TAN/X/087	73.	SM/028
30.	BL/105 R	74.	NY/193 G
31.	ITAHARI-2	75.	RA Nansung
32.	SRB/033	76.	BL/121 R
33.	BJRI/ACC≠1968	77.	SUC/033 G
34.	SUC/033	78.	KEN-DS/029
35.	DS/069	79.	PYPY/011
36.	KESAI/SUC/003	80.	KEN/BL/096
37.	BL/046 G	81.	KEN/SM/065
38.	X/07/ R	82.	SRB/020 G
39.	X/022	83.	KEN/BL/096
40.	SRB/021	84.	YPY/020

SN	Genotype	SN	Genotype
41.	BL/106 R	85.	YA/064
42.	BL/067	86.	XA-063
43.	X/071 G	87.	KEN/DS/004
44.	DS/060	88.	KEN/BL/82

Table 5. Germplasms of white jute (*Corchorus capsularis* L.) at JRP, Itahari

SN	Genotype	SN	Genotype
1	JRC-321	40	JRP/2007/012
2	JRC-212	41	JRP/2007/JH/023
3	Itahari-1	42	YA/058
4	Jagadish agrawal-tricol	43	JRP/2007/JH/018
5	Satyanarayan chaudhary	44	FJ/052
6	Bc/011	45	SITARAM NARSARI TRIOL-7
7	Munilalbardiya tricol	46	JRP/2007/002
8	Jrp/2007/004	47	HYBRID32-C
9	PACH/YPY/1058	48	0.05JRP/200257/0.05002
10	JRC/673	49	JRP/2007/PHP14
11	JRP/673	50	JRP/2007/002
12	LISA-BJRI	51	DS/035
13	Y 027	52	FJ/040
14	SM/B2/2-2	53	LAXMAN
15	THAI/Y/133	54	BZ-2-2
16	PRAMOD K. MANDAL NOCHA MORANG	55	NAGENDRA
17	JRP/ACC≠202	56	AMARLAL
18	JRP/2007/001	57	FJ-1009
19	HA/Y/127	58	YA-097
20	KUL/092	59	JRP/2007/06A
21	FJ/037	60	CVL-1
22	FJ/050	61	JRP/2007/005
23	RA-NON SONG	62	KUL.032
24	UPC/94	63	BUDHEYSHOR
25	JRP/2007/JH/020	64	Y/119
26	JRC/444	65	KEN/SUC/083
27	BC/017	66	CVL-CC
28	JRP/2007/JH/026	67	LAHAN PATA
29	YA/080	68	KUL/084
30	JRC/212	69	C/239
31	JRP/2007/JH/018	70	CC-45
32	CHAIR-1	71	JRC/321
33	JRP/2007/006	72	FJ-1040
34	JRP2007/OM/015	73	HARI
35	URLABARI BAMTITA	74	UPC/094
36	NPL/SUR/SRB/O88	75	KEN/DS/066
37	JRP/2007/011	76	JRP/2007/007
38	SOLINESS-CC	77	LISA
39	JRP/2007/JH/024	78	CPT-CC

Source: JRP 2016.

Table 6. Coffee varieties/collection maintained at the Horticulture Research Station, Malepatan, Pokhara

SN	Genotype	Major characteristics
1.	Arghakhachi Local	Tall size tree produced red ripe cherry
2.	Bourbon Amarillo	Yellow ripe cherry, medium, sized tree, new flush green
3.	Bourbon Vermelo	Yellow ripe cherry, tree size tall, new flush green
4.	Catimore	Red ripe cherry new flush copper red
5.	Catui Amarillo	Tree sized medium, red ripe cherry new flush green
6.	Catui Vermelo	Tree size medium, red ripe cherry, new flush green
7.	Indonesia	Tree size tall, open, red ripe cherry, new flush green
8.	Caturra Vermelo	Tree size tall, open, red ripe cherry, new flush green
9.	Caturra Amarillo	Tree size tall, open, red ripe cherry, new flush green

SN	Genotype	Major characteristics
10.	Chhetradeep	Tall sized tree red ripe cherry
11.	Gulmi Local	-
12.	Hawai Kona	Tree size tall, open, red ripe cherry, new flush copper red
13.	Indo Tim-Tim	-
14.	Kaski Local	Red ripe cherry, tall and new flush green
15.	Ketisic	-
16.	Mundo Novo	Tree size tall, red ripe cherry, new flush green
17.	Pacamara	-
18.	Pacas	-
19.	Puranchaur Local	-
20.	Selection 10	Tall tree sized produced red ripe cherry
21.	Syangja Special	-
22.	San Roman	Dwarf cultivar
23.	Tekisic	Tall tree sized produced red ripe cherry
24.	Yellow Caturra	Tall sized tree producing yellow ripe cherry

Source: HRS 2014.

Table 7. List of exotic and indigenous tea (*Camellia sinensis* (L.) Kuntze) germplasm at ARS, Pakhribas, Dhankuta

SN	Genotype	SN	Genotype
1.	Takdha-78	10.	Balason
2.	Takda-135	11.	Gumti Selection
3.	Takdha-383	12.	Tinali
4.	Banukbarna-157	13.	Badamtam
5.	Happy valley	14.	Phowasring-1258
6.	Ambari-2	15.	Tagda-345
7.	Phuwachhiring-312	16.	Tagda-145
8.	Phuwachhiring-1404	17.	Banokbarna-668
9.	Tarapur		-

Source: ARS 2014

CHARACTERISTICS OF TEA GENOTYPES

Takdha-78

Mature leaves of Takdha-78 is long, smooth surface, pale green in color, pointed leaf apex, short petiole and less serrated leaf margin, average length is 10.8 cm and width is 4.4 cm, leaf area is 47.8 cm^2. The flower color is white. This genotype produces 1430 kg/ha of fresh leaves and readymade tea is 327 kg/ha. This genotype gives 25.3% recovery percent of made tea from fresh green leaf. The color of made tea is black and amount of Caffeine and crude fiber is 3.5% and 10.9% respectively.

Takdha-135

Mature leaves of Takdha-135 is long and wide, soft in nature, smooth surface, green in color, pointed leaf apex, petiole short and serrated leaf margin with average leaf area of 88.8 cm^2. The genotype has white flower. The production of fresh leaves is 486 kg/ha, and made tea is 148 kg/ha. The recovery percent of made tea from fresh green leaf is 30.4% at ARS, Dhankuta condition. The color of made tea is black and amount of Caffeine and crude fiber is 3.6% and 12.3% respectively.

Takdha-383

Mature leaves of Takdha-383 is long and wide, soft in nature, smooth surface, dark green color, pointed leaf apex, petiole short and serrated leaf margin, average length is 12.5 cm and width 4.4 cm with average leaf area is 55.25 cm^2. This genotype has white flower. It produces 1463 kg from 1 hectare which gives made tea of 381 kg. The recovery percent of made tea from fresh green leaf is 25.9% at ARS, Dhankuta condition. The color of made tea is black and amount of Caffeine and crude fiber is 4.2% and 10.3% respectively.

Banukbarna-157

Mature leaves of Banukbarna-157 is smooth, dark green in color, oval leaf apex, petiole short, serrated leaf margin with average leaf area of 49.15 cm^2. It also produces white flower. The production of fresh leaves is 363 kg/ha which gives made tea at 106 kg/ha. The recovery percent of made tea from fresh green leaf is 29.2%. The color of made tea is black and amount of Caffeine and crude fiber is 3.4% and 10.1% respectively.

Happy valley

Happy valley is a genotype which has long and wide, strong, puckered surface, dark green in color, pointed leaf apex, petiole short and less serrated leaf margin with average length of 14.4 cm and width 4.6 cm matured leaves. The leaf area of matured leaf is 65.0 cm^2. It produces white flower. It has strong bush, production of fresh leaves is 1511 kg/ha, and made tea is 345 kg/ha. The recovery percent of made tea from fresh green leaf is 22.8%. The color of made tea is black and amount of Caffeine 3.6% and crude fiber 9.9%.

Ambari-2

Mature leaves of Ambari-2 is long, less serrated leaf margin, green in color, pointed leaf apex, small size of leaf and average length is 9.8 cm and width 3.8 cm with around 37.8 cm^2 leaf area. The flower is white in color. It has strong bush which produces 659 kg/ha fresh leaves and made tea approximately 193 kg/ha. The recovery percent of made tea from fresh green leaf is 29.3%. The color of made tea is black and amount of Caffeine 4.0% and crude fiber 11.4%.

Phuwachhiring-312

Mature leaves of Phuwachhring-312 is long, strong, puckered surface, dark green in color, pointed leaf apex, strong and serrated leaf margin. The average length of matured leaf is 13.9 cm and width 4.9 cm and 69.0 cm^2 average leaf. The color of new flush is pink. The flowers are white in color. It produces strong bush which gives 786 kg/ha fresh leaves and 208 kg/ha made tea. The recovery percent of made tea from fresh green leaf is 26.6%. The color of made tea is black and amount of Caffeine and crude fiber is 3.5% and 10.9% respectively.

Phuwachhring-1404

Mature leaves of Phuwachhring-1404 is long, strong, puckered surface, pale green in color, pointed apex, less serrated margin with 9.1 cm average length and 3.5 cm width. The leaf area of matured leaf is 32.1 cm^2. It produces white color flower. It has strong bush which produces 984 kg/ha fresh leaves and 269 kg/ha made tea, recovery per cent of made tea from fresh green leaf is 27.3%. The color of made tea is black and amount of Caffeine and crude fiber 2.9% and 12.0% respectively.

Tarapur

Mature leaves of Tarapur is broad, thick, pale green in color, pointed leaf apex, petiole short and serrated leaf margin, 11.8 cm in length and 5.5 cm in width. The leaf area of matured leaf is 65.7 cm^2. The flower is white in color. Since it has strong bush the production of fresh leaves is 1263 kg/ha and made tea is 359 kg/ha. The recovery percent of made tea from fresh green leaf is 28.4%. The color of made tea is black and amount of Caffeine and crude fiber is 3.9% and 11.2% respectively.

Balason

Mature leaves of Balason is small, strong, green in color, pointed leaf apex, dense serrated leaf margin, pink colour new flush, average length is 9.4 cm and width 3.2 cm. The matured leaf has 30.2 cm^2 area. Balason produces white flower. It has strong bush which produces 579 kg/ha fresh leaves and 155 kg/ha made tea. The recovery percent of made tea from fresh green leaf is 26.7%. The color of made tea is black and amount of Caffeine and crude fiber is 3.5% and 11.4% respectively.

Gumti Selection

Mature leaves of Gumti selection is curved, strong, smooth surface, green in color, pointed leaf apex, serrated leaf margin, 10.4 cm average length and 4.0 cm width and 41.3 cm^2 leaf area. New flushes have high pubescence. It produces white flower. It has strong bush and production of fresh leaves is 1001 kg/ha and 284 kg/ha made tea. The recovery percent of made tea from fresh green leaf is 28.3%. The color of made tea is brown and amount of Caffeine 4.2% and crude fiber 11.2%. This tea genotype has produces high quality tea with flavor than the other genotypes.

Tinali

Mature leaves of Tinali is long and wide, strong, puckered surface, pale green in color, erect and serrated leaf margin, 15.3 cm average length and 5.3 cm width, 81.5 cm^2 leaf area. It produces white flower. The bush is strong and produces 1701 kg/ha fresh leaves and 405 kg/ha made tea. The recovery percent of made tea from fresh green leaf is 24.1%. The color of made tea is brown and amount of Caffeine and crude fiber 4.1% and 11.4% respectively.

VARIETIES RELEASED IN NEPAL

After the establishment of National Sugarcane Research Program (NSRP) at Jeetpur, Bara testing of sugarcane varieties of different maturity groups had been started systematically. The various genotypes were introduced in Nepal from All India Coordinated Research Project on Sugarcane (AICRPS), India. The varietal improvement was carried out with the genotypes obtained from AICRPS and landraces collected from various parts of the country. Fourteen varieties have been recommended so far for cultivation of sugarcane in different agro-ecological zones, soil types, water availability and seasons (**Table** 8). Till now, four sugarcane genotypes have been released in the name of Jeetpur-1, Jeetpur-2, Jeetpur-3, Jeetpur-4. Jeetpur-2 has been denotified due to low performance and disease severity. In Nepal none of the coffee and tea genotypes have been released. Belachapi-1 is only one variety of tobacco released for cultivation (**Table** 9). Jute Research Program (JRP) have recommended two jute varieties viz Itahari-1 (*Corchorus capsularis*) and Itahari-2 (*Corchorus olitorius*) in Nepal (**Table** 10). JRO-524 is another pipeline variety which is going to be released in near future. Tamcot SP-37 is one and only variety released for cultivation (**Table** 11).

Table 8. Sugarcane varieties released and recommended in Nepal

SN	Variety	Year of recommendation	Maturity group	Yield potential (t/ha)	Recommendation for
1.	BO 84	1978	Late	82	Irrigated Condition
2.	BO 88	1978	Late	72	Upland, Low Input
3.	BO 89	1978	Late	80	Irrigated Condition
4.	BO 91	1981	Late	83	All Condition
5.	BO 110	1990	Mid Late	81	Irrigated Condition
6.	CoS 767	1984	Mid Late	82	Irrigated Condition
7.	CoS 802	1984	Mid Late	88	Irrigated Condition
8.	CoS 7918	1986	Mid Late	93	Irrigated Condition
9.	CoS 8315	1986	Mid Late	104	Irrigated Condition
10.	UP 1	1984	Early	105	Low Input Condition
11.	BO 99	1981	Early	86	Irrigated Condition
12.	Jeetpur-1	1996	Early	75	Irrigated Condition
13.	Jeetpur-2*	1996	Early	107	Both Irrigated and Non irrigated Condition
14.	Jeetpur-3	2004	Early	90	Irrigated Condition
15.	Jeetpur-4	2004	Mid Late	92	Irrigated Condition

**Denotified. Source: NSRP 2015.*

Table 9. Tobacco varieties released and recommended in Nepal

SN	Variety	Year of recommendation	Maturity days	Yield potential (t/ha)	Recommended for
1	Belachapi- 1	1989	65	0.9	Tarai

Source: AICC 2016.

Table 10. Jute varieties released and recommended in Nepal

SN	Variety	Year of recommendation	Maturity days	Yield potential (t/ha)	Recommended for
1	Itahari-1 (Setopaat)	1999	118	3.4	Eastern Tarai
2	Itahari-2 (Sunaulopaat)	1999	116	3.3	Eastern Tarai

Source: AICC 2016.

Table 11. Cotton varieties released and recommended in Nepal

SN	Variety	Year of recommendation	Maturity days	Yield potential (t/ha)	Recommended for
1	Tamcot SP-37	1977	65	0.9	Central and Far-Western Region

Source: AICC 2016.

SCENARIO OF CULTIVATION

Sugarcane, Tea, Coffee, Tobacco, Cotton and Jute are the major cash crops of Nepal. Sugarcane is being grown in all agro-ecological zones but intensive commercial production accounts highest in Tarai region. Tea is grown in Tarai and Mid Hill region while coffee is grown only in Mid Hill. Coffee is expanding in the areas above 800 masl as the coffee in high altitude has specialty character and has good market in international market. Tobacco is grown in Sarlahi, Parsa, Dhanusa, Siraha and Sunsari districts of Nepal. Jute is grown in an area of 8641 hectares producing 12547 t. Cotton is grown in an area of 122.5 hectares producing 137 t of cotton fiber. Sugarcane is grown in an area of 66.6 thousand hectares producing 3.06 million tons of cane with national average yield of 45.99 t/ha in Nepal which is very low as compared to neighboring and other developed countries. Nepal was ranked 40th among the sugarcane producing countries in the world (FAOSTAT 2014). Jute is the third largest commercial crop. It is grown in an area of 8641 hectares producing 12547 t with average productivity of 1.452 t/ha. Tea covers 19271 hectares of land producing 21394 mt of fresh leaves with average productivity of 1.11 t/ha. The total area covered by coffee is 2381 hectares with annual production of 21394. The productivity of coffee in Nepal is 0.2 t/ha. In case to tea it occupies second position in area (AICC 2016).

WAY FORWARD

Collection and Conservation of Genetic Resources

Due to diverse agro-climatic condition in Nepal, there are many indigenous local germplasm which will be useful in different crossing programs. In-situ, on-farm, ex-situ conservation of genetic resources should be started to prevent the loss of diversity. Various conservation options and methods like Tissue Bank, DNA bank, Field Genebank and Household Genebank are possible options for conservation of genetic resources. Effective collaboration with different stakeholders should be maintained for effective and efficient conservation of genetic resources.

Characterization of Genotypes

The agro-morphological characterization is fundamental in order to provide information for plant breeding programs. The variability among the accessions is of great importance for breeding programs or genetic studies on particular species. So the characterization of the genotypes helps to prevent the duplication and waste of resources necessary for conservation.

Utilization of Genetic Resources

In Nepal, Sugarcane seed fuzz could not be produced due to unfavourable climate for natural breeding thus, conventional breeding is not possible. So artificial environment should be created for breeding sugarcane. Artificial breeding either physical or chemical mutation might be the other option for improving the genotypes available in Nepal. The available germplasm of jute coffee and tea should also be utilized for improvement of the varieties.

Collaborative Research and Germplasm Exchange

Collaborative exchange of germplasm among the various neighboring or other countries is necessary to increase the diversity. The sugarcane along with jute, tea and coffee germplasm could be exchanged via movements of sets or movement of in-vitro materials according to technical recommendation of International guidelines for safe movement of germplasm.

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Forage Production and Livestock Feeding Status in Nepal: Past, Present and Future Perspectives

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ABSTRACT
Nepalese livestock are underfed by more than 30 percent on dry matter (DM) basis. Though the introduction and cultivation of improved forage date back to Rana regime still the percentage of total land coverage under improved forage cultivation is very low in Nepal. More than 100 indigenous grass forages, 30 indigenous leguminous forages and 100 indigenous fodders have been cultivated since long back by the farmers. Similarly, more than 50 species of improved annual and perennial forages (leguminous and non-leguminous) along with more than 30 species of fodder trees are already introduced and cultivated in Nepal. However, only fifteen forage species namely, oat (*Avena sativa* L.) varieties Netra and Kamadhenu (2004), varieties Parwati and Ganesh (2012); white clover (*Trifolium repens* L.) variety Pyauli (2012); oat (*Avena sativa* L.) varieties Nandini and Amritdhara (2015), Berseem (*Trifolium alexandrinum* L.) variety Green Gold (2015); Rye Grass (*Lolium Perenne* L.) variety Dhunche Rye Grass (2015); Teosinte (*Euchlaena maxicana* Schrad.) variety Makaichari 1 (2017); Common Vetch (*Vicia sativa* L.) variety Kutil Kosha 1 (2017); Stylo (*Stylosanthes guianensis* (Aubl.) Sw.) variety Palpa Stylo (2017); Cocksfoot (*Dactylis glomerata* L.) variety Rasuwa Cocksfoot (2017); Napier (*Pennisetum purpureum* Schumach.) variety Hatti Ghash 1 (2017) and Setaria (*Setaria sphacelata* (Schumach.) Stapf & C.E.Hubb. ex Moss variety Khumal Bansho (2017) are released by the Pasture and Forage Research Division of Nepal Agricultural Research Council (NARC) and two forage species, *Avena sativa* variety Swan and *Trifolium alexandrinum* variety Mescavi are registered in 2017. Forage based feeding is vital for the economical and commercial livestock production. Improved seeds are the precursors to accelerate the forage productivity in Nepal. However, present level of seed production especially for leguminous and perennial forage is less than 10 percent of the total requirement. Government programs such as already completed livestock development projects along with the forage research programs have created awareness among all the stakeholders including farmers. Some of the very important native forage species such as *Kote* and *Dhimchi* and others should not be undermined. Livestock Breed Improvement Program (AI Mission) and the Fodder Production Program (Forage Mission) are becoming very popular which have focused on breed and seeds, respectively. Forage Mission targets to cultivate improved forage crops annually in about 7,500 hectares of land which is far below the prescribed coverage (32,800 hectares) under perennial and annual forage crops. Forage research and seed production of native to improved species should get high priority and forage cultivation should take the constant momentum for the economical and sustainable livestock enterprises in Nepal.

Keywords: Forage, leguminous, livestock, productivity, varietal release

INTRODUCTION
Though the Federal Democratic Republic of Nepal is smaller in land area it is very rich in its culture, religion, plant and animal bio-diversity. Nepal lies along with the slope of the Himalaya between China and India. Having land area of 147,181 km^2 with 800 Km from east to west and 144 to 240 Km from south to north in an altitude varies from 60 m to 8848 m above the sea level (LRMP 1986). About 28 million people reside in the country among them 65% are engaged in agriculture. 75% of those who are engaged in agriculture have kept at least one livestock with them (MoAD 2014). However, most of the livestock farmers are small holders and practicing subsistence farming from generation to generation. Livestock contributes about 12% to the national Gross Domestic Production (GDP) and about 26% to the Agricultural GDP (AGDP). Among different components of livestock, dairy component contributes about 63% to the livestock contribution (ADS 2015). However, majority of the farmers complain that livestock is not becoming profitable business to them. It is mostly because of the low productive animals, higher cost of production especially because of the higher price of the concentrate feeding. To overcome or mitigate these problems, government of Nepal has been implementing breed and feed improvement campaigns since last 6 and 5 years, respectively (DLS 2016). There is no doubt that breed improvement along with round the year green production is a must for the profitable livestock farming. Nepalese livestock are underfed by 30% on dry matter (DM) basis (Pariyar 2004). This paper has tried to explore the present livestock breed and feed in general and forage production status in specific which would help to the policy makers to make appropriate policies for the livestock sector development in Nepal (CBS 2011).

Some of the very important definitions related to this paper have been mentioned below:

- **Digestibility**: This is the percentage of a food stuff taken into the digestive tract that is absorbed into the body of the animals.
- **Dry matter (DM) of the feed**: Dry matter of the feed refers to the material remaining after removal of water or moisture content in the feed or feed ingredients. The nutrients in feeds required by the livestock for maintenance, growth, production, reproduction and or work, are the part of the DM presence in the feed.
- **Fodder:** It particularly refers to the feed given to the animals (including plants cut and carried to them), rather than that which they forage for themselves.
- **Fodder tree:** These are various trees having foliage or fruits used as fodder for livestock.
- **Forages:** Grasses and legumes fed at the proper stage of maturity and quality are called forages. These are roughages of high feeding value.
- **Grasses:** Grasses belong to the family Poaceae or Gramineae of monocotyledonous flowering plants. Poaceae includes the cereal grasses, bamboos and the grasses of natural grassland and cultivated lawns and pasture. Grasses have stems that are hollow except at the nodes and narrow alternate leaves borne in two ranks.
- **Indigenous forage**: These are the forage originating and characteristic of a particular country or native to the specific region or country.
- **Indigenous livestock**: These are the livestock originating and characteristic of a particular country or native to the specific region or country.
- **Leguminous forages**: Forages belong to the Leguminosae family which are usually high in protein, have nitrogen fixing bacteria in their root nodules and naturally improves the nitrogen content of soil.
- **Livestock:** Domesticated animals raised in agricultural system to produce commodities such as food, fiber, manure and power.
- **Nutrients:** Nutrients are the components that are found in food that bodies of the livestock process to enable it to function. Macronutrients provide the bulk energy while micronutrients provide the necessary cofactors for the metabolism to be carried out by the livestock.
- **Pasture:** Pasture is a large area of land where animals feed or graze on the grasses and other forage species.
- **Tree fodder:** Fodder harvested from the fodder tree.

LIVESTOCK BREEDS IN NEPAL

Indigenous/local breeds of livestock have dominated the total population of each species of animals in Nepal. Though, indigenous breeds have lower productivity but they possess remarkable positive attributes that may not be present in exotic breeds. Indigenous breeds may produce reliable volume of milk, meat and other relevant products even if they are reared in low nutritional profile. Indigenous species/breeds can withstand in a harsh environmental situations, very cold weather, dry and windy environment, no green is available during rainy season (Manang and mustang district), limited health care, poor shed, etc (Paudel et al 2009). Therefore, these breeds should not be kept in lower profile comparing with the productivity of exotic breeds of livestock available in Nepal (Aryal 1998).

Table 1. Breeds of livestock available in Nepal

SN	Species	Indigenous breeds	Exotic breeds	Remarks
1	Cattle	Pahadi Black, Tarai White, Lulu, Achhami, Siri, Khaila, Chauri, Yak and Naks.	Brown Swiss, Jersey and Holstein crosses.	Siri cow is extinct. The number of Lulu and Achchhami is decreasing.
2	Buffalo	Lime, Parkote, Gaddi, Tarai	Murrah and Murrah crosses	The number of Lime is decreasing.
3	Sheep	Bhyanglung, Baruwal, Kage and Lampuchchhre	Polwarth and Merino crosses	
4	Goat	Khari, Chyangra, Sinhal and Tarai goat	Jamunapuri, Barbari, Saanen, Boer and their crosses	Boer is getting popular these days
5	Pig	Hurrah, Chwanche, Bampudke	Landrace, Hampshire, Yorkshire, Duroc, Nagpuri and Pakhribas black	Bampudke is about to extinct
6	Chicken	Sakhini, Ghanti Khuile, Pwankh ulte	Various commercial breeds	
7	Horse	Jumli horse		

It is important to note that these indigenous breeds of each species certainly have remarkable genetic potentialities that have not yet been exploited but theses could be the potential filed for the researchers, scientists and development workers in Nepal (Paudel et al 2009). Therefore, conservation, preservation and proper utilization of these important breeds must get higher priority in the annual programs of the respected ministries, departments, district offices and local bodies. If any of these indigenous breeds extinct or patented by other countries, nothing will be remained except regretting for not becoming responsible in conserving them in a proper manner (DOLP 2015).

LIVESTOCK MANAGEMENT SYSTEMS IN NEPAL

Livestock especially ruminant management is governed by factors such as forage availability, cropping intensity, availability of forest resources, animal species and productive stage, the overall farming system of the area, labour availability and animal numbers per household. There are three traditional management systems still in practice in the country:

1. **Transhumant system:** This system is adopted in high Himalayan areas where herds of yaks, chauries, cattle, sheep, goats and horses migrate from one place to another throughout the year. Livestock move together in an annual cycle according to their requirement and grazing availability at different altitudes. Yaks occupy an ecological niche at high altitudes (3,000–5,000 m), *chauries* move little below, ie, between 1,500 and 4,000 m, while cattle move between 2,000 and 3,000 m. In contrast, sheep, goats and horses are more adaptable and move between 1,200–4,000 m. Plant growth is limited by cold weather and a short growing season. Vegetation at higher altitudes is only accessible for grazing in summer (July–September). Thereafter herds are moved to lower areas for winter (December–March); however, yaks are adapted only to cold climates and are seldom taken below 2500 m. This system utilizes forage resources from the alpine pastures during the monsoon, and crop stubble and fallow land in winter. During upward and downward migrations undergrowth in the forest region is the major forage source. Livestock provide milk and fiber and their dried manure is a major source of energy for cooking. Crossbred males (dzopas) are used for local transport and also supply meat. Goats and sheep supply meat and fiber. The use of mules, sheep and goats for trading and transport of basic inputs provides an important source of income (Paudel et al 2013).
2. **Sedentary system:** In this system livestock make grazing forages from the village and return in the evening. The main grazing areas in summer are scrubland and community grazing land around the village. The sedentary population consists of work oxen, dry buffaloes and a small number of cattle. This system prevails in the lower altitudes of the Hills (900–1 000 m) and utilizes all the available forage in and around villages. Cattle, buffalo and goats are the main grazing livestock. Forages include: grazing in the forest, on cultivated land after harvest, and fallow land; also crop residues from paddy, maize, millet, wheat, mustard, soybean and vegetables; grass gathered from terraces and forests; as well as tree fodder gathered from farmer-owned trees and forest trees. The grazing area is usually degraded and gully formation and soil erosion evident. Animals spend more than half their time grazing, but most of the feed is crop by-products and tree fodder in winter and grasses and weeds from crop land in summers which are offered evening and morning (Shrestha and Sherchand 1988).
3. **Stall-fed system:** This is mainly found in the Tarai and Low Hills (< 900 m) and peri-urban areas with milking buffalo and exotic or crossbred cattle. It is governed both by the availability of community grazing land and the steepness of the terrain, which may mean that other classes of livestock are also kept under stall-feeding. The system prevails in areas of intensive cultivation (three-crop sites), where the availability of crop by-products is adequate to feed the animals in winter. In addition to crop by-products, tree fodder, grasses and weeds from farm land are an important forage source. Fodder is collected from all land use systems and the major sources are: cropland, forest, grassland, shrub-land and non-cultivated inclusions (Neopane and Sah 2003).

FEEDING SYSTEMS FOR LIVESTOCK IN NEPAL

1. **Mountain:** Ruminants in high mountain areas mostly graze for 6–8 hours. Cereal by-products are fed to both ruminants and monogastrics. Concentrate feed is given to lactating and growing animals. Stall-feeding is only practiced when one or two animals are kept. Kundo (a homemade cooked concentrate) is only fed to lactating animals. Salt is given once in a week or two mixed in kundo when kundo is fed. Oxen are given better care during cultivation time. Yaks and chauries graze for more time than other ruminants; mostly they are left to graze in pastures, forest and along the streams

when the land is not covered with snow. They are let loose in such areas continuously for several days. It is more systematic at higher altitudes where a fixed system of rotational grazing prevails in the kharkas (pasture land) with 15–30 days in one kharka depending on the availability of forage and strength of the herd. In this system, there is no shed for the animals, only a compound divided into compartments, where the animals spend the night. Once the forage is finished in a kharka, they are moved to another. In winter when snow covers the pasture, animals do not find sufficient forage. In April–May, even when the pasture is bare, animals are left to graze and cannot even compensate the energy they spend going and coming from such pastures and they suffered great hardship. Although farmers make hay in high altitude in the rainy season when some grass is available, it is not sufficient to meet their nutrient requirement because farmers do not have sufficient land and prefer to grow potato, buckwheat and other crops on the limited land. Hay from native species like *Elymus nutans* Griseb. (furcha), *Pennisetum flaccidum* Griseb. (dhimchi), *Medicago sativa* L., Falcate (kote), and other local grasses is very expensive and considered best by farmers. Potato is one of the main items given to these animals as concentrate because it is available in sufficient quantity in both winter and summer (FAO 2005).

2. **Hill:** Because of the high animal population and cultivation pressure and large human population in the Mid Hills, there is competition amongst livestock species for available feed. Productive animals, especially lactating buffaloes and cattle, are kept in the villages and others, especially sheep, goats and dry stock are often taken to the pastures for about four months in summer. The sedentary population consists of work oxen, buffaloes and a few of cattle. This system prevails at the lower altitudes of the Mid Hill (900–1 000 m above sea level) and utilizes all the forage in and around the village. The animals spend half their time grazing but most of the feed comes from crop by-products and tree fodder in winter, and grasses and weeds from cropland in summers, which are fed evening and morning. Usually, fodder trees play an important role to provide feed in late winter. Productive animals, eg lactating buffaloes, receive better feed in terms of concentrate, green fodder and straw. Others subsist on straw and around the fallow land and nearby forest.
3. **Tarai:** Most livestock are stall-fed or graze around the villages on fallows, waste land, roadsides and are also fed by-products. Forage is cut and carried. Goats are penned all day and fodder is fed in a rack. Where the market access by road has improved, farmers have started to adopt new production technology based on balanced farming with cultivated fodder, fodder trees and appropriate crops to improve the feed along with increased farm productivity and keeping improved animals, especially buffaloes for milk. In winter livestock raisers generally feed oats, berseem, winter vetch in combination with paddy straw. In the rainy season, farmers feed livestock with Stylo, teosinte, Napier, jowar, summer joint vetch etc with combination of locally available feed resources. Farmers collect green feed for cut-and-carry; stall-feeding prevails in intensively cultivated areas where availability of crop by-products is sufficient to maintain animals in winter (Neopane 2002).

IMPORTANCE AND HISTORY OF FORAGE IN LIVESTOCK FARMING IN NEPAL

Livestock feed accounts about 60% to the total cost of livestock farming. The livestock products of Nepal are said expensive because of less attention paid to the forage farming. To reduce the cost of production of livestock products, it is a must that livestock farming is based in forage production. Realizing this fact, Government of Nepal has given high priority for the forage production program. On project basis, High Mountain Pasture Development Program was initiated with the assistance of Food and Agriculture Organization (FAO) in 1980. From the Asian Development Bank (ADB) support, first and second livestock development project were launched from 1980 to 1994 where fodder and pasture were one of the major components. In the same manner, Northern Belt Pasture Development Programs were launched in 10 Northern Mountain district from 1982 to 1992. The Third Livestock Development Project (TLDP) which was started in 1996 has given high priority for the forage production program. Accordingly, tangible outcomes were seen in the areas of forage and dairy sector development in Nepal. Leasehold forestry and livestock project (phase 1 and 2) has also shown remarkable progress in the areas of forage production in the project districts. Similarly, community livestock development project (CLDP) from 2004 to 2012 had also given high priority to the forage and dairy sector development in Nepal. The Artificial Insemination (AI) campaign was started from the fiscal year (FY) 2068/69 with the aim to increase additional 100,000 AI in cattle and buffaloes. Since this program became very popular and effective, the program demanded higher quality forage production for feeding the additional numbers of crossbred animals in Nepal. Realizing this fact, Government of Nepal has initiated National Forage development Campaign from FY 2070/71 for a period of 5 years. This campaign aims to increase 45,000 hectares of additional land to be cultivated with improved forage in 45 project districts. In addition to the increase in the areas of improved forage, the program also aims to motivate farmers for silage preparation, contract farming, output based subsidies on forage production, improved seeds and saplings distribution, procurement and distribution of forage related machines and equipments and human resource development.

Despite of several programs for the forage development, Nepalese livestock are underfed by 1/3rd on dry matter (DM) basis. Therefore, it is a great challenge for the commercialization of livestock enterprise. The forage seed mapping study (TLDP 2002) estimated that a minimum 32,800 ha of additional land should have to be planted under perennial and annual forage crops to meet animal requirements. This requires about 1,062 MT of seed which is almost 9 times the present level of seed production (120 MT in 2001). Major constraints to forage seed production include a lack of foundation seed, lack of technology in seed production and lack of information on seed demand and supply. There is also a critical shortage of trained manpower in the area of forage and pasture development. The research on forage production is mainly concentrated on forage oat, Berseem and other few selected species mainly on seed rate, fertilizer requirement and varietal selection. Therefore, it could be convinced with the statement that it will take about 1600 years to cover the available rangelands and degraded forest/shrub lands under improved pastures with the existing allowances (TLDP 2002). The timeline of forage sector development has been given, in short, below:

Table 2. Time line of forage development in Nepal

Year	Events
1860	Introduction of white clover in Kathmandu by the then Prime minister Jung Bdr. Ranna.
1944	Introduction of sub-tropical forage species (Rye grass, cocks foot and paspalum) in sheep farm, Chitlang.
1960/61	Introduction of subtropical forage species: Pennisetum, Brachiaria, Chloris, Cencrus, etc.
1970	Over 17 different pasture species were introduced in Multi-purpose Agriculture Center, Jiri.
1980	Livestock Development Project, funded by ADB, forage got high priority.
1987-90	Himalayan Pasture and Fodder research Network Project funded by FAO.
1992	Establishment of Pasture and Fodder Development Section in Department.
1993	Leasehold Forestry and Forage Development Project, funded by IFAD/FAO.
1997-02	Third Livestock Development Project; Focused on forage pasture development based on pocket/package approaches.
2005	Community Livestock Development Project; forage based feeding system.
2011	Artificial Insemination Program (AI mission) focused on breed development.
2013	Livestock Feed Development National Program (Forage Mission).

PRODUCTIVITY, CARRYING CAPACITY AND STOCKING DENSITY OF GRASS AND FORAGES OF NEPAL

Livestock managed under the grazing systems have been facing serious problems because of the degradation of the productivity of the grasslands. Some of the grasslands, their areas, productivity, carrying capacity and present stocking rate are shown in **Table** 3.

Table 3. Productivity and carrying capacity of some of the selected grasslands of Nepal

Grassland type	Area (km^2)	Productivity (TDN, t/ha)	Carrying capacity (LU/ha)	Present stoking (LU/ha)	Stocking density over the carrying capacity (times)
Sub-tropical and tropical (Open grasslands)	6293	0.58	0.54	7.07	12.19
Alpine	10141	1.54	1.42	0.64	0.5
Steppe	1875	0.06	0.09	1.19	19.0
Mid Hills			0.31	4.08	13.2

LU = Livestock Unit; and one LU = 1.11 MT TDN per year. Source: Pariyar 2003, Miller 1987.

The grazing lands except the alpine meadows are under heavy grazing pressure (Pariyar 2003). The Mid Hill and the open grazing lands are stocked by about 13 times more than its carrying capacity and the steppe grazing lands by about 19 times, whereas the alpine meadows are under-stocked. The alpine meadows are grazed only for summer three to four months.

However, the carrying capacity of the rangelands could be significantly improved by adopting improved management practices and introduction of some exotic forage species that are already acclimatized under some Nepalese agro-climatic conditions.

Crop residues, farm weeds and forest supplies make up the diet of the livestock in Nepal. Agricultural lands contribute about 60% of the total requirements, mainly in the form of low quality crop residues, and forest and grazing lands contribute the remaining 40%. In totality, the Nepalese livestock are under fed at least by about one-third (Neopane 2002).

The fact that ruminants are underfed has resulted in late maturity, high calf and adult mortality, poor lifetime performance, and infertility in cattle and buffaloes. The grassland areas by physiographic region are shown in **Table** 4.

Table 4. Grassland areas by physiographic region

Physiographic	Total land area		Grazing land of percentage		
region	(000' ha)	Percent	(000' ha	of total land area	of grazing land
Tarai				0.34	2.92
Siwalik	1879.00	12.74	20.55	0.14	1.21
Mid Hill	4350.30	29.50	292.78	1.98	17.20
High Hill	2900.20	19.66	507.13	3.44	29.80
High Himal	3497.00	23.71	831.54	5.64	48.87
Total	14748.50	100.00	1 701.66	11.54	100.00

Source: LRMP 1986.

Common Forage Species Available in Nepal

There are many forage species, indigenous to exotic, available in Nepal. The improve forage farming dates back to Rana regimes when Rana Prime minister Janga Bahadur Rana introduced White clover from the United Kingdom to Kathmandu in 1860 B.S.

Potential Forage and Pasture Species

Nepal having diverse climatic condition has very high potentialities for the improvement of forage production. There are some potential indigenous as well as introduced forage species that can be grown in specific areas of Nepal.

1. **Indigenous species:** Some of the indigenous species of forage can perform very well in some specific location. For example, Kote (*Medicago sativa* var. *falcata* (L.) Alef.*),* Furcha (*Elymus nutans* Griseb.) and Dhimchi (*Pennisetum flaccidum* Griseb.) have been forming well in High Mountain districts (Manang and Mustang). Similarly, local banso (*Setaria pallidefusca* (Schumach.) Stapf & C.E. Hubb.), Rai grass (*Lolium perenne* L.), Ghode Dubo (*Cynodon dactylon* (L.) Pers.), etc are famous in Mid Hills. Some of the important indigenous grasses are listed in the following table with their scientific name and nutrients content on them.

Figure 1. Dhimchi (*Pennisetum flaccidum* Griseb.) in Mustang district.

2. **Introduced species of grasses:** Among more than 50 exotic species of forages, some are very popular in Nepal, For example, Teosinte, Fodder Oat, Napier, *Sumba setaria*, Paspalum, Forage Peanut, White Clover, Signal Grass, Stylosanthes, Joint Vetch, etc are very popular in Nepal.

Figure 2. Sumba setaria forage grown in one of the farmers in Arghakhanchi district.

Unique, Rare and Endangered Landraces/Varieties

Since very limited works have been carried out in the areas of forage production, it cannot specifically be said about the unique, rare and endangered landraces/varieties of indigenous forage. However, experienced farmers say that the diversity of indigenous forages has been reduced during last 20-30 years. It could be the potential area for the researchers and scientists to explore and find out about the real status of indigenous forage species of Nepal. Some of the species for example, Kote (*Medicago sativa* var. *falcata),* Furcha (*Elymus nutans*) and Dhimchi (*Pennisetum flaccidum*) are unique and their cultivation areas have been decreasing in last few years because of the limited works done in the areas of seed production and multiplication which are must for the sustainable utilization of these species.

Important Forage Species World Wide

Following are some of the important forage species appropriate for the selected grassland types in the world. Only a few of them are tested in Nepal. Some of them are recognized by common and Nepali names. However, most of them, with respect to package of practices, are new even for the forage scientists in Nepal. This would help to open the arena of research for the researchers and scientists to work for the appropriate package of practices for the livestock sector development in Nepal (APP 1995 and CBS 2011).

Table 5. Potential forage and pasture species

Grassland types	Plant species composition
Tropical	**Perennial grasses**: Arthraxon hispidis, Arundinella nepalensis, Bothriochloa intermedia, Bothriochloa odorata, Cymbopogon jwarancusa, Chrysopogon aciculatus, Cynodon dactylon, Cymbopogon pendulus, Desmostachya bipinnata, Digitaria longissima, Eragrostis nigra, Eragrostis atrovirens, Eragrostiella nardoides, Hymenachne pseudointerrupta, Heteropogon contortus, Imperata cylindrica, Ischaemum timorense, Narenga porphyrocoma, Neyraudia reynaudiana, Phragmites karka, Panicum notatum, Paspalum conjugagatum, Paspalidium flavidum, Paspalum scrobiculatum, Pogonatherum paniceum, Saccharum spontaneum, Saccharum arundinaceum, Sclerostachys fusca, Setaria spp., Sporobolus indicus, Vetiveria zizaniodes. **Annual grasses:** Brachiaria villosa, Eragrostis unioloides, Eragrostis pilosa, Hackelochloa granularis, Sacciolepis indica, Setaria pallide- fusca, **Perennial forbs**: Artemisia vulgaris, Cissus repens, Cyperus spp., Desmodium heterocarpa, Ranunculus microphyllus, Tridax procumbens **Annual forbs:** Ageratum conyzoides, Rotala indica
Sub-tropical	**Perennial grasses:** Arundinella bengalensis, Arundinella nepalensis, Apluda mutica, Arundinella setosa, Apocopis paleacea, Arthraxon hispidis, Agrostis pilosa, Artemisia vulgaris, Andropogon contortus, Andropogon humilis, Brachiaria decumbens, Brachiaria villosa, Bothriochloa intermedia, Bothriochloa pertusa, Capillipedium assimile, Capillipedium parviflorum, Cymbopogon jwarancusa, Chrysopogon aciculatus, Chrysopogon fulvus, Chrysopogon gryllus, Cynodon dactylon, Cymbopogon stracheyi, Cymbopogon pendulus, Cheilanthes grisea, Digitaria longiflora, Eragrostis nigra, Eragrostis. atrovirens,

Grassland types	Plant species composition
	Eragrostiella nardoides, Eulaliopsis binata, Eulalia mollis, Heteropogon contortus, Imperata cylindrica, Ischaemum timorense, Isachne globosa, Eleusine indica, Justicia procumbens, Phragmites karka, Paspalum dilitatum, Paspalidium flavidum, Paspalum scrobiculatum, Perotis hordeiformis, Pogonatherum paniceum, Saccharum spontaneum, Sclerostachys fusca, Sporobolus fertilis **Annual grasses:** Digitaria setigera, Dimeria fuscescens, Brachiaria villosa, Eragrostis unioloides, Eragrostis pilosa, Eragrostiella leioptera, Eleusine indica, Ischaemum baratum, Sacciolepis indica, Setaria pallide- fusca, Schizachyrium brevifolium **Perennial shrubs:** Eupatorium adenophorum, thysanolaena latifolia **Perennial forbs:** Carex spp., Campanula colorata, Cynogolossum zeylanicum, Cyperus rotundus, Cyperus spp., Desmodium heterocarpa, Desmodium microphyllus, Dryopteris filix-mas, Elephantopus scaber, Gonostegia hirta, Micromeria biflora, Phyllanthus parvifolius **Annual forbs:** Sida rhombifolia, Laggera alata, Rotala indca
Temperate	**Perennial grasses**: Arundinella hookeri, Arundinella spp., Arundinella nepalensis, Arundinella setosa, Andropogon tristis, Agrostis micrantha, Agrostis canina, Agropyron canaliculatum, Agropyron semicostatum, Agrostis filipes, Agrostis munroana, Agrostis myriantha, Agrostis pilosa, Apluda mutica, Apocopis paleacea, Arthraxon hispidis, Brachypodium sylvaticum, Bromus ramosus, Bothriochloa bladhii, Bothriochloa spp., Chrysopogon gryllus, Cymbopogon spp., Cymbopogon distans, Calamagrostis epigejos, Calamagrostis pseudophragmites, Calamagrostis emodensis, Cymbopogon schoenanthus, Cymbopogon pendulus, Capillipedium assimile, Dactylis glomerata, Danthonia jacquemontii, Deschampsia caespitosa, Deyeuxia scabrescens, Digitaria longissima, Erianthus longisetosus, Eragrostis nigra, Elymus caninus, Eulalia mollis, Eulaliopsis binata, Eragrostis pilosa, Festuca spp., Festuca gigantea, Festuca kashmiriana, Festuca ovina, Festuca rubra, Festuca lucida, Festuca valesiaca, Glyceria tonglensis, Helictotrichon pratense, Helictotrichon virescens, Helictotrichon asperum, Imperata cylindrica, Koeleria cristata, Muhlenbergia duthieana, Muhlenbergia huegelii, Muhlenbergia spp., Miscanthus nepalensis, Oryzopsis aequiglumis, Orinus hardii, Oryzopsis lateralis, Poa pratensis, Poa angustifolia, Poa pagophila, Poa spp., Phleum alpinum, Poa alpina, Pogonatherum crinitum, Pennisetum flaccidum, Stipa concinna, Schizachyrium delavayi, Trisetum micans, Trisetum spicatum, Themeda quadrivalis, Themeda anathera, Themeda triandra **Annual grasses**: Hackelochloa granularis, Poa annua, Setaria pallide-fusca **Perennial forbs:** Anaphalis triplinervis, Artemisia spp., Berberis spp., Colquhounia coceinea, Cotoneaster spp., Desmodium spp., Pteridium acquilinum, Rosa spp.
Sub-alpine	**Perennial grasses:** Agrostis inaequiglumis, Agrostis pilosa, Anthoxanthum hookerii, Bromus himalaiacus, Bromus grandis, Calamagrostis emodensis, Calamagrostis pulchella, Chrysopogon gryllus, Cymbopogon choeanthus, Danthonia schneideri, Duthiea nepalensis, Deyeuxia spp., Elymus conaliculatus, Elymus dahuricus, Elymus nutans, Elymus schrenkianus, Elymus dahuricus, Elymus spicatum, Festuca comminsii, Festuca leptopogon, Festuca ovina, Helictotrichon virescens, Koeleria cristata, Poa lugens, Poa spp., Pennisetum flaccidum, Stipa concinna, Stipa duthiea, Stipa koelzii, Stipa regeliana, Stipa sibirica, Trikeria oreophilia, Trisetum spicatum, **Perennial forbs:** Artemisia spp., Desmodium spp., Stellera chamaejasme, Trigonella spp.
Alpine	**Perennial grasses:** Agrostis spp., Poa spp. **Perennial forbs**: Aster stracheyi, Androsace esimani, Cyperus spp., Carex spp., Cortia depressa, Geranium donainum, Kobresia hookeri, Kobresia nepalensis, Kobresia spp., Picrorrhiza scrophulariflora, Polygonum viviparum, Potentilla peduncularis, Rheum moorcroftianum, Swertia multicanlis, Saussurea gossypiphosa, Nardostachys jatamansi.
Steppe	**Perennial grasses:** Andropogon tristis, Aristidaspp., Arthraxon spp., Aristida adscensionis, Arundinella setosa, Agrostis pilosa, Bothriochloa intermedia, Bromus himalnaincus, Bromus grandis, Cymbopogon stracheyi, Calamagrostis spp., Cymbopogon schoeanthusi, Chrysopogon gryllus, Calamagrostis pseudophragmites, Calamagrostis spp., Deyeuxia holciforumis, Deyeuxia pulchella, Danthonia cachemyriana, Deyeuxia scabrescens, Danthonia spp., Elymus canaliculatus, Elymus schrenkianus, Elymus dahuricus, Eulalia mollis, Elymus semicostatus, Festuca ovina, Festuca spp., Helictotrich rescens, Koeleria cristala, Melica scabessima, Melica jacquemontii, Oryzopsis lateralis, Orinus thoroldii, Poa poophagorum, Poa paqophila, Poa alpigena, Pennisetum flaccidum, Poa spp., Stipa capensis, Stipa bungeana, Themeda triandra, Themeda anathera, Trisetum spp. **Perennial legume**: Medicago falcata **Perennial forbs:-**Berberis spp., Caragana brevifolia, Cerastostigma spp., Cyperacae, Carex spp., Juniperus squamata, Indigofera spp., Kobresia spp., Lonicera spinosa, Lespedeza spp., Potentilla fructicosa, Rhododendron anthopogon, Rhododendron lepitodium, Rhododendron nivale, Rosa sericea, Sophora spp., Scirpus spp.

Source: Pariyar 2008 and MoAC 2004.

Figure 3. Providing output based incentives to the forage farmers.

Figure 4. Kote grass in Mustang district.

Popular Forage Species with the Commercial Farmers in Nepal

Though there are several forage species grown by the farmers, some are very popular to the commercial livestock farmers in Nepal. These common and popular forage and fodder species are mentioned in **Table** 6 and 7 below:

Table 6. Common forage species found in Nepal

Category	English name	Scientific name	Nepali name	Remarks
Cereal forage (introduced)	Fodder maize	Zea mays L.	Ghanse Makai	All sites, locally adapted
	Teosinte	Euchlaena mexicana Schrad.	Makai Chari	Introduced in all sites
	Fodder oats	Avena sativa L.	Jai	Introduced in all sites
	Napier	Pennisetum Purpureum Schumach.	Nepier	Introduced in all sites
	Sorghum	Sorghum bicolor (L.) Moench	Junelo	In Tarai and Mid Hill
	Sudan grass	Sorghum×drummondii (Nees ex Steud.) Millsp. & Chase	Sudan grass	In Tarai and Mid Hill
Cultivated grasses (Introduced)	Signal grass	Brachiaria decumbens Stapf	Signal	Sporadic
	Blue Panic	Panicum antidotale Retz.	Hariyo Panic	Sporadic
	Mulato	(Brachiaria brizantha (A.Rich.) Stapf × Brachiaria ruziziensis Germ. & C.M.Evrard)	Mulato	Introduced in all sits
	Sumba setaria		Sumba setaria	In all sites
	Broom grass	Thysanolaena maxima (Roxb.) Kuntze	Amriso	In Tarai and Mid Hill
	Cocks foot	Dactylis glomerata L.	Orchard grass	Mid Hill to High Hill
	Rye grass	Lolium perenne L.	Rye grass	Mid and High Hill
Ground legumes (Introduced)	Vetch	Vicia sativa L.	Bikasi Kutli kosa	Introduced in all sits
	Stylosanthes	Stylosanthes guianensis (Aubl.) Sw.	Stylo	Sporadic
	Forage peanut	Arachis glabrata Benth.	Ghanse badam	Introduced in all sites
	Joint vetch	Aeschynomene americana L.	Bikasi Ankara	Introduced in all sites
	Berseem	Trifolium alexandrinum L.	Barseem	Tarai and Mid Hill
	Field pea	Pisum sativum L.	Ghanse kerau	Introduced in all sites
	Fodder cowpea	Vigna spp.	Ghanse bodi	Locally adapted in all sites
Indigenous forage	Kote	Medicago sativa var. falcata (L.) Alef.	Kote	Locally adapted in high mountain

	Furcha	Elymus nutans Griseb.	Furcha	
	Dhimchi	Pennisetum flaccidum Griseb.	Dhimchi	
	Bermuda	Cynodon dactylon L.	Dubo	Locally adapted
	Rye grass	Lolium perenne L.	Rye grass	Mid and High Hills

Table 7. Common fodder trees of Nepal

SN	English	Nepali name	Scientific name (Family)	Remarks
1.	Babylon weeping willow	Bainsa	Salix babylonica L.	Mostly in Hill and High Hill
2.	Bainsa	Bainsa	Salix babylonica L.	Tarai, Hill and Mid Hill
3.	Bakaino	Bakaino	Melia azedarach L.	Tarai, Hill and Mid Hill
4.	Banjh	Banjh	Quercus incana Bartram	Mostly in Hill and High Hill
5.	Bar	Bar	Ficus benghalensis L.	Tarai, Hill and Mid Hill
6.	Barro	Barro	Terminalia bellirica (Gaertn.) Roxb.	Mostly in Hill and High Hill
7.	Bhakkimlo	Bhakkimlo	Rhus javanica L.	Tarai, Hill and Mid Hill
8.	Bhatmase	Bhatmase	Cochlianthus gracilis Benth.	Tarai, Hill and Mid Hill
9.	Bhimal	Bhimal	Grewia optiva J.R.Drumm. ex Burret	Tarai, Hill and Mid Hill
10.	Bhote Pipal	Bhote Pipal	Ficus religiosa L.	In Mid and High Hill
11.	Bodhi tree	Bhote pipal	Ficus religiosa L.	Mostly in Hill and High Hill
12.	Bohori	Bohori	Cordia dichotoma G.Frost.	Mostly in Hill and High Hill
13.	Camel's foot tree	Rato tanki	Bauhinia longifolia (Bong.) Steud.	Adapted upto Mid Hill
14.	Camel's foot tree	Koiralo	Bauhinia variegata L.	Mostly in Hill and High Hill
15.	Chanp	Chanp	Michelia spp.	Mostly in Hill and High Hill
16.	Chifle	Chifle	Machilus gamblei King ex Hook. f.	Tarai, Hill and Mid Hill
17.	Chilaune	Chilaune	Schima wallichii Choisy	Mostly in Hill and High Hill
18.	Chuletro	Chuletro	Brassaiopsis sp.	Mostly in Hill and High Hill
19.	Coral tree	Faledo	Erythrina variegata L.	Up to High Hill
20.	Dudhilo	Dudhilo	Ficus neriifolia Sm.	Mostly in Hill and High Hill
21.	Dumri	Dumri	Ficus racemosa L.	Mostly in Hill and High Hill
22.	Garuga	Dabdabe	Garuga pinnata Roxb.	Mostly upto Mid Hill
23.	Gayo	Gayo	Inula cappa f. cappa	Tarai, Hill and Mid Hill
24.	Gedulo	Gedulo	Ficus clavata Wall. ex Miq.	Tarai, Hill and Mid Hill
25.	Ghiu Chiuri	Ghiu Chiuri	Bassia butyracea Roxb.	Mostly in Hill and High Hill
26.	Gidari	Gidari	Premna integrifolia L.	Tarai, Hill and Mid Hill
27.	Gogan	Gogan	Saurauia napaulensis DC.	Mostly in Hill and High Hill
28.	Gogan	Gogan	Saurauia spp.	Mostly in Hill and High Hill
29.	Harro	Harro	Terminalia chebula Retz.	Mostly in Hill and High Hill
30.	Harro	Harro	Terminalis chebula Retz.	Mostly in Hill and High Hill
31.	Hattipaile	Hattipaile	Eulophia pratensis Lindl.	Mostly in Hill and High Hill
32.	Jack fruit	Jack fruit	Artocarpus heterophyllus Lam.	Tarai and Mid Hill
33.	Jamun	Jamun	Eugenia jambolana Lam.	Tarai, Hill and Mid Hill
34.	Kalo bohori	Kalo bohori	Cordia sp.	Tarai and Hill
35.	Kathe Kaulo	Kathe Kaulo	Persea gamblei (King ex Hook. f.) Kosterm.	Mostly in Hill and High Hill
36.	Katus thulo	Katus thulo	Castanopsis sp.	Mostly in Hill and High Hill
37.	Kauso	Kauso	Mucuna nigricans (Lour.) Steud.	Tarai, Hill and Mid Hill
38.	Kavro	Kavro	Ficus infectoria Willd.	Mostly in Mid and High Hill
39.	Khanayo	Khanayo	Ficus cunia Buch.-Ham. ex Roxb.	Introduced in all sites (Rai)
40.	Khari	Khari	Celtis australis L.	Mostly in Hills and High Hills
41.	Khasre khanyo	Khasre khanyo	Ficus semicordata Buch.-Ham. ex Sm.	Tarai, Hill and Mid Hill
42.	Khasreto/Gedilo	Khasreto	Ficus hispida L.f.	Mostly in Hill and Mid Hill

SN	English	Nepali name	Scientific name (Family)	Remarks
43.	Khasru	Khasru	Quercus semecarpifolia Sm.	Mostly in Hill and High Hill
44.	Koiralo	Koiralo	Bauhinia variegata L.	Mostly in Hill and High Hill
45.	Kukurdaine	Kukurdaine	Smilax perfoliata Lour.	Tarai, Hill and Mid Hill
46.	Kusum	Kusum	Schleichera oleosa (Lour.) Merr.	Tarai, Hill and High Hill
47.	Kutsimal	Kutsimal	Morus australis Poir.	Mostly in Hill and High Hill
48.	Lahare Pipal	Lahare Pipal	Populus deltoides Marshall	Mostly in Hill and High Hill
49.	Lakuri	Lakuri	Fraxinus floribunda Wall.	Mostly in Hill and High Hill
50.	Leucaena/ Ipil-Ipil	Ipil-Ipil	Leucaena leucocephala (Lam.) de Wit	Introduced in all except in High Hill
51.	Litsea	Kutmiro	Litsea polyantha Juss.	Mostly in Hill and High Hill
52.	Malingo	Malingo	Arundinaria maling Gamble	Tarai, Hill and Mid Hill
53.	Monkey's jackfruit	Badahar	Artocarpus lakoocha Roxb.	Adapted upto Mid Hill sites
54.	Mulberry	Kimbu	Morus indica L.	Introduced in all sites
55.	Nevaro	Nimaro	Ficus roxburghii Steud.	Mostly in Hill
56.	Nigalo	Nigalo	Phyllostachys nigra (Lodd. ex Lindl.) Munro	Mostly in Hill and High Hill
57.	Nivaro	Nivaro	Ficus roxburghii Steud.	Tarai, Hill and Mid Hill
58.	Paiyu	Paiyu	Prunus sarasoides	In Hill and High Hill
59.	Pakhuri	Pakhuri	Ficus globerrima	Mostly in Hill and High Hill
60.	Persian lilac	Sano bakaino	Melia azedarach	Introduced in all sites
61.	Phaleto	Phaleto	Erythrina variegata	In Hill and High Hill
62.	Phusre	Phusre	Lindera pulcherrima	In Hill and High Hill
63.	Pipal	Pipal	Ficus religiosa L.	Tarai, Hill and Mid Hill
64.	Premna	Ginderi	Premna integrifolia Willd.	Mostly in Mid Hill
65.	Rai Khanyu	Rai Khanyu	Ficus semicordata Buch.-Ham. ex Sm.	Mostly in Hill and High Hill
66.	Sajh	Sajh	Terminalia alata Wall.	Tarai, Hill and Mid Hill
67.	Sal	Sal	Shorea robusta Gaertn.	Tarai and Hills
68.	*Seto siris*	*Seto siris*	Albizia procera (Roxb.) Benth.	Tarai, Hill and Mid Hill
69.	Siltimur	Siltimur	Litsea cubeba (Lour.) Pers.	Tarai, Hill and Mid Hill
70.	Simal	Simal	Bombax malabaricum DC.	Tarai and Mid Hill
71.	Simali	Simali	Vitex negundo L.	Tarai, Hill and Mid Hill
72.	Siris	Siris	Lindera spp.	Mostly in Hill
73.	Tanki	Tanki	Bauhinia Purpuria L.	Tarai, Hill and Mid Hill
74.	Uttis	Uttis	Alnus nepalensis D.Don	Mostly in Hill and High Hill

Uprety and Uprety 2013

Released Varieties of Forage Species in Nepal

Despite of several varieties of forages of different species only 15 varieties (3 legumes and 12 non-legumes) have been released till now. These released varieties have been shown in **Table** 7.

Table 7. Released forage varieties in Nepal till March 2017

SN	Nepali name	Scientific name	Variety	Released year
1	Oat	Avena sativa L.	Netra and Kamadhenu	2004
2	Oat	Avena sativa L.	Parwati and Ganesh	2012
3	White clover	Trifolium repens L.	Pyauli	2012
4	Oat	Avena sativa L.	Nandini and Amritdhara	2015
5	Berseem	Trifolium alexandrinum L.	Green Gold	2015
6	Rye Grass	Lolium Perenne L.	Dhunche Rye Grass	2015
7	Teosinte	Euchlaena mexicana Schrad.	Makaichari 1	2017
8	Common Vetch	Vicia sativa L.	Kutil Kosha 1	2017
9	Stylo	Stylosanthes guianensis (Aubl.) Sw.	Palpa Stylo	2017
10	Cocksfoot	Dactylis glomerata L.	Rasuwa Cocksfoot	2017

12	Setaria	Setaria sphacelata (Schumach.) Stapf & C.E.Hubb. ex Moss	Khumal Bansho	2017
13	Napier	Pennisetum purpureum Schumach.	Hatti Ghash 1	2017
Total: 15 species: Oat- 6, Others- 9;		Legumes-3, non-legumes- 12		

KEY ISSUES

- Major problems associated with feeds and feeding, include both their quality and quantity during winter and summer, be it in migratory, sedentary or stall-fed systems.
- Shrinkage of pasture and community (public) grazing land, decreasing feed resources, unavailability of cereal and legume by-products for feeding animals etc have led to the quantity related problems.
- The available feeds and forages are mostly poor in nutritive value.
- Grazing in the forest area has been prohibited to a great extent causing some problems in the availability of feeds and fodders.
- Heavy dependence on poor quality roughages and degraded pasture and grazing lands has reduced the production and productivity of the livestock.
- Limited availability of improved seeds hinders the acreage of improved forage.
- Limited research on forage and fodder production.
- Silage preparation and feeding is not yet commonly practiced by the livestock farmers.
- Mechanization on feeds and feeding has not yet taken momentum.
- Selection of popular indigenous forage species, their seed production and multiplication is not yet materialized.
- Limited budget allocated for the forage development sector.

WAY FORWARD

- Enough and sustained focus must be provided for the forage and pasture production program.
- Selection of the outstanding species of local forage and seed production and multiplication should get high priority.
- Meaningful coordination among the stakeholders involved in forage production.
- Policy for availing natural forest, shrub-lands and degraded lands for livestock farmers to produce forage crops on lease basis.
- Quality regulation of forage seed testing, certification and truthful labeling.
- Capacity building of all the major stakeholders in forage research and development.
- Research for forage development must get the high priority.
- Use of Nobel technologies, eg, total mixed ration (TMR), feed blocks, urea-molasses-mineral blocks, urea and ammonia treatment, etc should be kept in the annual program of the district livestock services offices.
- The subsidy for the forage production must be concentrated on output base but not in input.
- The native forage, pasture and fodder species are to be recorded and documented from community level up to the national level leading to the patenting of the forage species in Nepal.

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Crop Wild Relatives: Status, Conservation and Utilization in Nepal

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ABSTRACT

Nepal being the hotspot of biodiversity, over 500 wild relatives of cultivated agricultural crop except maize and potato exists in the country. This study is primarily based on the desk review in combination with qualitative survey such as key informant survey, individual interviews conducted during field collections. Nepal being primary and secondary sources of origin of different cultivated plants, thus has harbored numerous crops wild relatives (CWR) like rice, wheat, barley, buckwheat, citrus and other fruits and vegetables. Based on Vavilov's center of origin, Nepal is the primary center of origin of 29 species of 11 genera under agronomical crops and 12 species of 6 genera under horticultural crops. Based on the classification of gene pool concept, 13 species of 10 genera of different wild related crops categorized under primary gene pool, are reported to be present in the country. About 40 species of 8 cereals, 55 species of 24 legumes, 73 species of 48 fruits, 68 species of 18 vegetables and 73 species of 24 aromatic/ spices have been reported to exist in Nepal. A significant portion of crop wild relatives has been lost since four decades. The CWR availability is in decreasing trend and 20-50% has been lost since a decade due to pressure of population growth, habit modification, urbanization, agriculture commercialization and climate change. However, the major two reasons for decreasing trend mentioned by the local people are due to lack of proper knowledge of its use value and lack of strong policy for conservation. Some of the wild genotypes have been identified and domesticated for economic value based on indigenous knowledge. Few wild fruits like *Malus, Pyrus* are used as rootstocks and few grain legumes; *Avena, Lathyrus* as fodder and feeds for livestock. The second Global Plan of Action (GPA) emphasizes the in-situ and ex-situ conservation of CWR for combating the extreme conditions of climate change. There are many wild relatives of cultivated food plants distributed all over the country but very scanty numbers of species are conserved in National Genebank. However, extensive collection and conservation work has been initiated in past two years along with the use of GIS tools for identification of analogue sites of different species. Ex-situ conservation in seed bank and field genebank has been the priority work for CWR in Genebank.

Keywords: Center of origin, conservation of CWR, crop wild relatives, gene pool

INTRODUCTION

Nepal with its unique geographic and subsequent climatic variation has been recognized as the hotspot of biodiversity with the existence of at least >25000 flowering plant species. The Biodiversity Profiles Project (1995) ranked Nepal as having the tenth richest flowering plant diversity in Asia. Although it covers only 0.03% of the earth's land area Nepal is home to more than 2% of all the flowering plants, 8% of all birds and 4% of all mammals.

In case of agriculture crops, 172 families, 296 genera, 599 species and 35 sub species have been reported to exist in the country (Regmi 1995). Out of these, 60 families, 155 genera, 225 species and 31 sub species are under cultivation and rest remains in wild condition. Except potato and maize, wild relatives of almost all cultivated crops exist. Nepal is reported to be the most probable northern most countries of origin for rice and at least five wild species of rice namely; *Oryza rufipogon* Griff., *Oryza nivara* S.D. Sharma & Shastry, *Oryza granulata* Nees & Arn. ex Watt, *Oryza officinalis* Wall. ex Watt and *Oryza minuta* J.Presl (Hara et al 1978, Koba et al 1994, Lu 1998, Shrestha and Vaughan 1989, Shrestha and Upadhyay 1999, Joshi 2005) and two wild relatives *Hygroryza aristata* (Retz.) Nees ex Wight & Arn. and *Leersia hexandra* Sw. and several weedy rice *Oryza sativa f. spontanea* Roshev. has been reported to exist in the country. In additions, several wild species of grain legumes, fruits crops are found in wild habitats of the country.

Crop wild relatives are wild plant species that are genetically related to cultivated crops, continue to evolve in the wild, developing traits such as drought tolerance or pest resistance that farmers and breeders can cross with domesticated crops to produce new varieties. They are the wild cousins of the cultivated crop species. Wild relatives contain a wealth of genetically important traits due to their adaptation to the diverse range of habitats and serve as a source of novel traits as most of them have experienced strong selective pressures and they share common ancestry with crops, easing the use of their genes in traditional breeding and biotechnology when required.

Nepali people depend on agro biodiversity within the country especially for food, fodder, fiber, fuelwood, medicine, timber and utilization and conservation has been a part of their lifestyle. Modern development has been accelerating the genetic erosion of overall biodiversity. Nepal has already lost a significant portion of the whole agricultural biodiversity within these three decades which also includes wild relatives. Agrobiodiversity conservation has been initiated within the country by formulation of conservation policies, rules and regulations. The less understanding of the agrobiodiversity including wild relatives has put these species under shadow. The lack of proper information or database on crop wild relatives has hindered the conservation activities and access to country's sovereign rights.

INFORMATION AND SEED COLLECTION PROCESS

Literature Review and Key informant Survey

Literatures related to crop wild relatives were reviewed. Basic information on crop wild relatives was collected from the literatures and key informant survey which included the members of community forestry groups, DADOs, Forest guards, tourist guides and mahouts.

Review of Herbarium Database

The reference herbarium available at National Herbarium under Department of Plant Resources Centre was reviewed for the documentation of identifying characters of the species and also to obtain the geo references of these species. The probable sites were obtained using Maxent and the collection plans and routes were planned to collect maximum species en-route.

Focus Group Discussion and Seed Collection

Focus group discussions at all sites on the available CWR were conducted with the locals of different identified sites. Our main objective of these discussion was to understand the people's perception on the status of CWR in the areas in terms of availability, reason for increase or decrease in availability, local and traditional knowledge. The site or probable site identification was the major focus of this discussion. These groups discussion also had the objective of sharing the information and awareness on CWR, the present conservation work and to obtain prior informed consent. Seeds and herbarium were collected with help of the local people after the discussion. The scientific sampling method taking into consideration the geographical extent, sampling representatives and environmental coverage was adopted to collect the maximum genetic diversity (**Figure** 1).

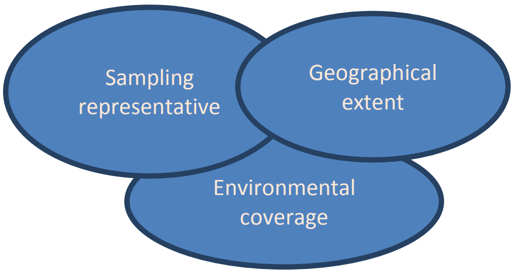

Figure 1. Sampling method.

CENTRE OF DIVERSITY AND GENE POOL

Gene pool centers refer to areas on the earth where important crop plants originated. They have an extra ordinary range of wild counterparts of cultivated plant species and useful plants. There are three gene pools; Primary gene pool (GP-1), Secondary gene pool (GP-2), Tertiary gene pool (GP-3).

Nepal is reported as proximal to the original and secondary origin of few crops like rice, wheat, buckwheat, citrus and other fruit crops and several vegetables. Based on the Vavilov's center of origin and Harlan and de wet's gene pool concept, 37 species of 15 crops of Nepal fall in Primary gene pool (GP-1) and are prioritized for collection and conservation (**Figure** 2). The species falling under GP-1 can intermate freely, crossing is easy; hybrids are generally fertile with good chromosome pairing.

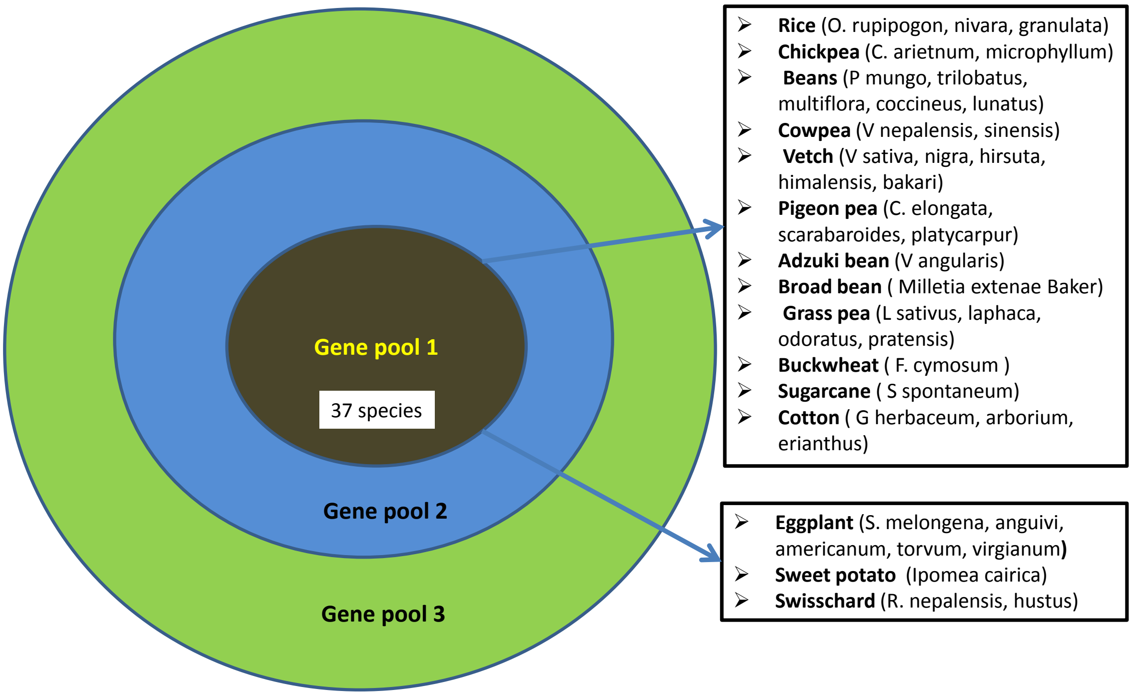

Figure 2. Gene pool of crops (Harlan and de Wet 1971) and Vavilov's center of Origin.

DISTRIBUTION OF THE CWR

The global analysis on distribution of CWR of 81 gene pools depicted that Nepal possesses 22-36 taxa of crop wild relatives (**Figure** 3) and is the hotspots for 18-22 taxas which needs urgent actions for ex-situ conservations (**Figure** 4) (Alvarez et al 2013). Based on the same analysis, Nepal is one of the five countries that have been identified as the high count of high priority taxa for urgent need of ex-situ conservation. More than 50 priority taxas exist with 0.04 CWR densities per square kilometer (**Figure** 5). Wild relative of sweet potato is priority species and a small insight on the gap analysis shows the collection gap of *Ipomoea cairiaca* (L.) Sweet species from Nepal's gene pool in global genebanks (**Figure** 6).

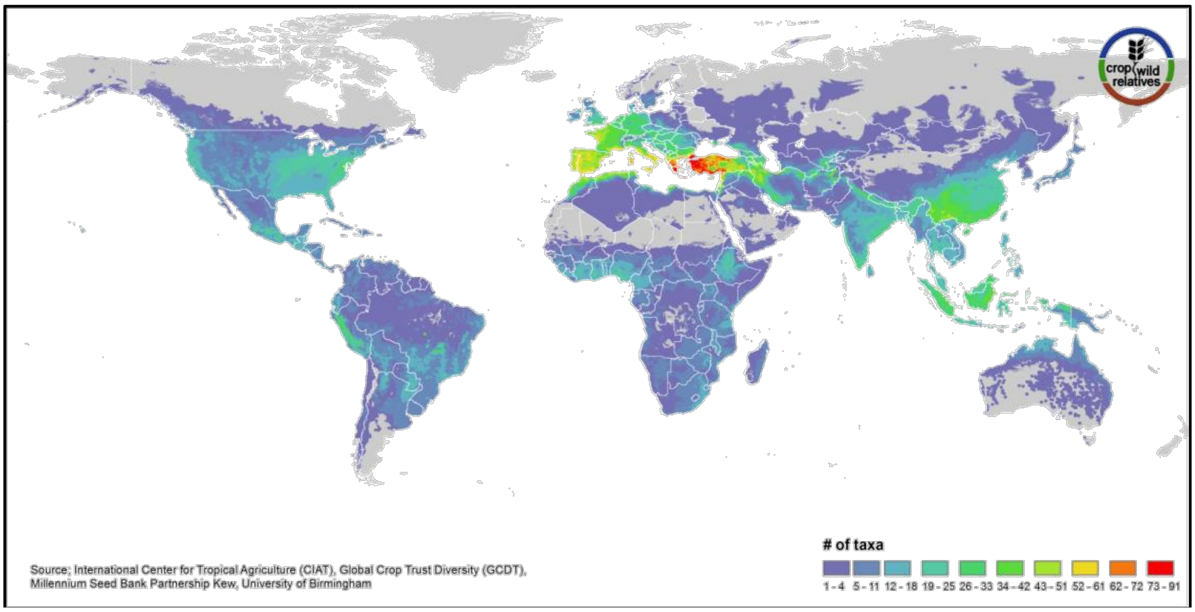

Figure 3. Global distribution of the CWR of 81 crop gene pool.

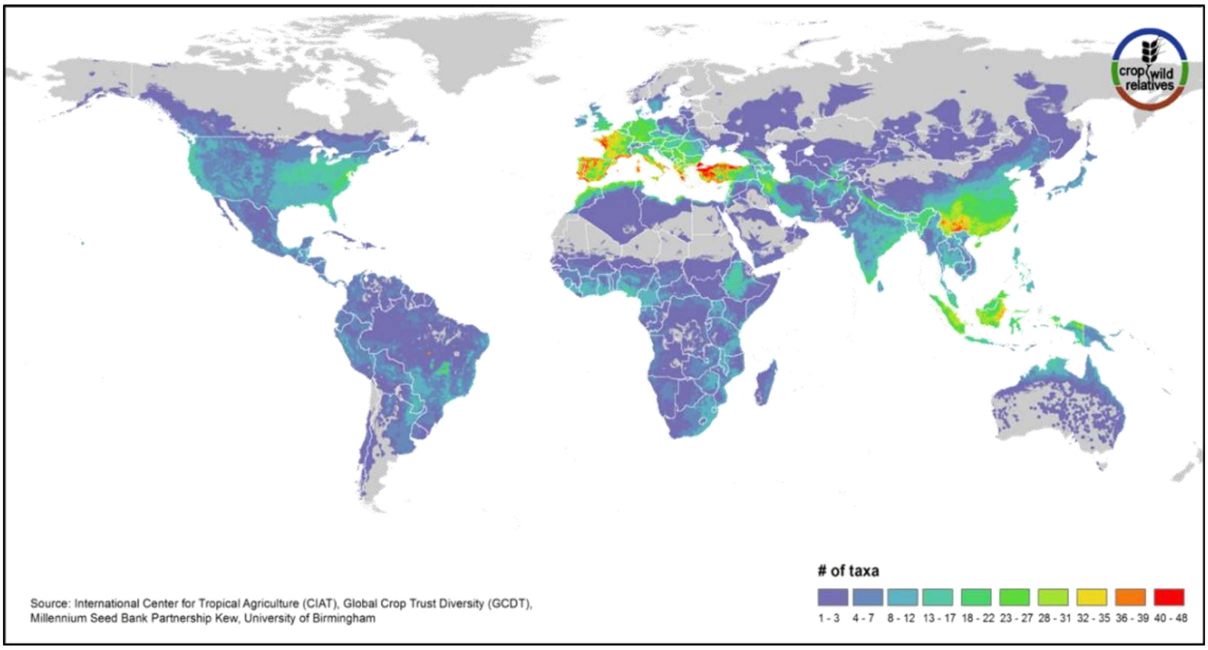

Figure 4. Global collecting hotspots for high priority taxa, for 76 crop gene pools.

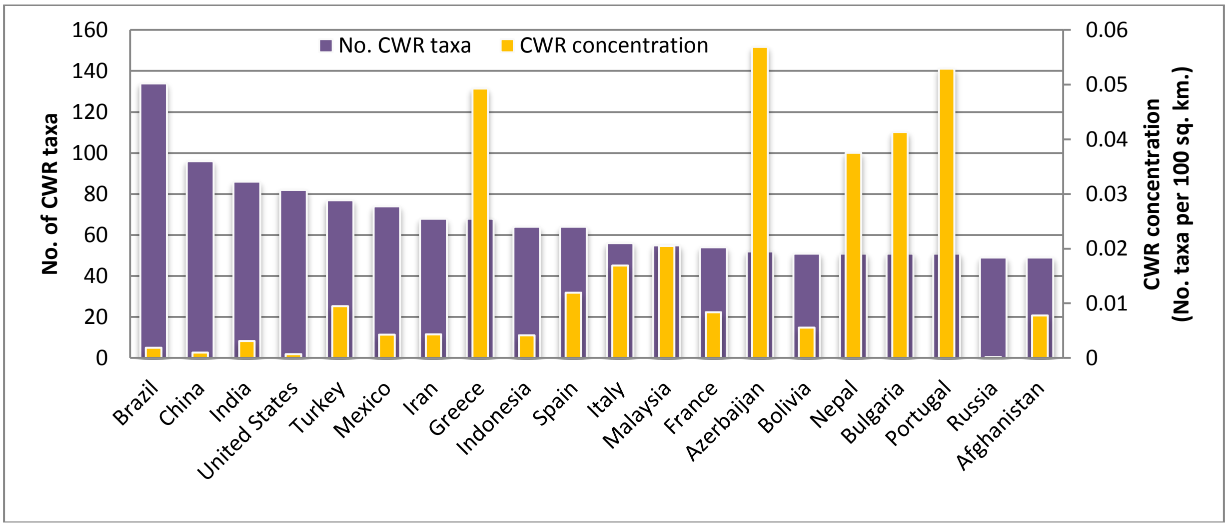

Figure 5. Top 20 countries with high count of high priority taxa for collection.

CWR IN NEPAL

Nepal is recognized as the hotspot of plant genetic resources, harbors large number of wild relatives of food crops. Regmi (1995) listed 64 wild species of 43 cultivated species. Shrestha and Shrestha (1996) reported 83 different wild relatives of 36 agricultural crops of Nepal. Upadhaya and Joshi (2003) reported 33 wild species of 5 cereal crops, 40 wild species of 14 grain legume crops, 56 species of 17 vegetable crops and 28 species of fruits. At least five wild species of rice has been reported to be found in the country (Hara et al 1978, Koba et al 1994, Lu 1998, Shrestha and Vaughan 1989, Shrestha and Upadhaya 1999, Joshi 2016). For wheat, Nepal being the proximal secondary origin, wild relative of wheat has been reported to be found in Northwestern districts of Jumla and Humla (Mudwari 1999, Joshi et al 2006) and five species of *Aegiolops* has been reported (Koba et al 1994, Joshi 2016). Nepal being the secondary centre of origin for finger millet and buckwheat, the existence of wild relatives of *Eleusine* and *Fagopyrum* needs to be explored and documented. Presence of *Fagopyrum megacarpum* H.Hara*, Fagopyrum tartaricum* sub sp. *potanni* or *annum* are reported by Baniya (1999) and Joshi (2008). There are many horticultural crop wild relatives that possess many values like disease and insect resistance, drought resistance, medicinal value, aesthetic value which is not yet domesticated.

Total 40 species of 8 cereals , 55 species of 24 legumes, 68 species of 18 vegetables, 73 species of 48 fruits , 73 species 24 spices and 17 species of 4 fodder crops has been reported to be present under wild relatives (**Figure** 6) (**Table** 1, 2,3,4,5,6).

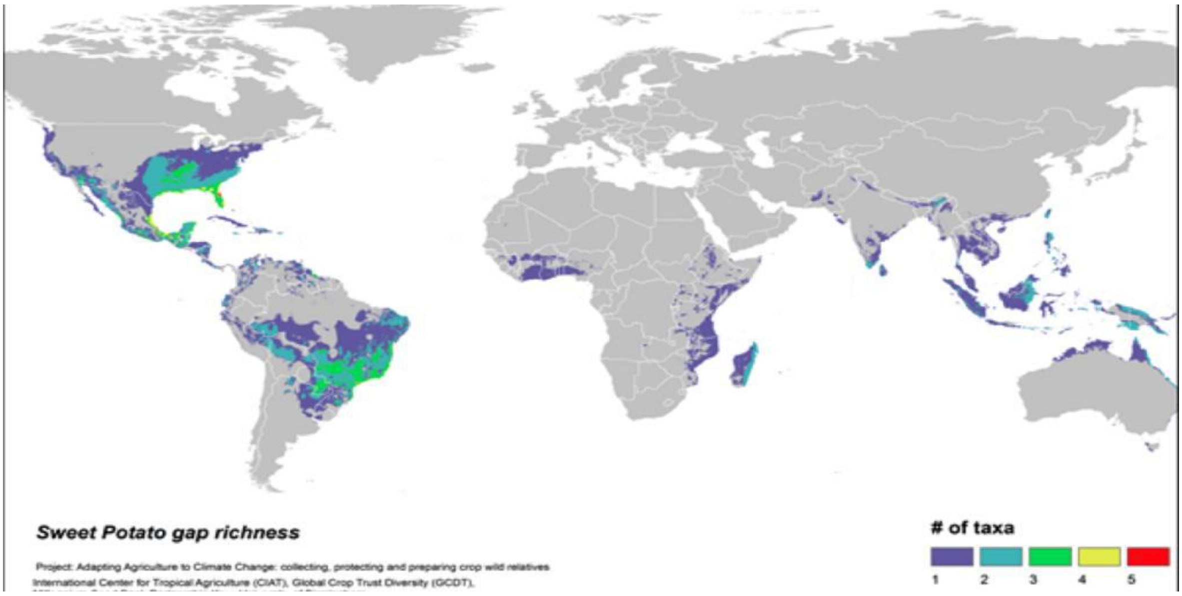

Figure 6. Gap analysis for collection of *Ipomoea.*

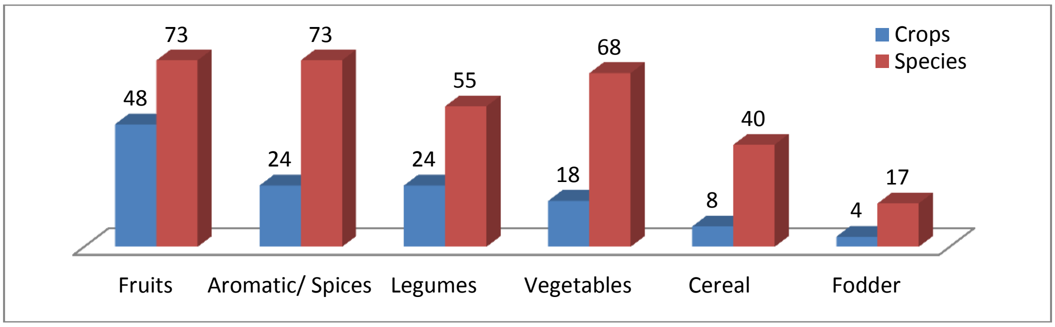

Figure 6. Number of wild relatives of different crops in Nepal.

Table 1. Wild relatives of cultivated cereal crop In Nepal

SN	Crop	Scientific names	Total
1.	Wheat	Ophiuros exaltatus (L.) Kuntze (Syn. Aegilops exaltata L.)	10
		Agropyron canaliculatum Nevski	
		Agropyron flexuosissimum Nevski	
		Agropyron longiaristatum (Boiss.) Boiss.	
		Agropyron microlepsis Melderis	
		Agropyron nepalense Melderis	
		Elymus schrenkianus (Fisch. & C.A.Mey.) Tzvelev (Syn. Agropyron schrenkianum (Fisch. & C.A. Mey.) Drobow)	
		Agropyron semicostatum Nees ex. Steud.	
		Agropyron sikkimense Melderis	
		Agropyron thomsonii Hook.F.	
2.	Barley	Hordeum spontaneum K.Koch	7
		Hordeum agriocrithon Aberg	
		Hordeum lagunculiforme Bacht.	
		Hordeum murinum subsp. glaucum (Steud.) Tzvelev	
		Hordeum murinum subsp. leporinum (Link) Arcang.	
		Hordeum bogdanii Wilensky	
		Hordeum brevisubulatum (Trin.) Link	

SN	Crop	Scientific names	Total
3.	Buckwheat	Fagopyrum cymosum (Trevir.) Meisn.	5
		Fagopyrum tataricum ssp. potanini Batalin	
		Fagopyrum tataricum ssp. annum	
		Fagopyrum megacarpum H.Hara	
		Fagopyrum gracilipes (Hemsl.) Dammer	
4.	Finger Millet	Eleusine indica (L.) Gaertn.	3
		Eleusine aegyptiaca (L.) Desf.	
		Dactyloctenium aegyptium (L.) P.Beauv.	
5.	Oat	Avena fatua L.	3
		Avena hybrida Peterm.	
		Avena barbata Pott ex Link	
6.	Rye	Lolium multiflorum Lam.	3
		Lolium perenne L.	
		Lolium temulentum L.	
7.	Fox-tail Millet	Setaria spp.	3
		Setaria italica (L.) P.Beauv.	
		Panicum spp.	
8.	Rice	Oryza rufipogon Griff.	4
		Oryza nivara S.D.Sharma & Shastry	
		Oryza granulata Nees & Arn. ex Watt	
		Oryza officinalis Wall. ex Watt	

Source: Koba et al 1994, Joshi 2008, Upadhyay and Joshi 2003, Joshi 2016.

Table 2. Wild relatives of cultivated legume crops In Nepal

SN	Crop	Scientific names	Total
1.	Pigeon Pea	Cajanus elongatus (Benth.) Maesen	
		Cajanus mollis (Benth.) Maesen	
		Cajanus scarabaeoides (L.) Thouars	
		Cajanus volubilis (Blanco) Blanco	6
		Cajanus platycarpus (Benth.) Maesen	
		Cajanus cajan (L.) Huth	
		Cajanus bicolor DC.	
2.	Chickpea	Cicer microphyllum Benth.	
		Cicer jacquemontii Jaub. & Spach	2
		Cicer arietinum L.	
3.	Broad Beans	Vicia angustifolia L.	
		Vicia himalensis (Camb.) Benth.	3
		Millettia extensa (Benth.) Baker	
4.	Vetch	Vicia sativa L.	
		Vicia hirsuta (L.) Gray	
		Vicia nigra (L.) Steud.	
		Vicia bakeri Ali	6
		Vicia tetrasperma (L.) Schreb.	
		Vicia rigidula Royle	
		Vicia tenuifolia Roth	
5.	Azuki Bean	Vigna angularis (Willd.) Ohwi & H.Ohashi var. nipponensis (Ohwi) Ohwi & H.Ohashi	
6.	Asparagus Bean	Vigna unguiculata subsp. sesquipedalis (L.) Verdc.	
7.	Black Gram	Vigna mungo (L.) Hepper	7
		Vigna sublobata (Roxb.) Babu & S.K.Sharma	
8.	Rice Bean	Vigna umbellata (Thunb.) Ohwi & H.Ohashi	
9.	Moth Bean	Vigna aconitifolia (Jacq.) Marechal	
		Vigna trilobata (L.) Verdc.	
10.	Beans	Phaseolus trilobatus L.	
		Phaseolus multiflorus Wild.	
		Phaseolus coccineus L.	5
		Phaseolus lunatus L.	
		Phaseolus vulgaris L.	
11.	Macrotylom	Macrotyloma axillare (E.Mey.) Verdc.	3

SN	Crop	Scientific names	Total
		Macrotyloma uniflorum (Lam.) Verdc.	
		Desmodium gangeticum (L.) DC.	
12.	Pea	Pisum sativum L.	2
		Pisum sativum ssp. arvense (L.) Asch. & Graebn.	
13.	Tate Simi	Lablab purpureus (L.) Sweet	4
		Dolichos lablab L.	
		Dolichos purpureus L.	
		Lablab vulgaris (L.) Savi.	
14.	Tarbare simi	Canavalia gladiata (Jacq.) DC.	2
15.	Khunde Simi	Canavalia ensiformis (L.) Poir.	
16.	Yambean	Pachyrhizus erosus (L.) Urb.	1
17.	Pate Simi	Pachyrhizus tetragonolobus (L.) DC.	1
18.	Cluster Bean	Cyamopsis tetragonoloba (L.) Taub.	1
19.	Cow Pea	Vigna unguiculata (L.) Walp.	2
		Vigna nepalensis Tateishi & Maxted	
20.	Ground Nut	Arachis hypogaea L.	1
21.	Soybean	Glycine max (L.) Merr.	1
22.	Velvet Bean	Mucuna nigricans (Lour.) Steud.	2
		Mucuna macrocarpa Wall.	
23.	Sun Hemp	Crotalaria juncea L.	2
		Crotalaria spp.	

Source: Neupane 1999, Upadhyay and Joshi 2003, Updated.

Table 3. Wild relatives of cultivated fruit crops In Nepal

SN	Crop	Genus Species	Total
A.	**Temprate Fruits**		
1.	Thekiphal	Actinidia callosa Lindl.	1
2.	Naru	Aesculus indica (Wall. ex Cambess.) Hook.	1
3.	Barberry	Berberis aristata DC.	2
		Berberis asiatica Roxb. ex DC.	
4.	Katus	Castanopsis hystrix Miq.	3
		Castanopsis tribuloides (Sm.) A.DC.	
		Castanopsis indica (Roxb. Ex Lindl.) A.DC.	
5.	Lapsi	Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill	1
6.	Jure Kafal	Eriobotrya dubia (Lindl.) Decne.	1
7.	Newaro (Angir)	Ficus carica L.	1
8.	Khanayo	Ficus semicordata Buch.-Ham. ex Sm.	1
9.	Panelu	Flacourtia indica (Burm.f.) Merr.	1
10.	Bhuin Kafal	Duchesnea indica (Andr.) Focke	1
11.	Okhar	Juglans regia L.	1
12.	Jangali Shyau	Malus baccata (L.) Borkh.	4
		Malus pumila Mill.	
		Malus sikkimensis (Wenz.) Koehne	
		Malus rockii Rehder	
13.	Kimbu	Morus alba L.	3
		Morus nigra L.	
		Morus rubra L.	
14.	Kafal	Myrica esculenta Buch.-Ham ex D.Don	1
15.	Dhurchuk	Hippophae salicifolia D.Don	2
		Hippophae tibetana Schltdl.	
16.	Jaitoon	Olea ferruginea Royle	2
		Olea glandulifera Wall. ex G.Don	
17.	Khurpani	Prunus armeniaca L.	1
18.	Painyu	Prunus cerasoides Buch.-Ham ex D.Don	3
		Prunus cornuta (Wall. ex Royale) Steud.	
		Prunus nepaulensis Ser.	
19.	Aloosha	Prunus salicina Lindl.	6
		Prunus undulata Buch.-Ha. ex D.Don	
		Prunus salicina Lindl.	

SN	Crop	Genus Species	Total
		Carissa arduina Lam.	
		Carissa spinarum L.	
		Carissa carandas L.	
20.	Peach	Prunus persica (L.) Batsch.	2
		Prunus jacquemontii Hook.f.	
21.	Anar	Punica granatum L.	1
22.	Pear	Pyrus pashia Buch.-Ham ex D.Don	2
		Pyrus serotina Rehder	
23.	Ainselu	Rubus ellipticus Sm.	3
		Rubus foliolosus D.Don	
		Rubus lineatus Reinw. ex Blume	
24.	Pureni	Parthenocissus himalayana (Royle) Planch.	2
		Parthenocissus himalayana var. rubrifolia (H. Lév. & Vaniot) Gagnep.	
25.	Grape	Vitis lanata Roxb.	2
		Vitis vinifera L.	
B. Sub Tropical and Tropical Fruits			
1.	Bel	Aegle marmelos (L.) Correa	1
2.	Archle	Antidesma acuminatum Wight	1
3.	Chiuri	Aesandra butyracea (Roxb.) Baehni	1
4.	Karaunda	Carissa spinarum L.	1
5.	Lasora	Cordia obliqua Willd.	1
6.	Madilo	Elaeagnus infundibularis Momiy.	1
7.	Amala	Emblica officinalis Gaertn.	1
8.	Jamun	Syzygium cumini (L.) Skeels	1
9.	Kaitha	Feronia limonia (L.) Swingle	1
10.	Sarifa	Annona squamosa L.	1
11.	Ramphal	Annona reticulata L.	1
12.	Bimiro	Citrus latipes (Swingle) Yu.Tanaka	2
		Citrus medica L.	
13.	Tindu	Diospyros malabarica (Desr.) Kostel.	1
14.	Satibayer	Rhus parviflora Roxb.	1
15.	Badahar	Artocarpus lakoocha Roxb.	1
16.	Jangali App	Mangifera sylvatica Roxb.	2
		Mangifera indica L.	
17.	Jangali Kera	Ensete glaucum (Roxb.) Cheesman	4
		Musa superba Roxb.	
		Musa superba Roxb.	
		Musa balbisiana Colla	
18.	Khajoor	Phoenix acaulis Roxb.	2
		Phoenix sylvestris (L.) Roxb.	
19.	Rasbari	Physalis divaricata D. Don	1
20.	Bhalayo	Cotinus coggygria Scop.	1
21.	Amera	Spondias pinnata (L. f.) Kurz	1
22.	Emli	Tamarindus indica L.	1
23.	Singhara	Trapa bispinosa Roxb.	1
24.	Alpine strawberry	Rubus calycinus Wall. ex D.Don	2
		Duchesnea indica (Andr.) Focke	
25.	Bayer	Ziziphus mauritiana Lam.	4
		Ziziphus incurva Roxb.	
		Ziziphus nummularia (Burm. f.) Wight & Arn.	
		Ziziphus oenoplia (L.) Mill.	

Source: Kaini 1999, Upadhyay and Joshi 2003, updated.

Table 4. Wild relatives of vegetable crops In Nepal

SN	Crop	Scientific name	Total
1.	Amaranths	Amaranthus lividus L.	13
		Amaranthus quitensis Kunth	
		Amaranthus oleraceus L.	

SN	Crop	Scientific name	Total
		Amaranthus polygamous L.	
		Amaranthus viridis L.	
		Amaranthus tricolor L.	
		Amaranthus blitum L.	
		Amaranthus hybridus L.	
		Amaranthus spinosus L.	
		Amaranthus hybridus ssp. cruentus (L.) Thell.	
		Amaranthus hybridus ssp. hypochondriacus (L.) Thell.	
		Amaranthus cruentus L.	
		Amaranthus hypochiondriacus L.	
2.	Fenugreek	Trigonella emodi Benth.	4
		Trigonella gracilis Benth.	
		Trigonella corniculata (L.) L.	
		Trigonella pubescens Edgew. ex Baker	
3.	Lamb's Quarter	Chenopodium ambrosioides L.	5
		Chenopodium murale L.	
		Chenopodium album L.	
		Chenopodium album ssp. amaranthicolor H.J.Coste & A.Reyn.	
		Chenopodium anthelminticum L.	
4.	Swiss Chard	Rumex nepalensis Spreng.	3
		Rumex hastatus D. Don	
		Rumex acetosa L.	
5.	Field Mint	Mentha spicata L.	2
		Mentha sylvestris L.	
6.	Egg Plant	Solanum torvum Sw.	6
		Solanum campylacanthum Hochst.	
		Solanum virginianum L.	
		Solanum americanum Mill.	
		Solanum anguivi Lam.	
		Solanum xanthocarpum Schrad. & H. Wendl.	
7.	Sponge Gourd	Momordica dioica Roxb. ex Willd.	4
		Trichosanthes cucumerina L.	
		Trichosanthes wallichiana (Ser.) Wight	
		Luffa echinata Roxb.	
8.	Rape Mustard	Rorippa nasturtium-aquaticum (L.) Hayek	3
		Rorippa indica (L.) Hiern	
		Rorippa dubia (Pers.) H.Hara	
9.	Common chilli	Capsicum frutescens L. conoides Bailey	2
		Solanum microcarpum DC.	
10.	Lady's Finger	Abelmoschus moschatus Medik.	2
		Abelmoschus manihot (L.) Medik.	
11.	Onion	Allium tuberosum Rottler ex Spreng.	2
		Allium ascalonicum L.	
12.	Sweet Potato	Ipomoea alba L.	6
		Ipomoea cairica (L.) Sweet	
		Ipomoea aquatica Forssk.	
		Ipomoea tuberculata Ker Gawl.	
		Ipomoea arachnosperma Welw.	
		Ipomoea purpurea (L.) Roth	
13.	Asparagus	Asparagus adscendens Roxb.	4
		Asparagus filicinus Buch.-Ham ex D.Don.	
		Asparagus racemosus Willd.	
		Asparagus penicillatus H.Hara	
14.	Waxgourd	Citrullus colocynthis Schrad.	2
		Cucumis callosus (Rottler.) Cong.	
15.	Cucumber	Cucumis melo var. agrestis Naudin	2
		Coccinia grandis (L.) Voigt	
16.	Carrot	Daucus carota L.	2
		Daucus carota L. var. sativa DC.	

SN	Crop	Scientific name	Total
17.	Yam	Dioscorea bulbifera L.	4
		Dioscorea deltoidea Wall. ex Griseb.	
		Dioscorea prazeri Prain & Burkill	
		Dioscorea pentaphylla L.	
18.	Jimbu	Allium hypsistum Stearn	1
19.	Taro	Alocasia navicularis (K.Koch & C.D.Bouché) K.Koch & C.D.Bouché	5
		Alocasia indica (Roxb.) Schott	
		Alocasia macrorrhizos (L.) G.Don	
		Colocasia affinis Schott	
		Alocasia fallax Schott	
20.	Sponge gourd	Momordica dioica Roxb. ex Willd.	3
		Momordica cochinchinensis (Lour.) Spreng.	
		Momordica charantia L	
21.	Pointed Gourd	Trichosanthes cordata Roxb.	2
		Trichosanthes dioica Roxb.	
22.	Sanke Gourd	Trichosanthes cucumerina L.	2
		Trichosanthes anguina L.	
23.	Mint	Mentha spicata L.	3
		Mentha longifolia (L.) Huds.	
		Mentha arvensis L.	
24.	Wild Garlic	Allium wallichii Kunth	2
		Allium hypsistum Stearn	
25.	Ashwagandha	Withania somnifera (L.) Dunal	3
		Withania coagulans (Stocks) Dunal	
		Withania ashwagandha Kaul	
26.	Bojho	Alpinia allughas (Retz.) Roscoe	2
		Alpinia bracteata Roxb.	
27.	Auised	Pimpinella spp.	2
		Pimpinella anisum L.	
28.	Ivy Gourd	Solena heterophylla Lour.	2
		Coccinia grandis (L.) Voigt	
29.	Devil's Tounge	Amorphophallus bulbifer (Roxb.) Blume	2
		Amorphophallus campanulatus Decne.	
30.	Bhir Kaulo	Coix lacryma-jobi L.	2
		Setaria spp.	
31.	Apple Peru Belladona	Nicandra physalodes (L.) Gaertn.	2
		Atropa belladonna L.	
32.	Lemon Grass	Cymbopogon flexuosus (Nees ex Steud.) W.Watson	5
		Cymbopogon jwarancusa (Jones) Schult.	
		Cymbopogon martini (Roxb.) W.Watson	
		Cymbopogon pendulus (Nees ex Steund.) W.Watson	
		Cymbopogon nardus L. var. stracheyi (Hook.f.) Raizada & Jain	

Source: Pandey 1999, Upadhyay and Joshi 2003, Updated.

Table 5. Wild relatives of fodder crops In Nepal

SN	Crop	Scientific name	Total
1.	Grass pea	Lathyrus sativus L.	9
		Lathyrus aphaca L.	
		Lathyrus laevigatus (Waldst. & Kit.) Gren.	
		Lathyrus odoratus L.	
		Lathyrus pratensis L.	
		Lathyrus sphaericus Retz.	
		Lathyrus humilis (Ser.) Spreng.	
		Calopogonium mucunoides Desv.	
		Desmodium gangeticum (L.) DC.	
2.	Sorghum	Sorghum halepense (L.) Pers.	4
		Sorghum miliaceum (Roxb.) Snowden	
		Sorghum roxburghii Stapf	
		Sorghum vulgare Pers.	

SN	Crop	Scientific name	Total
	Pearl Millet	Pennisetum spp.	3
		Pennisetum typhoides (Burm.f.) Stapf & C.E.Hubb.	
		Pennisetum orientale Rich.	
3.	Alfalfa	Medicago sativa L.	1
4.	Sama millet Grass	Echinochloa colona (L.) Link	3
		Echinochloa crus-galli (L.) P.Beauv.	
		Echinochloa frumentacea Link	

Table 6. Wild relatives of root and spice crops In Nepal

SN	Crop	Scientific name	Total
1.	Taro	Colocasia navicularis K.Koch & C.D.Bouche	5
		Colocasia indica (Roxb.) Schott	
		Colocasia macrorrhizos (L.) Schott	
		Colocasia affinis Schott	
		Colocasia fallax Schott	
2.	Greater Yam/ white Yam	Dioscorea spp.	5
		Dioscorea bulbifera L.	
		Dioscorea deltoidea Wall. ex Griseb.	
		Dioscorea prazeri Prain & Burkill	
		Dioscorea pentaphylla L.	
3.	Wild Garlic	Allium hypsistum Stearn	2
		Allium wallichii Kunth	
4.	Turmeric	Curcuma angustifolia Roxb.	6
		Curcuma aromatica Salisb.	
		Curcuma domestica Valton	
		Curcuma zedoaria Roxb.	
		Curcuma caesia Roxb.	
		Curcuma amada Roxb.	
5.	Sweet Potato	Ipomoea cairica (L.) Sweet	6
		Ipomoea alba L.	
		Ipomoea aquatica Forssk.	
		Ipomoea tuberculata Ker Gawl.	
		Ipomoea arachnosperma Welw.	
		Ipomoea purpurea (L.) Roth	

Source: Tiwari 1999, Pandey 1999 updated.

Table 7. Wild relatives of cash crops In Nepal

SN	Crop	Scientific name	Total
1.	Cotton	Gossypium spp.	1
2.	Tobacco	Nicotiana plumbaginifolia Viv.	2
		Nicotiana rustica L.	
3.	Sugarcane	Saccharum spontaneum L.	3
		Saccharum edule Hassk.	
		Saccharum robustum E.W.Brandes & Jeswiet ex Grassl	
4.	Jute	Chorchorus aestuans L.	2
		Chorchorus tridens L.	

Source: Shrestha 1999, Barakoti and Regmi 1999.

IDENTIFICATION OF ANALOGUE SITES

GIS is one of the most used tools in the field of CWR. The few references on geo locations of the crops were obtained from herbarium collections from the National Herbarium, Godawari and based on these, the possible analogue sites were analyzed for future explorations. The districts in red color are the high suitable districts for the specific species. The wild oat (*Avena fatua*) was collected from the western Tarai district which has wider distribution across the agro ecology but the analogue sites are the Mid Hill and High Hill of the eastern and central districts (**Figure** 6). The analogue sites for wild rice species, *Oryza nivara* is entire Tarai regions of the country (**Figure** 7). *Oryza meriyana* is found in the few districts on far west, mid-west and central region (**Figure** 8). *Oryza rufipogan* is highly concentrated in far western districts and few mid western districts (**Figure** 9).

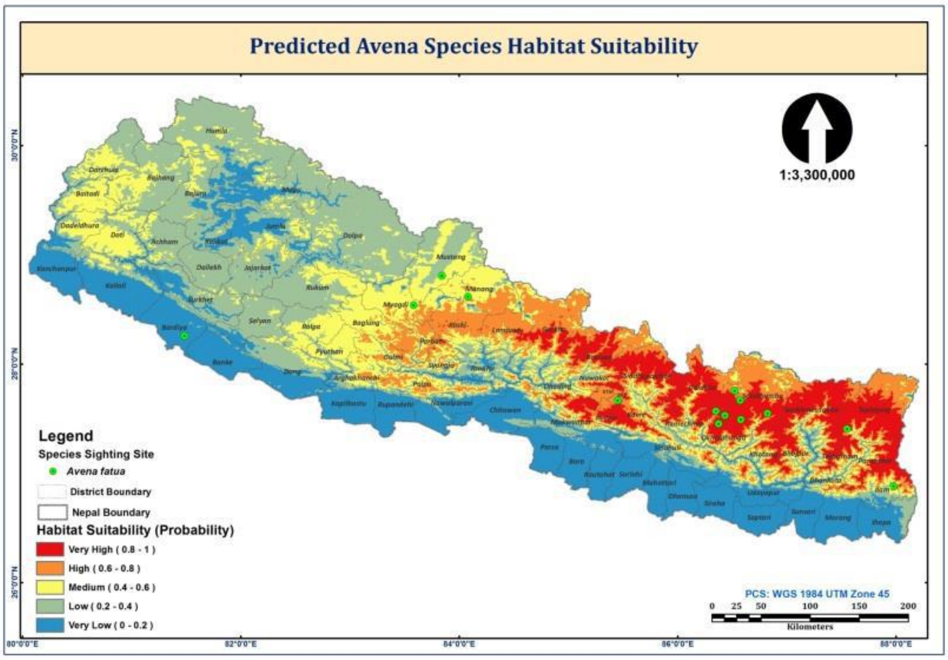

Figure 6. Analogue sites for *Avena fatua.*

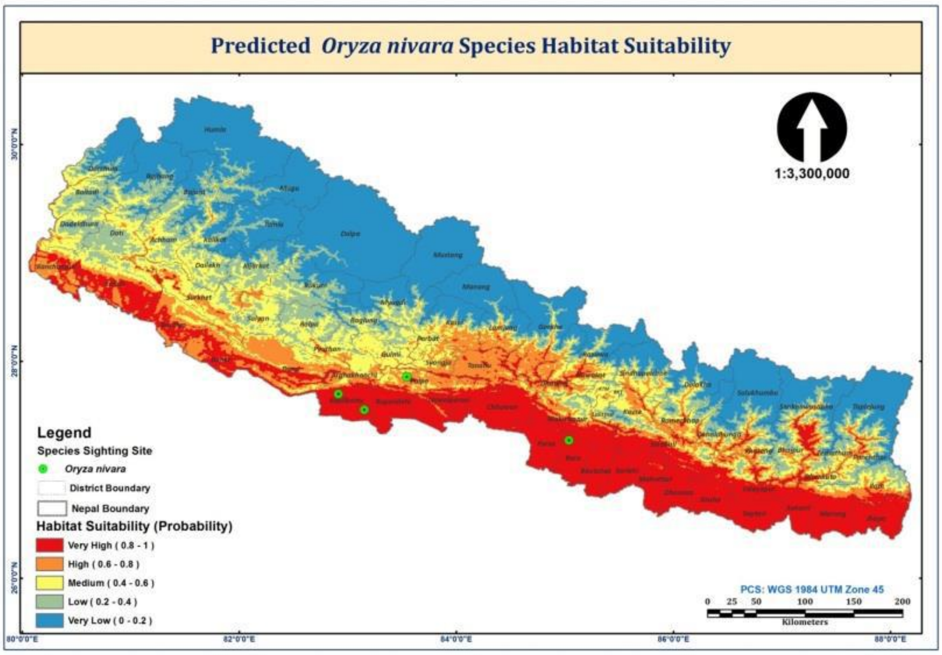

Figure 7. Analogue sites for *Oryza nivara.*

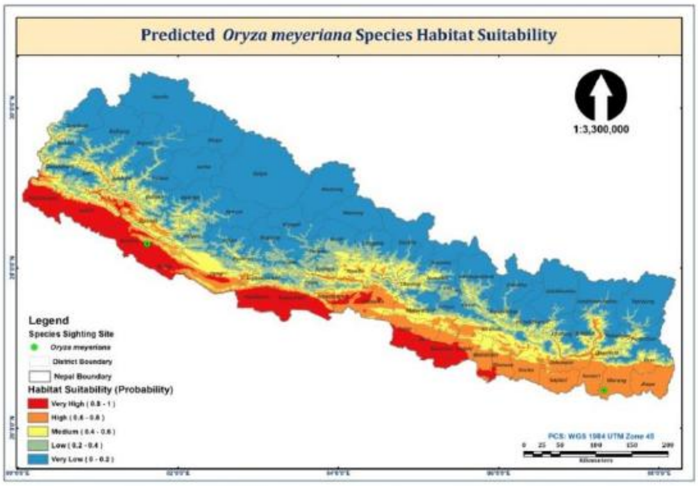

Figure 8. Analogue sites for *Oryza meriyana.*

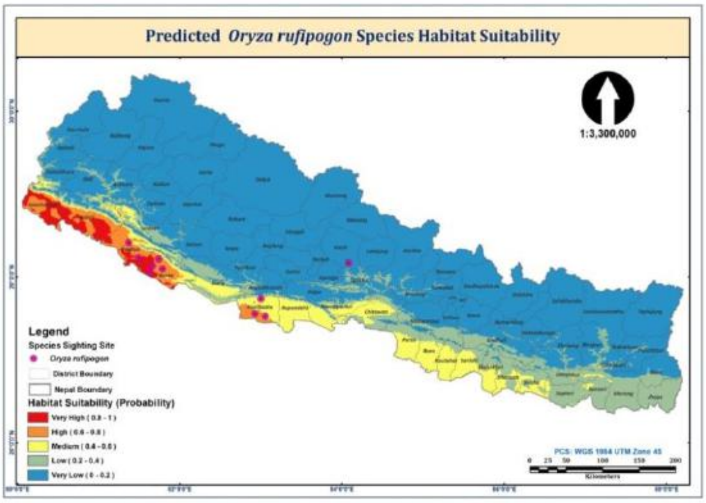

Figure 9. Analogue sites for *Oryza rufipogan.*

PERCEPTION ON STATUS OF CWR OVER 10 YEARS

Majority of local people perceive the decrease of CWR by 20-50% in last 10 years period. However, there are cases of increase in the availability status of the species like *Prunus salicina* (Alucha) due to the awareness on the medicinal value of this species (**Figure** 10, 11). Loss and even extinction of the crop wild species have been reported by many reports. For instance, *Oryza officinalis* has been reported to be almost extinct from Nepal by Shrestha and Upadhyay (1999). Nepal has observed considerable genetic erosion of agricultural plant genetic resource (APGRs) in last one decade due to several reasons. The major reasons for the loss are perceived as the lack of knowledge on its importance and use value. Lack of policy focusing on the conservation of wild relatives combined with the massive commercialization in agriculture is the other two reasons. Low focus on conservation efforts, increasing urbanization leading to deforestation, encroachment of forest lands are additional factors contributing to this trend (**Figure** 12).

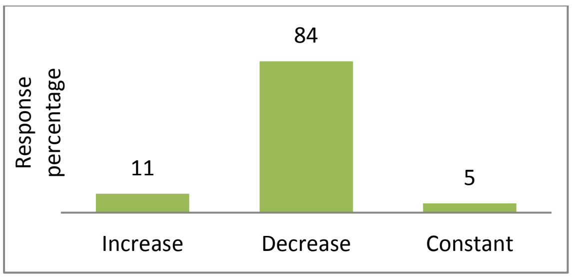

Figure 10. Status on the availability of CWR in percentage.

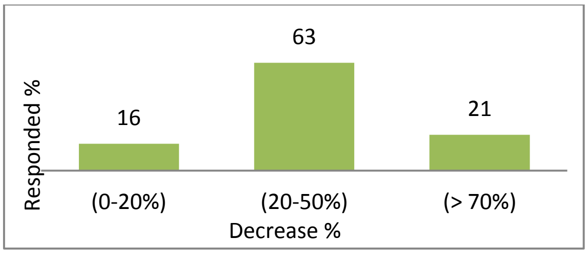

Figure 11. Trend on the availability of CWR in percentage.

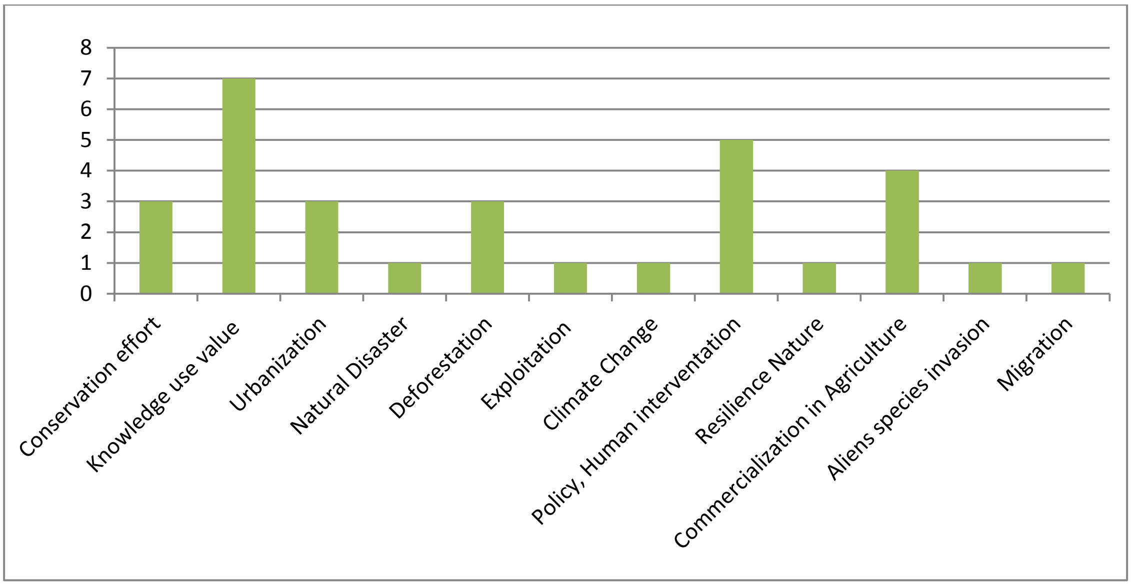

Figure 12. Reasons for genetic erosion of CWR in frequency.

CONSERVATION EFFORTS ON CROP WILD RELATIVES

Populations of a crop wild relative across its natural distribution area tend to show genetic differences between them. In addition to this, many crop wild relatives have not been collected at all. Thus, there is a lot of currently uncollected and non-conserved genetic diversity in the field that may be of importance for the further development of our crops. The populations containing this uncollected genetic diversity are subjected to the local environmental conditions, and thus to global changes such as climate change and land use change. Such changes can pose a threat to the survival of crop wild relatives and their genetic diversity. Under climate change, natural populations of plant species can either track suitable climate and thus shift to new regions where the climate becomes suitable, or adapt to the changing conditions.

The contribution of CWR in developing modern varieties of different agricultural crops has been well documented. The different biological factors and climatic factors are possessing threat to the genetic loss of crop wild relatives which has immense importance in development of new varieties in the world. Crop wild relatives can be an important source of traits such as drought resistance or pest resistance. CGIAR and other genebanks have been collecting and conserving the wild relatives of crops to make them available for plant breeders.

Collection and conservation of crop wild relatives has been the most neglected area in Nepal. First work on CWR was initiated by Dr Gyan Lal Shrestha and few collections of rice were collected and conserved in the genebank in collaboration with IRRI during 1988 (Shrestha and Vaughan 1989). This collection and identification brought Nepal into the global picture in the presence of wild relatives. With the recent focus on conservation of CWR, 53 accessions of 19 genera have been collected from different part of the country in year 2016 (**Figure** 13) and conserved in Genebank (**Table** 8). Same set has been deposited in Millennium Seed Bank UK. Fruit species are conserved also in field genebank in Genebank, Khumaltar.

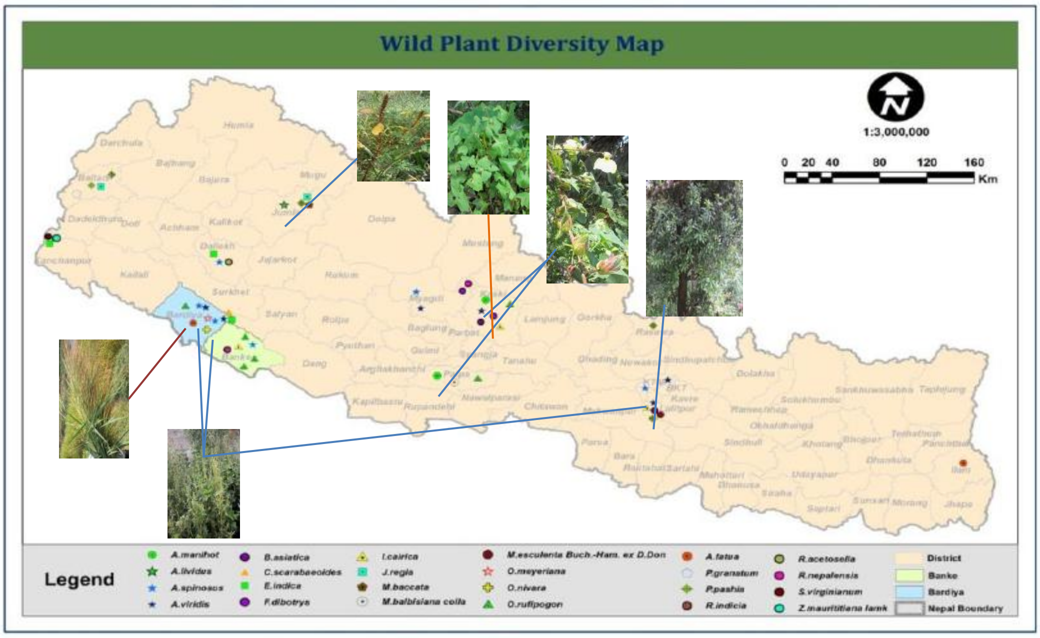

Figure 13. Collection map of the Crop wild relative in year 2016

Table 8. List of wild relatives conserved in National Genebank

SN	Crop	Local Name	Scientific name	Total
1	Finger Millet	Kode Jhar	Eleusine indica (L.) Gaertn.	3
2	Rice	Tinni Dhan,Nabo	Oryza rufipogon Griff.	6
		Bandhan	Oryza meyeriana ssp. granulata (Nees & Arn. ex Steud.) Tateoka	1
		Nabo	Oryza nivara S.D.Sharma & Shastry	1
3	Carrot	Chhiru	Selinum candollei Edgew.	2
4	Apple	Edimayal	Malus baccata (L.) Borkh.	1
5	Egg plant	Kauwa khursani	Solanum virginianum L.	1
6	Sweet potato	Jangali Sakharkhanda	Ipomoea cairica (L) Sweet	3
7	Banana	Ban kera, Ban kola, Jangali kera	Musa balbisiana Colla	2
8	Cow pea		Vigna nepalensis Tateishi & Maxted	1
9	Pigeon Pea	Ban Marther	Cajanus scarabaeoides (L.)Thouars	1
10	Amaranths	Latte,Marse	Amaranthus spinosus L.	5
		Latte,Marse	Amaranthus viridis L.	7
		Latte,Marse	Amaranthus lividus L.	1
11	Lady's Finger	Bankapas,Jangali Bhindi	Abelmoschus manihot (L.) Medik.	2
12	Walnut	Jangali okhar	Juglans regia var. kamaonia C. DC.	2
13	Barberry	Chutro	Berberis asiatica Roxb. ex DC.	2
14	Pear	Mayal	Pyrus pashia Buch.-Ham. ex D.Don	5
15	Pomegranate	Dadim	Punica granatum L.	1
16	Bayberry	Hade kafal	Myrica esculenta Buch.-Ham. ex D.Don	1
17	Indian plum	Bayar	Ziziphus mauritiana Lam.	1
18	Rape Mustard	Jangali Tori	Rorippa indica (L.) Hiern	1
19	Buck Wheat	Bharbare	Fagopyrum dibotrys (D.Don) H.Hara	2
20	Swiss Chard	Kapo, Amilo ghas,Halhale	Rumex nepalensis Spreng.	1
			Total	53

UTILIZATION OF CWR

Crop wild relatives are wild plant species that are genetically related to cultivated crops. Un-attended by humans, they continue to evolve in the wild, developing traits such as drought tolerance or pest resistance that farmers and breeders can cross with domesticated crops to produce new varieties. Wild relatives contain a wealth of genetically important traits (stress tolerance) due to their adaptation to the diverse range of habitats. It has been the source of resistance to biotic and abiotic stresses and has been used globally. Importance of CWR species for developing desirable varieties especially in the context of climate change is well documented. Breeding technologies and biotechnological advances are being used to incorporate key genetic traits of wild relatives into crop varieties to combat different biotic and abiotic changes.

In addition to their use in breeding, crop wild relatives are also used in their wild state. A number of wild cowpea species (*Vigna* spp.) in Africa contribute directly to food security through consumption of their fruits and seeds. Wild yams (*Dioscorea* spp.) are an important source of carbohydrates and incomes in Madagascar, and wild fruits such as apple, pistachio and sea buckthorn are harvested for food in Central Asia and the Caucuses. CWR species also provide other invaluable products such as animal fodder, building materials and medicines. In Nepal, few wild relatives are used as rootstocks, fodder and directly eating purpose (**Table** 9)

Table 9. Utilization of Crop Wild Relatives in Nepal

SN	Species	Uses	Remarks
1.	Malus baccata (L) Borkh. Malus sikkimensis (Wenz.) Koehne ex C.K.Schneid.	Rootstocks (soil borne disease, vigor)	Used
2.	Prunus domestica L.	Eating (health benefits)	Used
3.	Solanum torvum Sw.	Rootstocks (Soil borne disease – BW)	Used
4.	Avena fatua L.	Fodder	Used
5.	Lathyrus aphaca L.	Fodder	Used
6.	Vicia sativa L.	Fodder	Used
7.	Oryza rufipogon Griff.	Eating (Tinni dhan as pure dhan)	Used
8.	Oryza nivara S.D.Sharma & Shastry Oryza minuta J.Presl	Resistance to GSVI Resistance to BPH, WBPH, Blast and BLB	Not used yet
9.	Prunus salicina Lindl. (Alucha)	Eating (Medicinal)	Used
10.	Musa balbisiana var. balbisiana Colla	Fodder	Used
11.	Luffa echinata Roxb.	Medicine for dropsy and bronchitis	Used
12.	Amaranthus spp.	Vegetables	Used
14.	Beta vulgaris var. cicla L.	Vegetables	Used
15.	Calopogonium mucunoides Desv.	Fodder	Used
16.	Allium wallichii Kunth	Aromatic spice	Used
17.	Asparagus adscendens Roxb.	Vegetable	Used
18.	Curcuma angustifolia Roxb.	Medicinal and as arrowroot	Used
19.	Mentha sylvestris L. Mentha spicata L.	Spice	Used

CASE STUDY OF PRABASH TAAL, PALPA AND AJIGARA TAAL, BANKE

Prabash lake of Palpa (**Figure** 14) and Ajigara lake of Banke are two swampy areas and natural ponds. These areas showed the existence of two wild rice; *Oryza rufipogon and Oryza nivara* and their natural inter cross. These are two major hotspots for wild rice for these species (Vaughan 1998, Shrestha and Upadhyay 1999). Prabash lake used to be recreational spot in the past. But due to the recent construction of medical college near its periphery and the dumping of sewage of this college in to this lake has slowly converted it into sewage. The lake is very polluted and neglected and the wastes dumped in this have made the environment unsuitable for the wild rice as well as other crop genetic resources present around the area. In the near future, there is possibility that this whole lake will turn into a sewage which impose great threat to the existing wild rice populations.

A. Prabash Taal for boating | B. Two wild rice in Prabash Taal

C. Construction of medical college, Near to Prabash Taal

D. Swage from medical college in Prabash Taal

Figure 14. Conditions in Prabash Tall, Palpa.

CASE STUDY OF IPOMOEA CAIRICA

Ipomoea cairica L. Sweet is one of the priority species of sweet potato for collection and conservation based on global gap analysis. The general perception on the occurrence of wild relatives in the wild areas contrasts for this species. This species have beautiful and attractive blue flowers and are abundantly occurring in the main cities, abundant plots within Kathmandu and Lalitpur (**Figure** 15). The accelerated urbanization is the greatest threat for this species as these species will be completely destroyed when these lands will be used for constructions. The number of populations within Kathmandu is very rare whereas in Lalitpur and Kirtipur, is still high. Thus, the government should adopt immediate ex-situ conservation and also re-allocate these species in safer areas for on-farm and in-situ conservation.

Figure 15. Wild sweet potato around Sanepa and Pulchowk in Lalitpur.

CHALLENGES AND WAY FORWARD

Conservation of crop wild relatives is new area of work, and the major challenge in this part of work is the species identification due to the limited knowledge of agriculturist on botanical classification. The crop phenology is quite unique of the majority of CWR crops, the seeds shred off as it reaches maturity so the estimation of collections time is very difficult due to this sensitive nature. The seed dormancy, one of the coping mechanism and unique character of CWR is imposing challenge for conservation. The detail documentation of CWR of Nepal and database is lacking which hampers the conservation work. The detail documentation of available CWR and development of descriptive catalogues along with the pictures is utmost necessary to protect country's sovereign rights and also facilitate the research and conservation work.

Nepal has very well structured protected areas and National parks under Ministry of Forestry and Soil Conservation which protects wild animals exclusively. These parks and protected areas have been documented with existence of crop wild relatives too. The holistic approach on conservation of biodiversity will encompass the CWR along with the animals. Protected areas (National parks, religious places) should have a component of plant diversity. The public awareness activities to the tour guides, locals especially on CWR would contribute in protection of them as they would impart the knowledge on wild life and CWR to the tourists. In addition, some additional locations identified for specific species; Ajigara and Prabash lakes, lakes of Pokhara valley should conserved legally for wild rice populations.

For *Impomea* and *Amaranthus* species occurring in urban and peri-urban areas which are under great threat, immediate ex-situ conservation strategy should be adopted by the genebanks or Government agencies. In-situ conservation is the proven method for conservation of CWR therefore needs to protect special places like Prabash lake and lakes of Pokhara valley. Ex-situ (seed storage, field genebank, in-vitro maintenance, DNA and pollen banks) can be taken as complimentary conservation strategy for whole gene pools.

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Annex 1. Some crop wild relatives


Oat: *Avena fatua* L.


Grass pea: *Lathyrus aphaca* L.


Barberry/Chutro: *Berberis asiatica* Roxb. ex DC.


Rice (Nabo): *Oryza nivara* S.D.Sharma & Shastry


Rice(Tinni Dhan): *Oryza rufipogon* Griff.


Vetch/Kutelikosha: *Vicia sativa* L.


Amaranths: *Amaranthus spinosus* L.


Amaranths: *Amaranthus lividus* L.


Amaranths: *Amaranthus viridis* L.


Edimayal: *Malus baccata* (L.) Borkh.


Swiss Chard/ Kapo/ Amilo ghas/Halhale: *Rumex nepalensis* Spreng.

Wild Edible Plants in Nepal

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ABSTRACT

Wild edible plants have noteworthy roles and contributions in Nepalese diets and food security since time immemorial. Even in the 21st century, its importance continues to the rural, ethnic, poor and marginalized people. Most of these plants are still in the wild forms, except some domestication that have religious and medicinal values. Many researchers have conducted studies on wild edible plants in different parts of Nepal. This paper has attempted to compile and analyze the information on wild edible plants, their family names, vernacular names, habit, plant parts and uses. With this compilation and analysis, it is revealed that 394 wild plants are still used for different purposes such as vegetables (246 spp.), fruits (125 spp.), pickle (44 spp.), jam (11 spp.), spices and condiments (10 spp.), oil (6 spp.) and other uses. The results have also shown that different parts of the plants are used in daily dietaries and also the specific nourishments during feasts and festivals contributing the overall food security of the households. Based on the study, following recommendations can be made in the research field of wild edible plants: 1) detail analysis of the nutritional values, contribution to the food security and livelihood; 2) analysis of the abundance and status of these plants in nature; 3) evaluation of commercial use and market values including potentials for its domestication and promotion; 4) use values and preference of the foods and other values; 5) develop human resources for conservation of potential wild plant genetic resources and 6) integrate wild plant genetic resources as an important unit by the concerned government bodies.

Keywords: Food security, livelihood, plant genetic resources, use values, wild edibles

INTRODUCTION

Nepal is rich in its biodiversity both in terms of plant and animal diversity and cultural diversity, despite being a small country, occupying only 0.1% of the global area (MoFSC 2014). The country has unique geography and climatic variation suited for diverse biological and cultural diversity. Biodiversity and cultural diversity are interlinked as different ethnic groups are highly depended on the biodiversity for their food security and livelihood security. These biodiversity have significant roles in fulfilling the fundamental human needs such as food, shelter and other livelihood support (Uprety et al 2012). The country has 118 different types of ecosystems harboring 3.2% of the world's flora that includes 5.1% of gymnosperms and 8.2% of bryophytes (MoFSC 2014). Nepal is rich in wild edible plants growing in different ecosystems. Number of agricultural crops, their wild relatives and wild edible plants enrich the species and genetic diversity in the country.

Wild edible plants (WEPs) are uncultivated plants found in the wild forms that have nutritive values and can be used for fulfilling dietary requirements. The Food and Agriculture Organization (FAO) has defined it as "the plants that grow spontanenously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action" (FAO 1999). These plants have important contributions to the food security and livelihood by providing the staple and supplement foods and income generating opportunities to the communities. These plants have additional importance to the rural, ethnic, poor and marginalized people even in the age of modernized world. However, these plants are often ignored in the process of biodiversity conservation and economic development (Uprety et al 2012). Despite its importance on food security, livelihood and economic development, these plants are still in the wild forms. Very few of them are domesticated for medicinal and religious purposes. As these are in the wild state, the number, abundance, density and availability of many of these plants are still unknown to the public, except some of the researchers and the communities who have been continuously utilizing them for their livelihood and well-being.

The WEP are very important for the Nepalese people and knowledge on utilization is confined in local people. It is, therefore, scientists are interested to understand the state of wild edible plants and conserve them for future. The scientists conducted number of researches and published their results in national and international journals and also communicated through seminars, conferences and workshops. Many researches and studies have been conducted focusing on different aspects of wild edible plants in different parts of Nepal. Some studies were concentrated in wild food plants (Singh 1968, DMP 1982, Manandhar 1986, 1989, 1993, 1995, 2002, Shrestha 1987, Upretry et al 2012, Acharya and Acharya 2010, Shrestha 2001, Shrestha and Dhillon 2006), wild vegetables (Adhikari et al 1993, Shakya et al 1995); wild fruits (Maden and Dhakal 1998, Bajracharya 1999, Mahato 2014) or nutritive values of edible wild fruits (Bajracharya 1980), wild leafy and fruity vegetables (Shrestha 1983). Some studies reported the wild edible plants used by Bote (Pradhan 2006), Chepangs (Khan 1997, Aryal et al 2009, Limu and Thapa 2011), Darai (Dangol and Gurung 2000), Raji (Thapa et al 2014), Satars (Siwakoti et al 1997), and Tharu (Dangol 2002, Bhattarai et al 2011). Some researchers conducted studies on wild edible plants in Tarai (Dangol 2002, Dangol and Gurung 2000, Dangol et al 2014), Hills (Bajracharya 1999, Joshi et al 2007, Ghimeray et al 2010, Mahato 2014), Tinjure area (Gurung 2003), or high mountains (Bhattarai et al 2009). However, they have different focuses in terms of use values of the WEPs and different locations in the country either in Tarai or Hills or Mountains. Shrestha (2013) attempted to compile information on indigenous vegetables of Nepal reviewing the available literature. No research has been conducted to synthesize the WEPs as a whole in the national context. This paper has attempted to compile and analyze the information on wild edible plants, their family names, vernacular names, habit, plant parts and uses.

HISTORY AND TREND

Since time immemorial, WEPs have been sustainable utilized by our ancestors in fulfilling daily food requirements. It was even mentioned in the ancient and indigenous histories. At that time it was utilized based on their traditional and indigenous knowledge and skills. It's nutritive and medicinal values were unknown. Even in epic holy book Ramayana has described the importance of such plants with certain sacred qualities for medicinal and other purposes which is still extant and form for the basis of study by many present day scholars and researchers (Amirthalingam 2013). Many researchers and scholars have continued to carry out research on WEPs in different parts of the world. In the present age, food insecurity and malnutrition have become severe issue affecting the World population. FAO estimated that a total of 925 milion people were undernourished in 2010. It also revealed that reduction of dietary diversity among rural and urban population has serious impacts on the nutrition and health. Wild, underutilized and neglected plants have constituted the bedrock of the diversity in traditional and indigenous food systems especially among the indigenous and rural communities in developing countries (FAO 2014).

THE WILD EDIBLE PLANTS INVENTORY

This inventory has listed a total of 394 plant species of 105 families used as wild edibles in Nepal. These species belong to 371 angiosperms (in 92 families and 247 genera), 1 gymnosperm and 22 pteridophytes (in 12 families and 17 genera) (**Figure** 1). Of the total families, the most dominant one is Leguminosae with 31 species, followed by Moraceae (21 spp.), Compositae (18 spp.), Rosaceae (16 spp.), Polygonaceae (15 spp.), Cucurbitaceae (13 spp.), Anacardiaceae and Urticaceae (11 each) and Araceae and Malvaceae (10 spp.) (**Table** 1). Other 95 families contained 9 or less than 9 species per family (**Table** 1). Of the total genera, the largest one is the *Ficus* with 12 spp. followed by *Dioscorea* (8 spp.), *Arisaema* and *Smilax* (6 spp. each), *Morus, Polygoum, Rubus,* and *Rumex* (5 spp. each), and *Amaranthus, Bauhinia, Crotalaria, Solanum, Syzygium* and *Ziziphus* (4 spp.). The rest 250 genera contain less than 4 species in each genus (**Table** 2). Of the total species, herbs are the highest in number (187 spp.) followed by trees (109 spp.). Other life forms of wild edible plants are shrubs (60 spp.), climbers (35 spp.) and bamboo (4 spp.) only (**Annex** 1).

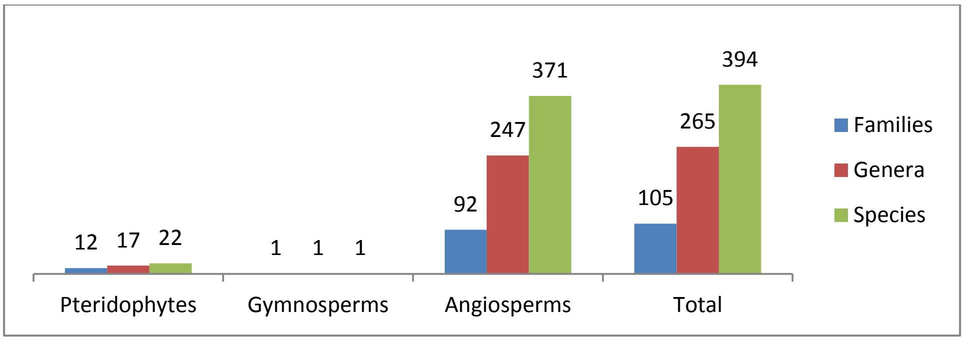

Figure 1. Plant families, genera and species of wild edible plants in pteridophytes, gymnosperms and angiosperms in Nepal.

Table 1. Species distribution in different families of Pteridophytes (P), Gymnosperm (G) and Angiosperms (rest)

SN	Families	Species	Frequency	Total
1	Leguminosae	31	1	31
2	Moraceae	21	1	21
3	Compositae	18	1	18
4	Rosaceae	16	1	16
5	Polygonaceae	15	1	15
6	Cucurbitaceae	13	1	13
7	Anacardiaceae, Urticaceae	11	2	22
8	Araceae, Malvaceae	10	2	20
9	Apiaceae, Poaceae	9	2	18
10	Dioscoreaceae, Lamiaceae, Solanaceae	8	3	24
11	Amaranthaceae	7	1	7
12	Arecaceae, Brassicaceae, Rubiaceae, Smilacaceae	6	4	24
13	Asparagaceae, Capparaceae, Myrtaceae, Phyllanthaceae, Ranunculaceae,	5	5	25
14	Adoxaceae, Dryopteridaceae (P), Euphorbiaceae, Lauraceae, Ophioglossaceae (P), Primulaceae, Rhamnaceae, Rutaceae, Vitaceae	4	9	36
15	Berberidaceae, Chenopodiaceae, Commelinaceae, Musaceae, Pteridaceae (P), Sapotaceae, Sapindaceae	3	7	21
16	Acanthaceae, Alismataceae, Amaryllidaceae, Araliaceae, Athyriaceae (P), Bignoniaceae, Caryophyllaceae, Combretaceae, Convolvulaceae, Dilleniaceae, Ericaceae, Fagaceae, Liliaceae, Lythraceae, Piperaceae, Plantaginaceae, Schizaeaceae (P), Typhaceae, Zingiberaceae	2	19	38
17	Achariaceae, Actinidiaceae, Aizoaceae, Apocynaceae, Aquifoliaceae, Asclepidiaceae, Balsaminaceae, Basellaceae, Blechnaceae (P), Betulaceae, Bombacaceae, Buxaceae, Cannabaceae, Colchicaceae, Costaceae, Dennstaedtiaceae (P), Dipterocarpaceae, Ebenaceae, Elaeocarpaceae, Icacinaceae, Juglandaceae, Linaceae, Loranthaceae, Melastomataceae, Moringaceae, Myricaceae, Myristicaceae, Nephrolepidaceae (P), Nyctaginaceae, Osmundaceae (P), Oxalidaceae, Pandanaceae, Parkeriaceae (P), Pedaliaceae, Phytolaccaceae, Pinaceae (G), Pontederiaceae, Portulacaceae, Saururaceae, Schisandraceae, Symplocaceae, Tectariaceae (P), Thelypteridaceae (P),Trapaceae, Verbenaceae	1	45	45
	Grand Total			**394**

Table 2. Species distribution in different genera of wild edible plants of Nepal

SN	Families	Species	Frequency	Total
1	Ficus	12	1	12
2	Dioscorea	8	1	8
3	Arisaema, Smilax	6	2	12
4	Morus, Polygonum, Rubus, Rumex	5	4	20
5	Amaranthus, Bauhinia, Crotalaria, Solanum, Syzygium, Ziziphus	4	6	24
6	Acmella, Artocarpus, Chenopodium, Fagopyrum, Grewia, Indigofera, Oenanthe, Ophioglossum, Phoenix	3	9	27
7	Abelmoschus, Acacia, Allium, Antidesma, Ardisia, Asparagus, Bambusa, Berberis, Bidens, Capparis, Castanopsis, Cinnamomum, Clematis, Colocasia, Commelina, Crateva, Dendrocalamus, Dillenia, Elatostema, Euphorbia, Ipomoea, Lathyrus, Leea, Lygodium, Malva, Mangifera, Momordica, Musa, Physalis, Pilea, Plantago, Pleurospermum, Polygonatum, Pteris, Pyrus, Ranunculus, Remusatia, Rhus, Rorippa, Sagittaria, Schleichera, Solena, Sonchus, Tectaria, Terminalia, Trichosanthes, Typha, Urtica, Viburnum, Vicia	2	50	100
8	The rest 191 genera (See **Annex** 1).	1	191	191
	Grand Total			**394**

USES OF WILD EDIBLE PLANTS

Wild edible plants were found to be used for different purposes. Vegetables were obtained from 246 plant species followed by fruits (126 spp.), pickles (44 spp.), spices and condiments (10 spp.) and marcha (fermenting substrate from 9 species) (**Figure** 2, **Annex** 1). The edible seeds were either consumed after boiling or roasting.

Different plant parts were also used to make selroti (special bread), jam, jelly, tea and even alcoholic beverages. Some seeds of the plants were found to be used to make cooking oil.It is also found that some plants are rich in nectar in the flowers such as *Diploknema butyracea* (Roxb.) H.J. Lam and *Woodfordia fruticosa* (L.) Kurz.

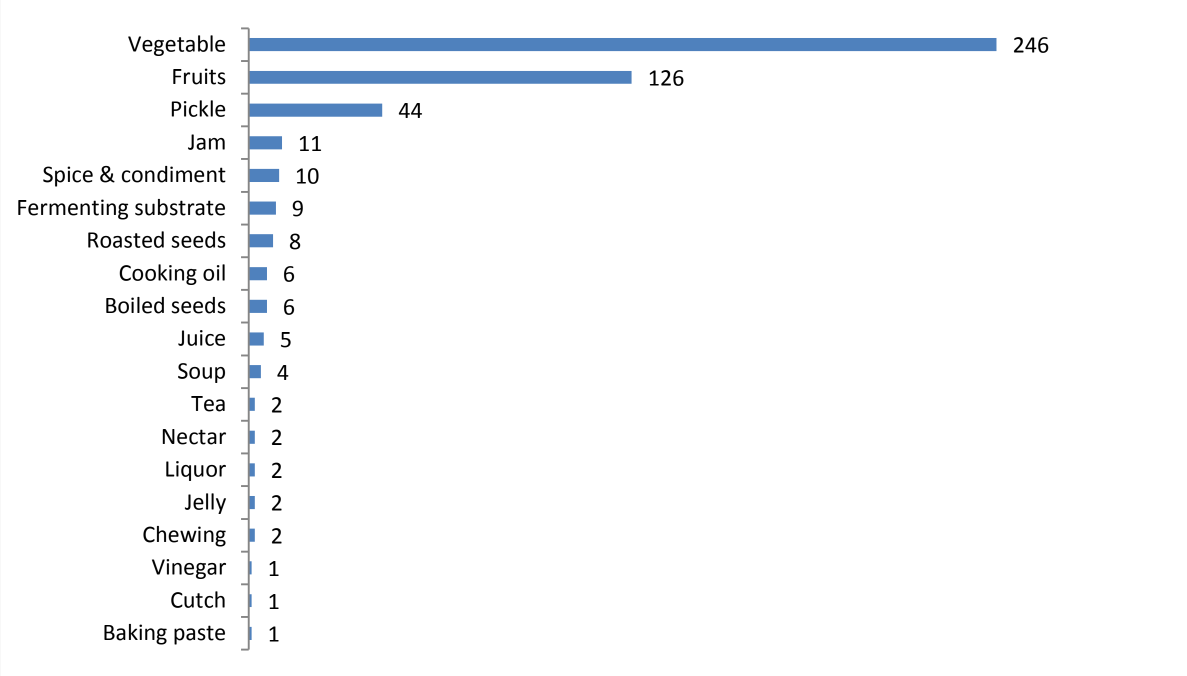

Figure 2. Total number of species under different use categories.

WAY FORWARD

Nepal is very rich on wild edible plants which are used mainly as vegetables, fruits, pickles, spices and condiments, and fermenting substrates. Besides these use values, wild edibles are also important for making juice or alcoholic beverages or tea.

Based on this study, following recommendations are proposed.

- Detail analysis of the nutritional values, contribution to the food security and livelihood
- Monitoring population of wild edible plants in nature
- Evaluation of commercial use and market values including potentials for its domestication and promotion
- Use values and preference of the foods and other values
- Develop human resources for conservation of potential wild plant genetic resources and
- Integrate wild plant genetic resources as an important unit by the concerned government bodies.

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Annex 1. List of wild edible plants of Nepal

SN	Local name	Species	Family	Habit	Part	Uses
1.		Caltha palustris L.	Ranunculaceae	Herb	Leaves	Veg
2.		Caragana brevispina Benth.	Leguminosae	Shrub	Flowers	Veg
3.		Clintonia udensis Trautv. & C.A.Mey.	Liliaceae	Herb	Leaves	Veg
4.		Crotalaria tetragona Andrews	Leguminosae	Herb	Fruits, Seeds	Veg
5.		Deeringia amaranthaoides (Lam.) Merr.	Amaranthaceae	Herb	Leaves, Seeds	Veg
6.		Elatostema sessile J.R.Forst. & G.Forst.	Urticaceae	Herb	Seeds /Stems	Veg
7.		Erysimum cuspidatum (M.Bieb.) DC (Syn. Erysimum hieracifolium Pall.)	Brassicaceae	Herb	Leaves, Seeds	Veg
8.		Impatiens bicornuta Wall.	Balsaminaceae	Herb	Shoots	Veg
9.		Oenanthe javanica (Blume) DC.	Apiaceae	Herb	Leaves	Veg
10.		Oreocnide frutescens (Thunb.) Miq.	Urticaceae	Herb	Seeds	Veg
11.		Osmunda claytoniana L.	Osmundaceae	Herb	Leaves	Veg
12.		Pilea symmeria Wedd.	Urticaceae	Herb	Leaves	Veg
13.		Pleurospermum angelicoides (Wall. ex DC.) Benth. ex C.B. Clarke	Apiaceae	Herb	Leaves	Veg
14.		Pleurospermum apiolens C.B. Clarke	Apiaceae	Herb	Leaves	Veg
15.		Polygonatum cirrhifolium (Wall.) Royle	Asparagaceae	Herb	Leaves	Veg
16.		Pouzolzia sanguinea (Blume) Merr.	Urticaceae	Herb	Leaves	Veg
17.		Pteridium aquilinum (L.) Kuhn	Dennstaedtiaceae	Herb	Shoots	Veg
18.		Remusatia pumila (D.Don) H.Li & A.Hay	Araceae	Herb	Leaves	Veg
19.		Sambucus adnata Wall. ex DC.	Adoxaceae	Shrub	Shoots	Veg
20.		Woodwardia biserrata C. Presl	Blechnaceae	Herb	Stems	Veg
21.	Aanp/Aam (Th)	Mangifera indica L.	Anacardiaceae	Tree	Fruits (ripe, unripe)	Fru, Pic
22.	Abhijalo	Drymaria cordata (L.) Willd. ex Schult.	Caryophyllaceae	Herb	Leaves	Veg
23.	Ainjeru	Scurrula elata (Edgew.) Danser	Loranthaceae	Shrub	Fruits	Fru
24.	Amala	Phyllanthus emblica L. (Syn. Emblica officinalis Gaertn.)	Phyllanthaceae	Tree	Fruits (unripe), young shoot	Fru, Pic, Veg
25.	Ambakay	Syzygium kurzii (Duthie) N.P.Balakr. (Syn. Eugenia kurzii Duthie)	Myrtaceae	Tree	Fruits (pulp)	Fru
26.	Amile ghans	Rumex acetosa L.	Polygonaceae	Herb	Leaves	Veg
27.	Amilo tanki	Bauhinia malabarica Roxb.	Leguminosae	Tree	Flowers	Veg
28.	Amora	Spondias pinnata (L. f.) Kurz (Syn. Spondias magnifera Willd.)	Anacardiaceae	Tree	Flowers	Fru, Pic, Spi, Veg
29.	Ander	Ricinus communis L.	Euphorbiaceae	Tree	Flowers	Veg
30.	Angeri	Melastoma malabathricum L.	Melastomataceae	Shrub	Fruits	Fru
31.	Archal	Antidesma acidum Retz.	Phyllanthaceae	Tree	Fruits (ripe)	Fru
32.	Archal; Dakhi (Th)	Antidesma montanum Blume	Phyllanthaceae	Shrub	Leaves	Pic
33.	Armale	Anagallis arvensis L.	Primulaceae	Herb	Leaves	Veg
34.	Asarey	Viburnum erubescens Wall.	Adoxaceae	Tree	Fruits (ripe)	Fru
35.	Asuro	Justicia adhatoda L.	Acanthaceae	Shrub	Leaves, Flowers, Fruits	Pic, Veg
36.	Badahar	Artocarpus lacucha Buch.-Ham. (Syn. Artocarpus lakoocha Roxb.)	Moraceae	Tree	Fruits (raw)	Fru, Veg
37.	Bagh mukhwa	Capparis spinosa L.	Capparaceae	Shrub	Fruits	Veg

SN	Local name	Species	Family	Habit	Part	Uses
	(Th)					
38.	Baghnangre	Martynia annua L.	Pedaliaceae	Herb	Fruits	Fru
39.	Bahabulaba	Lathyrus aphaca L.	Leguminosae	Herb	Leaves	Veg
40.	Bakle	Ardisia solanacea Roxb.	Primulaceae	Shrub	Fruits (ripe)	Fru
41.	Baluni sag; Jaskali (Th)	Polygonum plebeium R. Br.	Polygonaceae	Herb	Leaves	Veg
42.	Ban champa	Spermadictyon suaveolens Roxb.	Rubiaceae	Shrub	Shoots	Veg
43.	Ban chichinda	Trichosanthes cucumerina L.	Cucurbitaceae	Herb	Fruits	Veg
44.	Ban haledo	Curcuma aromatica Salisb.	Zingiberaceae	Herb	Powder of rhizome	Spi
45.	Ban kane, Kane sag, Kane jhar; Kane bon (Da), Kaunak sag (Th)	Commellina benghalensis L.	Commelinaceae	Herb	Young vegetative parts, Young leaves	Veg
46.	Ban karaili (Th)	Momordica charatia L.	Cucurbitaceae	Herb	Fruits	Veg
47.	Ban karela	Momordica dioica Roxb. ex Willd.	Cucurbitaceae	Climber	Fruits	Veg
48.	Ban karela; Titambi (Th)	Diplocyclos palmatus (L.) C. Jeffery	Cucurbitaceae	Climber	Fruits, Flowers	Veg
49.	Ban kurilo	Asparagus filicinus Buch.-Ham. ex D.Don	Asparagaceae	Herb	Shoots	Veg
50.	Ban lasun	Lilium nepalense D.Don	Liliaceae	Herb	Leaves	Veg
51.	Ban lunde	Amaranthus spinosus L.	Amaranthaceae	Herb	Leaves, tender shoot	Veg
52.	Ban mungi	Vigna mungo (L.) Hepper (Syn. Phaseolus mungo L.)	Leguminosae	Herb	Seeds	Pic
53.	Ban nalu	Abelmoschus manihot (L.) Medik.	Malvaceae	Herb	Fruits	Veg
54.	Ban nigalo	Thamnocalamus spathiflorus (Trin.) Munro (Syn. Thamnocalamus aristatus Gamble) E.G.Campus)	Poaceae	Bamboo	Shoots	Veg
55.	Ban phanda kanda, Kaligedi	Lantana camara L.	Verbenaceae	Shrub	Fruits	Fru
56.	Ban phaper	Fagopyrum acutatum (Lehm.) Mansf. ex K.Hammer. (Syn. Fagopyrum dibotrys (D.Don) H.Hara)	Polygonaceae	Herb	Leaves	Veg
57.	Ban pipla; Pipar (Th)	Piper longum L.	Piperacae	Climber	Fruits	Spi
58.	Ban pire	Polygonum microcephalum D. Don. (Syn. Persicaria microcephala (D. Don) H. Gross)	Polygonaceae	Herb	Leaves	Veg
59.	Ban pyaj	Chlorophytum nepalense (Lindl.) Baker	Asparagaceae	Herb	Leaves	Veg
60.	Ban sanai	Crotalaria spectabillis Roth	Leguminosae	Herb	Flowers	Veg
61.	Ban tarul	Dioscorea hamiltonii Hook.f.	Dioscoreaceae	Climber	Tuber and root	Boi
62.	Ban timilo, Bedulo	Ficus sarmentosa Buch.-Ham. ex Sm. (Syn. Ficus foveolata (Wall. ex Miq.) Miq.	Moraceae	Tree	Ripe figs	Fru
63.	Bankera	Ensete glaucum (Roxb.) Cheesman	Musaceae	Shrub	Young fruits	Veg
64.	Bankera	Musa balbisiana Colla	Musaceae	Herb	Fruits (green), Spathes	Pic, Veg
65.	Bankera, Malvok kera	Musa x paradisiaca L. (Syn. Musa x sapientum L.)	Musaceae	Herb	Fruits (green), Spathes	Pic, Veg
66.	Banko	Arisaema tortuosum (Wall.) Schott	Araceae	Herb	Root/tuber	Veg
67.	Banneem; Boke januno/ (Th)	Murraya koenigii (L.) Spreng.	Rutaceae	Tree	Leaves, Fruits	Fru, Spi

SN	Local name	Species	Family	Habit	Part	Uses
68.	Bans	Bambusa bambos (L.) Voss. (Syn. Bambusa arundinacea Willd.)	Poaceae	Tree	Young shoots	Veg
69.	Bansimi/Bansem (Th)	Ceropegia pubescens Wall.	Asclepidiaceae	Climber	Young beans	Veg
70.	Bantarul	Dioscorea bulbifera L.	Dioscoreaceae	Climber	Boiled bulbs, Root/tuber	Nec, Veg
71.	Bar; Bargat (Th)	Ficus benghalensis L.	Moraceae	Tree	Fruits (ripe)	Fru
72.	Barro	Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	Tree	Roasted or unripe cotyledons	Fru, Roa
73.	Bayar	Ziziphus jujuba Mill. (Syn. Ziziphus mauritiana Lam.)	Rhamnaceae	Shrub	Fruits (ripe)	Fru
74.	Bedulo	Ficus palmata Forssk.	Moraceae	Tree	Fruits (ripe)	Fru
75.	Bel	Aegle marmelos (L.) Corrêa	Rutaceae	Tree	Fruits (ripe)	Fru, Jui
76.	Belauti; Amrut (Th)	Psidium guajava L.	Myrtaceae	Tree	Fruits (ripe)	Fru
77.	Berulo	Ficus subincisa Buch.-Ham. ex Sm.	Moraceae	Tree	Fruits	Fru
78.	Bethe; Bathuwa (Da)	Chenopodium album L.	Chenopodiaceae	Herb	Young twigs; Leaves	Pic, Veg
79.	Betlauri; Larkaiya (Th)	Cheilocostus speciosus (J. König) C. Specht (Syn. Costus speciosus (Koenig.) Sm.)	Costaceae	Herb	Young shoots	Veg
80.	Bhadrasey	Elaeocarpus sikkimensis Mast.	Elaeocarpaceae	Tree	Fruits (pulp) and seeds	Fru
81.	Bhaise ainselu	Rubus barberi H.E.Weber (Syn. Rubus rugosus E. Barber)	Rosaceae	Shrub		Fru
82.	Bhaisi kanda	Rosa macrophylla Lindl.	Rosaceae	Shrub	Fruits	Fru
83.	Bhakimlo	Rhus chinensis Wall. (Syn. Rhus semialata Murray)	Anacardiaceae	Tree	Fruits	Pic
84.	Bhakmilo	Brucea javanica (L.) Merr. (Syn. Rhus javanica L.)	Anacardiaceae	Tree	Fruits	Fru
85.	Bhalayo	Semecarpus anacardium L.f.	Anacardiaceae	Tree	Petals, Fruit (ripe)	Fru, Veg
86.	Bhangray sisnu, Lekali sisnu	Girardinia diversifolia (Link) Friis	Urticaceae	Herb	Inflorescences and young leaves	Roa, Veg
87.	Bhanthi	Clerodendrum infortunatum L. (Syn. Clerodendrum viscosum Vent.)	Lamiaceae	Herb	Leaves	Mar
88.	Bharlo; Mahuraen (Th)	Bauhinia vahlii Wight & Arn.	Leguminosae	Climber	Roasted seeds	Roa, Veg, Fru
89.	Bhemila hara (Th)	Spatholobus parviflorus (Roxb.) Kuntze	Leguminosae	Climber	Seeds (mature)	Oil
90.	Bhirin sag	Medicago falcata L.	Leguminosae	Herb	Leaves	Veg
91.	Bhogate	Maesa macrophylla Wall.	Primulaceae	Shrub		Fru
92.	Bhote palunge	Rumex vesicarius L.	Polygonaceae	Herb	Leaves	Veg
93.	Bhringraj	Eclipta prostrata (L.) L.	Compositae	Herb	Leaves	Veg
94.	Bhui aiselu	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	Rosaceae	Shrub	Fruits (berry)	Fru
95.	Bhui kaphal	Duchesnea indica (Jacks.) Focke	Rosaceae	Herb	Fruits	Fru
96.	Bhujetro	Butea buteiformis (Voigt) Mabb. (Syn. Butea buteiformis (Voigt) Grierson & D.G.Long)	Leguminosae	Shrub	Roasted seeds	Roa
97.	Bhutkesh	Cortia depressa (D.Don) C.Norman	Apiaceae	Herb	Leaves	Veg
98.	Boromi (Da)	Cucumis melo L. (Syn. Cucumis melo var. agrestis Naudin)	Cucurbitaceae	Herb	Fruits	Fru
99.	Brameli dhaniya	Eryngium foetidum L.	Apiaceae	Herb	Leaves	Veg

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100.	Chakramandi	Senna tora (L.) Roxb. (Syn. Cassia tora L.)	Leguminosae	Herb	Leaves	Veg
101.	Chamsure ghans	Cardamine scutata Thunb.	Brassicaceae	Herb	Leaves	Veg
102.	Chandra kali	Ipomoea alba L.	Convolvulaceae	Herb	Flowers	Veg
103.	Charchare lahara	Tetrastigma serrulatum (Roxb.) Planch.	Vitaceae	Climber	Fruits	Fru
104.	Charemala	Rumex hastatus D. Don	Polygonaceae	Herb	Leaves	Veg
105.	Charhenti (Th)	Solanum surattense Burm. f.	Solanaceae	Herb	Fruits (unripe)	Veg
106.	Chariamilo	Oxalis corniculata L.	Oxalidaceae	Herb	Vegetative parts; Leaves	Pic, Veg
107.	Chathil (Th)	Edgaria darjeelingensis C.B.Clarke	Cucurbitaceae	Climber	Fruits	Veg
108.	Chhuka	Hibiscus sabdariffa L.	Malvaceae	Shrub	Leaves, Fruits	Veg
109.	Chimphing	Heracleum wallichii DC.	Apiaceae	Herb	Inflorescences and seeds	Pic
110.	Chinde	Aralia leschenaultii (DC.) J.Wen (Syn. Pentapanax leschenaultia (DC.) Seem.)	Araliaceae	Tree	Tender leaves	Veg
111.	Chiniya	Macropanax dispermus (Blume) Kuntze	Araliaceae	Tree	Shoots	Veg
112.	Chiuri	Diploknema butyracea (Roxb.) H.J.Lam (Syn. Bassia butyracea Roxb.)	Sapotaceae	Tree	Fruits (pulp), seeds; Flowers (n), Fruits (ripe)	Fru, Jui, Nec
113.	Choya bans	Bambusa nepalensis Stapleton	Poaceae	Tree	Young shoots	Veg
114.	Chuchche aanp	Mangifera sylvatica Roxb.	Anacardiaceae	Tree	Fruits (ripe)	Pic
115.	Chutro	Berberis aristata Roxb. ex DC.	Berberidaceae	Shrub	Fruits	Fru
116.	Chutro	Berberis asiatica Roxb. ex DC.	Berberidaceae	Shrub	Fruits	Fru
117.	Chuwa	Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	Acanthaceae	Herb	Leaf, flowers	Pic, Veg
118.	Dabdabe	Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	Tree	Fruits	Fru
119.	Dahidhula (=Dhuliphula)	Callicarpa macrophylla Vahl	Lamiaceae	Shrub	Fruits	Fru
120.	Damaru	Maclura cochinchinensis (Lour.) Corner	Moraceae	Shrub	Fruits	Fru
121.	Dammarai	Ardisia macrocarpa Wall.	Primulaceae	Shrub	Fruits (ripe)	Fru
122.	Danthe, Niuro; Kochiya (Th)	Dryopteris cochleata (D. Don) C. Chr.	Dryopteridaceae	Herb	Tender leaves	Pic, Veg
123.	Dapher (Th)	Grewia sclerophylla Roxb. ex G.Don	Malvaceae	Shrub	Fruits	Fru
124.	Dawanra	Ziziphus rugosa Lam.	Rhamnaceae	Tree	Fruits	Fru
125.	Dhalnae katoos	Castanopsis indica (Roxb. ex Lindl.) A.DC.	Fagaceae	Tree	Fruits (nut)	Fru, Roa
126.	Dhangera, Dhayaro; Dhawatha (Th)	Woodfordia fruticosa (L.) Kurz.	Lythraceae	Shrub	Nector	Nec
127.	Dhasingari	Gaultheria fragrantissima Wall.	Ericaceae	Shrub	Fruits	Fru
128.	Dhokaya	Arisaema utile Hook.f. ex Engl.	Araceae	Herb	Shoots	Veg
129.	Dhungre jhar	Ranunculus sceleratus L.	Ranunculaceae	Herb	Leaves	Pic, Veg
130.	Dudhe ghans	Euphorbia hirta L.	Euphorbiaceae	Herb	Leaves	Veg
131.	Dudhe jhar	Launaea asplenifolia (Willd.) Hook.f.	Compositae	Herb	Leaves	Veg
132.	Dudhi kanda	Sonchus oleraceus (L.) L.	Compositae	Herb	Leaves	Veg
133.	Dundu	Allium wallichii Kunth	Amaryllidaceae	Herb	Leaves	Veg
134.	Farsa; Bhumbhur fursa (Darai)	Grewia sapida Roxb. ex DC. (Syn. Grewia pumila Buch.-Ham. ex D.Don)	Malvaceae	Herb	Fruits	Fru
135.	Fotangi (Da)	Physalis divaricata D. Don	Solanaceae	Herb	Fruits	Fru
136.	Fotongi (Da)	Physalis minima L.	Solanaceae	Herb	Fruits	Veg
137.	Gadapuraina	Trianthema portulacastrum L.	Aizoaceae	Herb	Shoots	Veg

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138.	Gai tihare	Inula cappa (Buch.-Ham. ex D.Don) DC.	Compositae	Shrub	Plant powder	Mar
139.	Galen, Galeno	Leea macrophylla Roxb. ex Hornem. (Syn. Leea aspera Wall. ex G. Don)	Vitaceae	Shrub	Fruits (ripe)	Fru
140.	Gane	Ageratum conyzoides (L.) L.	Compositae	Herb	Leaves	Veg
141.	Gane	Houttuynia cordata Thunb.	Saururaceae	Herb	Shoots	Jam
142.	Ganja, Bhang	Cannabis sativa L.	Cannabaceae	Shrub	Dried leaves & seeds are mixed on Laddu, Peda, and Sarbat	Pic, Fru
143.	Gante	Gynocardia odorata R.Br.	Achariaceae	Tree	Seeds (ripe)	Oil
144.	Gayo; Jhaijhuwa (Th)	Bridelia retusa (L.) A.Juss.	Phyllanthaceae	Tree	Fruits (ripe)	Fru
145.	Ghangaru	Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	Rosaceae	Shrub	Fruits	Fru
146.	Ghar tarul	Dioscorea alata L.	Dioscoreaceae	Climber	Root/tuber	Veg
147.	Ghodtaprile (Th)	Centella asiatica (L.) Urb.	Apiaceae	Herb	Leaves	Veg
148.	Ghueya (Th)	Colocasia fallax Schott	Araceae	Herb	Leaves, Corms	Veg
149.	Ghumauro kanda	Polygonum perfoliatumL. (Syn. Persicaria perfoliata (L.) H.Gross)	Polygonaceae	Climber	Leaves	Fru, Veg
150.	Gidha	Dioscorea oppostifolia L.	Dioscoreaceae	Climber	Tuber	Boi, Spi
151.	Githa, Githa tarul, Vyakur; Aruwa (Th)	Dioscorea deltoidea Wall. ex Griseb.	Dioscoreaceae	Climber	Root tuber, Fruits (ripe)	Boi, Fru, Veg
152.	Githi	Boehmeria rugulosa Wedd.	Urticaceae	Herb	Bark paste /powder	Sel
153.	Goada (Th)	Leea asiatica (L.) Ridsdale (Syn. Leea crispa L.)	Vitaceae	Herb	Fruit	Fru
154.	Golkakri; Dudur (Th)	Zehneria japonica (Thunb.) H.Y. Liu (Syn. Zehneria indica (Lour.) Keraudren)	Cucurbitaceae	Climber	Fruits (ripe)	Fru
155.	Golkankri	Coccinia grandis (L.) Voigt	Cucurbitaceae	Climber	Fruits (green)	Veg
156.	Golkankri	Solena heterophylla Lour.	Cucurbitaceae	Herb	Fruits	Veg
157.	Gorkhi; Bilauri thesa (Th)	Solena amplexicaulis (Lam.) Gandhi (Syn. Melothria heterophylla (Lour.) Cogn.)	Cucurbitaceae	Herb	Fruits	Fru
158.	Gullar (Th)	Ficus racemosa L.	Moraceae	Tree	Fruits (ripe)	Fru
159.	Guma	Leucas cephalotes (Roth) Spreng.	Lamiaceae	Herb	Leaves	Veg
160.	Gurash; Laligurans	Rhododendron arboreum Sm.	Ericaceae	Tree	Flowers	Jam, Jui, Rak, Veg
161.	Gurbe	Arisaema erubescens (Wall.) Schott	Araceae	Herb	Shoots, Corn	Veg
162.	Hade bayer	Ziziphus incurva Roxb.	Rhamnaceae	Tree	Fruits	Fru
163.	Halhale	Rumex nepalensis Spreng.	Polygonaceae	Herb	Young shoots and leaves	Veg
164.	Harro	Terminalia chebula Retz.	Combretaceae	Tree	Fruits	Veg
165.	Imili	Tamarindus indica L.	Leguminosae	Tree	Fruits (Fleshy fruit pulp)	Fru, Pic
166.	Indrajau, Dudhkhiri	Holarrhena pubescens Wall. ex G.Don	Apocynaceae	Shrub	Leaves, flowers	Veg
167.	Indreyni	Ceratosanthes palmata (L.) Urb. (Syn. Trichosanthes palmata L.)	Cucurbitaceae	Herb	Tender shoots	Veg
168.	Isamgol	Nicandra physaloides (L.) Gaertn.	Solanaceae	Herb	Fruits	Fru
169.	Isapgol	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li (Syn. Plantago erosa Wall.)	Plantaginaceae	Herb	Leaves	Veg

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170.	Isapgol	Plantago lanceolata L.	Plantaginaceae	Herb	Leaf	Veg
171.	Jalebi	Pithecellobium dulce (Roxb.) Benth.	Leguminosae	Shrub	Flowers	Veg
172.	Jaluko	Botrychium lanuginosum Wall. ex Hook. & Grev.	Ophioglossaceae	Herb	Shoots	Veg
173.	Jaluko	Remusatia vivipara (Roxb.) Schott	Araceae	Herb	Tender shoots	Veg
174.	Jamanimandro	Mahonia nepaulensis DC.	Berberidaceae	Shrub	Fruits	Fru
175.	Jamuna, Jamun; Jamuwa (Th)	Syzygium cumini (L.) Skeels (Syn. Syzygium jambolana Lam.)	Myrtaceae	Tree	Fruits (ripe)	Fru, Jam, Jel, Vin
176.	Jangali anar	Punica granatum L.	Lythraceae	Tree	Fruits	Fru
177.	Jangali bayar	Ziziphus nummularia (Burm. f.) Wight & Arn.	Rhamnaceae	Shrub	Fruits	Fru
178.	Januaryai lahara	Lygodium japonicum (Thunb.) Sw.	Schizaeaceae	Climber	Leaves	Veg
179.	Januarygali	Allium stracheyi Baker	Amaryllidaceae	Herb	Leaves	Veg
180.	Jaringo sag	Phytolacca acinosa Roxb.	Phytolaccaceae	Herb	Leaves	Veg
181.	Jethimadhu	Stellaria monosperma Buch.-Ham. ex D. Don	Caryophyllaceae	Herb	Leaves	Veg
182.	Jharikath	Lindera nacusua (D. Don) Merr. (Syn. Lindera bifaria (Nees) Benth. ex Hook. f.)	Lauraceae	Tree	Fruits	Fru
183.	Jhunkhuna jhangi (Th)	Crotalaria alata D. Don	Leguminosae	Herb	Plant powder	Mar
184.	Jhuse til	Guizotia abyssinica (L.f.) Cass.	Compositae	Herb	Seeds	Veg
185.	Jhyalicha swan (Ne)	Crotalaria pallida Aiton	Leguminosae	Herb	Flowers	Veg
186.	Jibre sag	Ophioglossum nudicaule L.f.	Ophioglossaceae	Herb	Leaves	Veg
187.	Jibre sag	Ophioglossum reticulatum L.	Ophioglossaceae	Herb	Leaves	Veg
188.	Jibre sag	Ophioglossum vulgatum L.	Ophioglossaceae	Herb	Whole plant	Veg
189.	Jiriyako mausi	Capsicum annuum L.	Solanaceae	Herb	Fruits	Spi
190.	Jogi lahara	Cissus javana DC.	Vitaceae	Climber	Leaves	Pic
191.	Junege lahara	Clematis acuminata L.	Ranunculaceae	Climber	Shoots	Veg
192.	Junege lahara	Clematis buchananiana DC.	Ranunculaceae	Climber	Shoots	Veg
193.	Jure kaphal	Eriobotrya dubia (Lindl.) Decne	Rosaceae	Tree	Fruits	Fru
194.	Jure mayal	Stranvaesia nussia (Buch.-Ham. ex D.Don) Decne. (Syn. Stranvaesia glaucescens Lindl.)	Rosaceae	Shrub	Fruits	Fru
195.	Kabro; Pakad (Th)	Ficus lacor Buch.-Ham.	Moraceae	Tree	Young buds, Leaf buds; leaves, ripe fruits	Veg
196.	Kadam	Neolamarckia cadamba (Roxb.) Bosser (Syn. Anthocephalus cadamba (Roxb.) Miq.)	Rubiaceae	Tree	Seeds	Oil
197.	Kadam	Neonauclea purpurea (Roxb.) Merr.	Rubiaceae	Tree	Fruits (ripe)	Fru
198.	Kafal	Myrica esculenta Buch.-Ham. ex D. Don	Myricaceae	Tree	Fruits (ripe)	Fru
199.	Kag bhalayo	Toxicodendron wallichii (Hook. f.) Kuntze (Syn. Rhus wallichii Hook.f.)	Anacardiaceae	Tree	Fruit pulp	Fru
200.	Kale kath	Symplocos pyrifolia Wall. ex. G. Don	Symplocaceae	Tree	Fruits	Fru
201.	Kali lahara	Natsiatum herpeticum Buch.-Ham. ex Arn.	Icacinaceae	Herb	Leaves	Veg
202.	Kalmi sag	Ipomoea aquatica Forssk.	Convolvulaceae	Herb	Young shoots; Leaves	Veg
203.	Kalo ainselu	Rubus niveus Thunb. (Syn. Rubus foliolosus D.Don)	Rosaceae	Shrub	Fruits	Jam, Fru

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204.	Kalo ainselu	Rubus paniculatus Sm.	Rosaceae	Shrub		Fru
205.	Kalo bethe; Pahade bathuwa (Da)	Chenopodium murale L.	Chenopodiaceae	Herb	Leaves; Seeds (fried)	Pic, Veg
206.	Kalo bihi, Bihi, Kawai (Da), Bulbul (Th)	Solanum americanum Mill. (Syn. Solanum indicum L.)	Solanaceae	Herb	Tender parts, Leaves, Fruits (ripe)	Veg
207.	Kalo neuro	Deparia boryana (Willd.) M. Kato	Athyriaceae	Herb	Leaves	Veg
208.	Kalo neuro	Tectaria gemmifera (Fée) Alston. (Syn. Tectaria coadunata C. Chr.)	Dryopteridaceae	Herb	Young leaves	Veg
209.	Kalo neuro	Tectaria macrodonta C.Chr.	Dryopteridaceae	Herb	Shoots	Veg
210.	Kane sag	Commelina paludosa Blume	Commelinaceae	Herb	Root /tuber	Veg
211.	Kantakari; Chhorhenta (Da)	Solanum aculeatissimum Jacq.	Solanaceae	Herb	Fruits (unripe)	Veg
212.	Karaluwa (Th)	Capparis zeylanica L.	Capparaceae	Shrub	Young fruits	Veg
213.	Karauji, Kanja (Th)	Caesalpinia decapetala (Roth) Alston	Leguminosae	Shrub	Fruits	Fru
214.	Katahar	Artocarpus heterophyllus Lam.	Moraceae	Tree	Fruit (ripe/unripe)	Fru, Veg
215.	Katahar	Artocarpus integer (Thunb.) Merr. (Syn. Artocarpus integrifolius L.f.)	Moraceae	Tree	Leaves	Mar
216.	Katoos	Castanopsis hystrix Hook.f. & Thomson ex A. DC.	Fagaceae	Tree	Fruits (nut)	Roa
217.	Kattabans	Phyllostachys edulis (Carrière) J.Houz.	Poaceae	Herb	Young shoots	Pic, Veg
218.	Kaudena jhangi, Gadlak biro (Th)	Aerva lanata Juss.	Amaranthaceae	Herb	Plant	Mar
219.	Kauso	Mucuna pruriens (L.) DC.	Leguminosae	Climber	Fruits	Fru, Veg
220.	Khaki baku	Oenanthe linearis Wall. ex DC.	Apiaceae	Herb	Leaves	Veg
221.	Khalluk, Tendu, Tendak (Th)	Diospyros malabarica (Desr.) Kostel.	Ebenaceae	Tree	Fruits, Leaves	Fru
222.	Khamari	Gmelina arborea Roxb.	Lamiaceae	Tree	Flowers	Veg
223.	Khanyu, Khaniya, Khaniyo; Khurhur (Th)	Ficus semicordata Buch.-Ham. ex Sm. (Syn. Ficus cunia Buch.-Ham. ex Roxb.)	Moraceae	Tree	Fruits (ripe)	Fru
224.	Khasreto; Kothayo (Th)	Ficus hispida L.f.	Moraceae	Tree	Fruits	Veg
225.	Khayar	Acacia catechu (L.f.) Willd.	Leguminosae	Tree	Bark, wood	Kat, Tea
226.	Khesari (Th)	Lathyrus sativus L.	Leguminosae	Herb	Seeds	Pul
227.	Khicha bhwatha (Ne)	Blumea lacera (Burm.f.) DC.	Compositae	Herb	Leaves	Veg
228.	Khinraula	Polygonatum verticillatum (L.) All.	Asparagaceae	Herb	Leaves	Veg
229.	Khole jhar	Lecanthus peduncularis (Wall. ex Royle) Wedd.	Urticaceae	Herb	Leaves	Veg
230.	Khyamuna; Bhadreja muno,Tenuwa (Th); Badra (Da)	Syzygium nervosum A.Cunn. ex DC. (Syn. Cleistocalyx operculatus (Roxb.) Merr. & L.M.Perry, Syzygium operculatum (Roxb.) Nied.)	Myrtaceae	Tree	Fruits (ripe)	Fru
231.	Kimbu	Morus australisPoir.	Moraceae	Tree	Fruits	Fru
232.	Kimbu	Morus nigra L.	Moraceae	Tree	Fruits	Fru
233.	Kimbu	Morus serrata Roxb.	Moraceae	Tree	Fruits	Fru
234.	Kimmu, Kimbu	Morus indica L.	Moraceae	Tree	Berries	Fru, Jel, Jam, Rak
235.	Kochaya	Cyclosorus auriculata (J. Sm.) C.M. Kuo (Syn. Thelypteris	Pteridaceae	Herb	Young shoots	Veg

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		auriculata (J. Sm.) K. Iwats				
236.	Koche (Th)	Thelypteris multilineata (Wall. ex Hook.) C.V.Morton	Thelypteridaceae	Herb	Shoots	Veg
237.	Koiralo; Koilara (Th)	Bauhinia variegata L.	Leguminosae	Tree	Buds, flowers. Young tender shoots	Pic, Veg
238.	Kongatahari (Th)	Malva parviflora L.	Malvaceae	Herb	Leaves	Veg
239.	Kubhindo	Benincasahispida (Thunb.) Cogn	Cucurbitaceae	Climber	Fruits	Pic, Veg
240.	Kukurdainy	Smilax zeylanica L.	Smilacaceae	Herb	Leaves, Shoots	Veg
241.	Kukurdiano	Smilax aspera L. (Syn. Smilax rigida Sol. ex Sm.)	Smilacaceae	Climber	Shoots	Veg
242.	Kukurdiano	Smilax ferox Wall. ex Kunth	Smilacaceae	Climber	Shoots	Veg
243.	Kukurdiano	Smilax lanceifolia Roxb.	Smilacaceae	Climber	Shoots	Veg
244.	Kukurdiano	Smilax perfoliata Lour.	Smilacaceae	Climber	Fruits	Veg
245.	Kukurdiano; Hana (Th)	Smilax ovalifolia Roxb. ex D.Don	Smilacaceae	Climber	Tender shoots, leaves, Fruits (unripe)	Fru, Veg
246.	Kurilo	Asparagus racemosus Willd.	Asparagaceae	Shrub	Young shoots, roots, boiled tuber	Boi, Sou, Pic, Veg
247.	Kuro	Bidens biternata (Lour.) Merr. & Sherff	Compositae	Herb	Shoots	Veg
248.	Kuro	Bidens pilosa L.	Compositae	Herb	Shoots	Veg
249.	Kusum	Schleichera trijuga Willd.	Sapindaceae	Tree	Fruits	Fru
250.	Kusum	Syzygium aromaticum (L.) Merr. & L.M. Perry	Myrtaceae	Tree	Fruits (pulp), aerial succulent parts	Fru
251.	Kusum; Kosam (Th)	Schleichera oleosa (Lour.) Oken	Sapindaceae	Tree	Fruits (green) with yellow inside	Fru
252.	Kuthurke	Pteris biaurita L.	Pteridaceae	Herb	Shoots	Veg
253.	Kutilkosa	Vicia hirsuta (L.) Gray	Leguminosae	Herb	Fruits	Veg
254.	Kutilkosa	Vicia sativa subsp. nigra (L.) Ehrh. (Syn. Vicia angustifolia L.)	Leguminosae	Herb	Fruits	Fru, Veg
255.	Lapchephal	Machilus edulis King ex Hook.f.	Lauraceae	Tree	Fruits	Fru
256.	Laphe sag	Malva verticillata L.	Malvaceae	Herb	Leaves	Veg
257.	Lapsi	Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill	Anacardiaceae	Tree	Fruits (Semi-ripe)	Jam, Fru
258.	Lata kasturi	Abelmoschus moschatus Medik.	Malvaceae	Herb	Fruits	Veg
259.	Lata pate	Peperomia pellucida (L.) Kunth	Piperacae	Herb	Leaves	Veg
260.	Lato ghans	Acmella calva (DC.) R.K.Jansen	Compositae	Herb	Flowers	Veg
261.	Latte sag	Amaranthus caudatus L.	Amaranthaceae	Herb	Leaves	Veg
262.	Leruwi jhangi (Th)	Platostoma hispidum (L.) A.J.Paton (Syn. Acrocephalus capitatus (Roth) Benth.)	Lamiaceae	Herb	Whole plants	Veg
263.	Lise	Ilex hookeri King	Aquifoliaceae	Tree	Fruits (ripe)	Fru
264.	Lude sag	Amaranthus blitum subsp. oleraceus (L.) Costea (Syn. Amaranthus lividus L.)	Amaranthaceae	Herb	Leaves	Veg
265.	Lude sag	Amaranthus viridis L.	Amaranthaceae	Herb	Leaves, tender shoot	Veg
266.	Mael	Docynia indica (Wall.) Decne.	Rosaceae	Tree	Fruits	Fru, Jam, Pic
267.	Magarkachey	Begonia longifolia Blume (Syn. Begonia inflata C.B.Clarke)	Bignoniaceae	Herb	Shoots, Leaves	Jam, Pic
268.	Mahuwa	Bassia eriophora (Schrad.) Asch. (Syn. Bassia latifolia (Fresen.) Asch. & Schweinf.)	Sapotaceae	Tree	Flowers	Veg
269.	Mahuwa	Madhuca longifolia (J.Konig ex L.) J.F. Macbr.	Sapotaceae	Tree	Flowers, Fruits	Che, Fru, Veg
270.	Maidal; Pidar,	Tamilnadia uliginosa (Retz.)	Rubiaceae	Tree	Fruits	Veg

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	Pedar (Th)	Tirveng. & Sastre (Syn. Xeromphis uliginosa (Retz.) Maheshw.)				
271.	Main kanda; Mainphal; Mainato; Maidalo; Main (Th)	Catunaregam spinosa (Thunb.) Tirveng. (Syn. Xeromphis spinosa (Thunb.) Keay)	Rubiaceae	Shrub	Young Fruits, Flowers	Pic, Veg
272.	Malingo	Yushania maling (Gamble) R.B.Majumdar & Karthik. (Syn. Arundinaria maling Gamble)	Poaceae	Herb	Young shoots	Pic, Veg
273.	Malo	Viburnum mullaha Buch.-Ham. ex D. Don	Adoxaceae	Shrub	Fruits	Fru
274.	Marehathi (Darai)	Acmella uliginosa (Sw.) Cass. (Syn. Spilanthes uliginosa Sw.)	Compositae	Herb	Flowers; Fruits	Spi
275.	Masino kanike	Viburnum cylindricum Buch.-Ham. ex D. Don. (Syn. Viburnum coriaceum Blume)	Adoxaceae	Shrub	Fruits	Fru
276.	Masino neuro	Diplazium esculentum (Retz.) Sw.	Athyriaceae	Herb	Leaves	Veg
277.	Masino sakhino	Indigofera hebepetala Baker	Leguminosae	Shrub	Fruits	Veg
278.	Mayur kutea	Tectaria zeylanica (Houtt.) Sledge	Tectariaceae	Herb	Leaves	Veg
279.	Mithe phaper	Fagopyrum esculentum Moench	Polygonaceae	Herb	Leaves	Veg
280.	Mithe tarul	Dioscorea pentaphylla L.	Dioscoreaceae	Climber	Root/tuber	Veg
281.	Muslendi (Th)	Morus alba L.	Moraceae	Tree	Fruits	Fru
282.	Nakore	Ranunculus diffusus DC	Ranunculaceae	Herb	Leaves	Veg
283.	Nakuri	Oenanthe stolonifera (Roxb.) DC.	Apiaceae	Herb	Young plants	Veg
284.	Nalu (Ne); Phute jhangi (Da)	Corchorus aestuans L. (Syn. Corchorus acutangulus Lam.)	Malvaceae	Herb	Tender parts, Leaves	Veg
285.	Narkat	Phragmites australis (Cav.) Trin. ex Steud. (Syn. Phragmites maxima Mabille)	Poaceae	Shrub	Shoots	Veg
286.	Nebharo	Ficus hookeriana Corner	Moraceae	Tree	Fruits thalamus, receptacles	Fru
287.	Nigalo	Drepanostachyum falcatum (Nees) Keng f.	Poaceae	Bamboo	Shoots	Veg
288.	Nil danthe	Pilea umbrosa Blume	Urticaceae	Herb	Leaves	Veg
289.	Nundhiki (Da)	Flueggea virosa (Roxb. ex Willd.) Royle (Syn. Phyllanthus glaucus Wall. ex Müll.Arg.)	Phyllanthaceae	Herb	Fruits	Fru
290.	Nundhiki; Kicha nathi (Th)	Portulaca oleracea L.	Portulacaceae	Herb	Tender shoots	Veg
291.	Odal	Sterculia vilosa Roxb.	Malvaceae	Tree	Fruits	Fru
292.	Okhar	Juglans regia L.	Juglandaceae	Tree	Fruits (kernel)	Fru
293.	Padamchal	Rheum australe D. Don	Polygonaceae	Herb	Leaves	Veg
294.	Pahelo ainselu	Rubus ellipticus Sm.	Rosaceae	Shrub	Fruits	Jam, Fru
295.	Pahelo jhar	Rorippa indica (L.) Hiern	Brassicaceae	Herb	Leaves	Veg
296.	Painyu, Paiyon	Prunus cerasoides Buch.-Ham. ex D.Don	Rosaceae	Tree	Fruits (ripe)	Fru
297.	Pakhri	Ficus glaberrima Blume	Moraceae	Tree	Fruits	Fru
298.	Palki mausi (Th)	Rumex dentatus L.	Polygonaceae	Herb	Tender parts, Leaves	Veg
299.	Panchphal	Dillenia indica L.	Dilleniaceae	Tree	Fruits	Veg
300.	Pani amala	Nephrolepis cordifolia (L.) C. Prest	Nephrolepidaceae	Herb	Tuber and root	Fru
301.	Pani dhaniya	Ceratopteros thalictroides (L.) Brongn.	Parkeriaceae	Herb	Whole plant	Veg
302.	Parandi sag;	Lygodium flexuosum (L.) Sw.	Schizaeaceae	Climber	Young shoots,	Veg

SN	Local name	Species	Family	Habit	Part	Uses
	Parewapoti (Da)				Leaves	
303.	Parwar; Chathail (Th)	Trichosanthes dioica Roxb.	Cucurbitaceae	Climber	Fruits (unripe)	Veg
304.	Pat	Typha angustifolia L.	Typhaceae	Herb	Young leaves; inner shoots	Veg
305.	Pat	Typha latifolia L.	Typhaceae	Herb	Tender shoots	Veg
306.	Pedar	Ceriscoides campanulata (Syn. Gardenia companulata Roxb.)	Rubiaceae	Shrub	Flowers	Veg
307.	Phekray	Prinsepia utilis Royle	Rosaceae	Tree	Seeds	Oil
308.	Phorsa; Phorshat (Th)	Grewia optiva J.R. Drumm. ex Burret	Malvaceae	Tree	Fruits	Fru
309.	Phusre neuro	Polystichum squarrosum (D. Don) Fée	Dryopteridaceae	Herb	Shoots	Veg
310.	Pindalu, Karkalo	Colocasia esculenta (L.) Schott.	Araceae	Herb	Root/Tuber, Young plants, corms	Veg
311.	Pipal/Pipar (Th)	Ficus religiosa L.	Moraceae	Tree	Fruits (ripe)	Fru
312.	Pirpiriya (Th)	Acmella ciliata (Kunth) Cass. (Syn. Spilanthes ciliata Kunth)	Compositae	Herb	Flowers	Pic, Veg
313.	Piyari/Pyaruwa (Th)	Buchanania cochinchinensis (Lour.) M.R.Almeida (Syn. Buchanania latifolia Roxb.)	Anacardiaceae	Tree	Fruits	Fru, Rak
314.	Poi sag	Basella alba L. (Syn. Basella rubra L.)	Basellaceae	Herb	Leaves	Veg
315.	Preetbir	Sarcococca pruniformis Lindl. (Syn. Sarcococca coriacea Sweet)	Buxaceae	Shrub	Fruits	Fru
316.	Priya ghans	Persicaria nepalensis (Meisn.) Miyabe	Polygonaceae	Herb	Leaves	Veg
317.	Pudina	Mentha spicata L.	Lamiaceae	Herb	Leaves	Pic
318.	Punarva	Boerhavia diffusa L.	Nyctaginaceae	Herb	Leaves	Veg
319.	Pyauli	Reinwardtia indica Dumort.	Linaceae	Shrub	Young leaves	Veg
320.	Rajbrikshya	Cassia fistula L.	Leguminosae	Tree	Fruits (young)	Fru, Veg
321.	Raksya banko	Arisaema consanguineum Schott	Araceae	Herb	Shoots	Veg
322.	Ramgua	Horsfieldia kingii (Hook.f.) Warb.	Myristicaceae	Tree	Fruits	Jam, Pic
323.	Rangbhang	Caryota urens L.	Arecaceae	Tree	Inner core pith and terminal buds	Veg
324.	Ratnaulo	Polygonum runcinatum Buch.-Ham. ex D. Don. (Syn. Persicaria runcinata (Buch.-Ham. ex D. Don) H. Gross)	Polygonaceae	Herb	Whole plant parts, Leaves	Veg
325.	Rato ainselu	Rubus acuminatus Sm.	Rosaceae	Shrub	Fruits	Jam, Fru
326.	Rato latte	Chenopodium ambrosioides L.	Chenopodiaceae	Herb	Leaves	Veg
327.	Rittha	Sapindus detergens Roxb.	Sapindaceae	Tree	Fruits	Oil
328.	Ryau ryau	Murdannia nudiflora (L.) Brenan	Commelinaceae	Herb	Young shoots	Veg
329.	Sadhan; Panan (Th)	Desmodium oojeinense (Roxb.) H. Ohashi	Leguminosae	Tree	Flowers	Pic
330.	Sahadeva; Gadlak biro (Th)	Vernonia cinerea (L.) Less.	Compositae	Herb	Whole plants	Mar
331.	Sajana, Sajiwan, Sitalchini	Moringa oleifera Lam.	Moringaceae	Tree	Flowers, Fruits	Veg
332.	Sakhino (Th), Bilhul (Da)	Indigofera cassioides DC. (Syn. Indigofera pulchella Roxb.)	Leguminosae	Shrub	Flowers, Fruits	Pic, Veg
333.	Sakhino, Jhimiliya (Th)	Indigofera atropurpurea Hornem.	Leguminosae	Shrub	Flowers	Pic, Veg
334.	Sal; Sakhuwa (Th)	Shorea robusta Gaertn.	Dipterocarpaceae	Tree	Seeds (boiled and roasted	Boi, Roa

SN	Local name	Species	Family	Habit	Part	Uses
					seeds)	
335.	Sallo	Pinus roxburghii Sarg.	Pinaceae	Tree	Seeds	Roa
336.	Sankatra	Citrus decumana L.	Rutaceae	Shrub	Fruits	Jam, Pic
337.	Sano gangleto	Elatostema platyphyllum Wedd.	Urticaceae	Herb	Leaves	Veg
338.	Sano kukurdaino	Disporum cantoniense (Lour.) Merr.	Colchicaceae	Herb	Leaves	Veg
339.	Sano mayal	Pyrus pashia Buch.-Ham. ex D.Don(i)	Rosaceae	Tree	Fruits	Fru
340.	Sano saro	Cautleya spicata (Sm.) Baker	Zingiberaceae	Herb	Stems	Veg
341.	Saranchi sag	Alternanthera sessilis (L.) R.Br. ex DC.	Amaranthaceae	Herb	Leaves	Veg
342.	Sarpako makai	Arisaema jacquemontii Blume	Araceae	Herb	Root/tuber	Veg
343.	Satibayer	Rhus parvifloraRoxb.	Anacardiaceae	Shrub	Fruits	Fru
344.	Saur	Betula cylindrostachys Wall. ex Diels	Betulaceae	Tree	Bark	Che
345.	Sigan godai	Sagittaria sagittifolia L.	Alismataceae	Herb	Leaves, Rhizomes	Veg
346.	Sikakai	Acacia rugata (Lam.) Fawc. & Rendle (Syn. Acacia rugata (Lam.) Voigt)	Leguminosae	Climber	Young shoots	Veg
347.	Silam	Perilla frutescens (L.) Britton	Lamiaceae	Herb	Seeds.	Pic
348.	Sim sag	Nasturtium officinale R. Br.	Brassicaceae	Herb	Leaves, whole plant	Veg
349.	Sim sag	Rorripa nasturtium Scop.	Brassicaceae	Herb	Leaves	Veg
350.	Simal	Bombax ceiba L.	Bombacaceae	Tree	Flowers, fruits, Seeds	Roa, Veg
351.	Simal aru	Manihot esculenta Crantz (Syn. Manihot utilissima Pohl)	Euphorbiaceae	Shrub	Root tuber	Veg
352.	Simi	Dolichos lablab L.	Leguminosae	Climber	Seeds	Pul, Veg
353.	Singada	Trapa bispinosa Roxb.	Trapaceae	Herb	Nuts	Fru
354.	Singato	Schisandra grandiflora (Wall.) Hook.f. & Thomson (Syn. Schisandra grandiflora Wall.)	Schisandraceae	Climber	Fruits	Fru
355.	Sinkauli	Cinnamomum bejolghota (Buch.-Ham.) Sweet (Syn. Cinnamomum obtusifolium (Roxb.) Nees)	Lauraceae	Tree	Whole plants	Spi
356.	Sipligan	Crateva religiosa G.Forst.	Capparaceae	Tree	Shoots	Veg
357.	Sipligan	Crateva unilocularis Buch.-Ham.	Capparaceae	Tree	Young shoots, leaves, flowers	Veg
358.	Sisnu	Urtica dioica L.	Urticaceae	Herb	Inflorescences and young leaves	Veg
359.	Sisnu	Urtica parviflora Roxb.	Urticaceae	Herb	Inflorescences and young leaves	Veg
360.	Siudi	Euphorbia royleana Boiss.	Euphorbiaceae	Shrub	Flowers	Veg
361.	Suga phool	Piptanthus nepalensis (Hook.) D.Don	Leguminosae	Shrub	Flowers	Veg
362.	Swibhama (Ne); Hulhule (Da)	Cleome viscosa L.	Capparaceae	Herb	Leaves; Seeds	Oil, Veg
363.	Tama bans	Dendrocalamus hamiltonii Nees & Arn ex Munro	Poaceae	Bamboo	Young shoots	Pic, Veg
364.	Tama bans	Dendrocalamus strictus (Roxb.) Nees	Poaceae	Bamboo	Shoots	Pic, Veg
365.	Tanki	Bauhinia purpurea L.	Leguminosae	Tree	Shoots, Flowers	Veg
366.	Tantari	Dillenia pentagyna Roxb.	Dilleniaceae	Tree	Young fruits	Fru, Pic, Veg
367.	Tarika	Pandanus furcatus Roxb. (Syn. Pandanus nepalensis H.St.John)	Pandanaceae	Tree	Fruits	Pic
368.	Tarul	Dioscorea esculenta (Lour.)	Dioscoreaceae	Climber	Root/tuber	Veg

SN	Local name	Species	Family	Habit	Part	Uses
		Burkill				
369.	Tatelo	Oroxylum indicum (L.) Kurz	Bignoniaceae	Tree	Flowers, Fruits, Pods	Pic, Veg
370.	Tejpat	Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Lauraceae	Tree	Leaves	Spi
371.	Thakal	Chamaerops humilis L. (Syn. Phoenix humilis Royle)	Arecaceae	Shrub	Fruits, tender leaves	Fru, Veg
372.	Thakal	Cirsium wallichii DC.	Compositae	Herb	Shoots	Veg
373.	Thakal	Phoenix acaulis Roxb.	Arecaceae	Tree	Fruits (Raw)	Fru, Veg
374.	Thakal	Phoenix sylvestris (L.) Roxb.	Arecaceae	Tree	Soft piths	Fru
375.	Thakal	Wallichia disticha T.Anderson	Arecaceae	Tree	Fruits and Pith	Fru, Veg
376.	Thakal/Khajur (Th)	Phoenix loureiroi Kunth	Arecaceae	Tree	Pith of stem and ripe fruits	Fru, Veg
377.	Thekiphal	Actinidia callosa Lindl.	Actinidiaceae	Tree	Fruits	Fru
378.	Thokarak sag (Th)	Monochoria hastata (L.) Solms.	Pontederiaceae	Herb	Tender shoots, leaves	Veg
379.	Thokarak sag (Th)	Sagittaria aginashii Makino (Syn. Sagittaria gyayanensis Kunth)	Alismataceae	Herb	Whole plants	Veg
380.	Thotne	Polygonum molle D. Don (Syn. Aconogonum molle (D.Don) H. Hara)	Polygonaceae	Herb	Young shoots	Veg
381.	Thulo bihi; Badaki bihidi (Th)	Solanum torvum Sw.	Solanaceae	Shrub	Fruits (fresh)	Pic, Veg
382.	Thulo mayal	Pyrus pashia Buch.-Ham. ex D.Don (ii)	Rosaceae	Tree	Fruits	Fru
383.	Timchu	Arisaema flavum (Forssk.) Schott	Araceae	Herb	Shoots	Veg
384.	Timila	Ficus auriculata Lour.	Moraceae	Tree	Leaves	Veg
385.	Timur	Zanthoxylum armatum DC.	Rutaceae	Shrub	Fruits	Fru, Pic, Spi
386.	Tinko jhangi	Elephantopus scaber L.	Compositae	Herb	Plant shoot	Mar
387.	Tite phaper	Fagopyrum tataricum (L.) Gaertn.	Polygonaceae	Herb	Leaves	Veg
388.	Tite sag	Sonchus wightianus DC.	Compositae	Herb	Leaves	Veg
389.	Tori gande	Blumeopsis flava (DC.) Gagnep. (Syn. Blumeopsis falcate (D. Don) Merr.)	Compositae	Herb	Plant	Mar
390.	Tori ghans	Capsella bursa-pastoris (L.) Medik.	Brassicaceae	Herb	Leaves	Veg
391.	Tori phool	Emilia sonchiholia (L.) DC. ex DC.	Compositae	Herb	Leaves	Veg
392.	Tulsi	Ocimum sanctum L.	Lamiaceae	Herb	Leaves	Jui
393.	Tyaguna	Dioscorea kamaoonensis Kunth.	Dioscoreaceae	Climber	Tuber, bulbil	Veg
394.	Urakthewn (Th)	Pteris vittata L.	Pteridaceae	Herb	Shoots	Veg

Local names: Da=Darai, Ne= Newari, Th=Tharu. Use categories: Boi= Boiled seed, Fru=Fruit, Jui=juice, Kat= Katha, Jel= jelly, Mar= Marcha, Nec= nectar, Oil= cooking oil, Jam, Pic=pickle, Pul=pulse, Rak= raksi wine, Roa= roasted seed, Sou=soup, Spi=spice and condiments, Tea, Veg= vegetables; Vin= vinegar. Source: Aryal and Aryal 2010, Bajracharya 1980, Dangol 2002, 2010, Dangol and Gurung 2000, Dangol et al 2014, Ghimireya et al 2010, Joshi et al 2007, Pradhan 2006, Shrestha 2013, Uprety et al 2012.

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Semi-domesticated Plant Genetic Resources in Nepal

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ABSTRACT

Many plant species in the world are neither in fully wild state nor fully domesticated. The semi-domestication means a kind of plant species that is in between wild plants and domesticated crops. Semi-domesticated plants are mostly in or around the farm and are under human intervention to care and maintain them. These plants have different uses such as food, fruits and vegetables, spices, flower and others in the community. In Nepal, 42 plant species are in the state of semi-domestication, distributed in different ecological regions. Among them one species is uses as grain, 22 as vegetables, 9 as fruits, 3 as spices and condiments, one as flower juice and 6 as oil and fiber. Their values are increasing because of high adoptive capacity to environment, possessing medicinal properties and ease of maintenance. Research on diversity and nutrient properties of such species available in the country needs to initiate along with conservation activities.

Keywords: Community, distribution, plant species, semi-domesticated, use value

INTRODUCTION

Many plant species in the world are neither in fully wild state nor fully domesticated thus in the state of semi-domestication. Semi-domesticated plants are mostly in or around the farm and are under human intervention to care and maintain them. These plants have different uses in the community, as food item, fruits and vegetables, spices, flower and others. The domestication of plants in the form of cultivated crops is the great turning point in human history. The notion of semi-domestication originated to refer to a kind of plant that is in between wild plants and domesticated crops (Torigoe and Kada 2007). The semi-domesticated crops are thus mostly gathered/collected rather than harvested. These plants are mostly in wild state but are conserved due to their importance for human beings. Major features of semi domesticated species are i. they grow naturally in farming lands, ii. farmers' harvest economic parts without giving any inputs, iii. they do not adopt intensive cultivation practices, iv. seeding materials for next season maintain on-farm naturally (ie dormant and active period of life in same site), v. knowledge on agronomic practices, biology poorly understood, vi. population size in wild forms is narrow, etc. The domestication implies an increased interdependence between human cultivators and the plants they cultivate, and that this can be considered a case of symbiotic co-evolution (Rindos 1980). The transition between wild plant forms and domesticated species can be considered an evolutionary adaptation by plants in response to a human driven ecology (Fuller and Allaby 2009). Agricultural scientists regards these species mostly on the developmental stage of domestication due to their importance to human beings while Anthropologists do not consider semi-cultivated plants to be in a developmental process from wild to domesticated plants, but instead regard them as having their own specific cultural roles. There are a number of plant species growing naturally in the farming lands and they have religious, cultural, food and nutritional values. They have high potential in agri-business; however, attention has not been given by development organizations. Here we have documented semi domesticated plant species applicable to Nepal after literatures survey, key informants interview including farmers and field visits.

HISTORY AND TREND OF SEMI-DOMESTICATED PLANT SPECIES

Actual date of giving value to semi domesticated plant species are not known in Nepal. It is generally perceived that after modernization of agriculture in around 1980s, many farmers and consumers started giving due attention to such plant species. Main attractions of these species are their good taste, easy growing and high adaptation. Now a day, areas and number of such plant species is increasing in farming lands as well as in the market.

SEMI-DOMESTICATED SPECIES

The category of semi-domesticated species is sometimes confusing thus it overlaps with wilds or plants that are now started cultivation. It also differs in different localities. The plants listed here are selected based on their state of semi-domestication in certain part of the country. Most of them are being used either as vegetables, fruits, spices and other various purposes by the local people since long. In Nepal, many plant species are in the state of semi-domestication and distributed in different ecological regions. However, any systematic survey to list out the semi-domesticated crops has not been done so far. Few reports list them as semi-domesticated (Joshi et al 2017) or underutilized crops (Aryal et al 2009, Khanal et al 2014) or minor crops. Based on the available literature and personal communication with key informants, altogether 42 plant species are listed here as semi-domesticated plant species in Nepal (**Table** 1).

Table 1. List of semi-domesticated crops in Nepal with their distribution and uses

SN	English name	Nepali name	Scientific name	Distribution	Use value
1.		Dhatelo	Prinsepia utilis Royale	1500-2000 m	Oil/fence
2.	Amaranthus	Latte/ lude sag	Amaranthus tricolor L./ A. blitum L.	Mid Hill and Tarai	Vegetables
3.	Ander	Castor	Ricinus communis L.	Low Hill and Tarai	Oil
4.	Gooseberry	Amala	Phyllanthus emblica L.	Mid Hill and Tarai	Fruits
5.	Barnyard millet	Sama	Echinochloa crus-galli (L.) P.Beauv.	Mid Hill and Tarai	Seeds Used as millet
6.	Black Plum, Java Plum, Surinam Cherry	Jamun	Syzygium cumini (L.) Skeels	low Hill and Tarai	Fruits
7.	Butter tree/Bassia	Chiuri	Diploknema butyracea (Roxb.) H.J.Lam	Mid Hill	Butter
8.	Caraway	Himalijeera	Carum carvi L.	High Hill	Spices
9.	Chinese date, Indian cherry plum	Bayer	Ziziphus jujuba Mill.	Mid Hill and Tarai	Fruits
10.	Chinese Leek	Dundusaag	Allium tuberosum Rottler ex Spreng.	High Hill	Vegetables
11.	Cinnamon	Tejpat/ Dalchini	Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	450-2100 m	Spices/condiments
12.	Citron	Bimiro	Citrus medica L.	Mid Hill	Fruits
13.	Deltoid Yam	Vyakur	Dioscorea nepalensis (Jacquem. ex Prain & Burkill) Sweet ex Bernardi	Mid Hill and Tarai	Vegetables
14.	Edible Emetic nut	Pidar	Tamilnadia uliginosa (Retz.) Tirveng. & Sastre	Tarai and Inner Tarai	Fruits
15.	Garlic pear	Sipligan	Crateva religiosa G.Forst	Mid Hill	Vegetables
16.	Hairy vetch	Kutilkosa	Vicia hirsuta (L.) Gray	Mid Hill and Tarai	Vegetables
17.	Himalayan Bamboo	Nigalo/tusa/ Kalonigalo	Arundinaria falcata Nees/Phyllostachys nigra (Lodd. ex Lindl.) Munro	High Hill	Vegetables/ hedges
18.	Himalayan Nettle	Allo	Girardinia diversifolia (Link) Friis	1200-3000 m	Bark for fibre
19.	Horse chestnut	Pangra, Pangar	Aesculus indica (Wall. ex Cambess) Hook.	900-3000 m	Leaves to make flour
20.	Indian Poke	Jaringo	Phytolacca acinosa Roxb.	500-2400 m	Vegetables
21.	Ivy guord	Kundruk	Coccinia grandis (L.) Voigt	Mid Hill and Tarai	Vegetables
22.	Lamb's Quater	Bethe	Chenopodium album L.	All ecological range	Vegetables
23.	Malabar Night Shade / Indian Spinach	Poisag	Basella alba L.	Mid Hill and Tarai	Vegetables
24.	Mexican Coriander	Ban Dhaniya	Eryngium foetidum L.	Mid Hill	Vegetables/pickles
25.	Mint	Pudina	Mentha arvensis L.	1200-2700 m	Vegetables
26.	Mountain ebony	Koiralo	Bauhinia variegata L.	Mid Hill	Vegetables
27.	Nepali bamboo	Tama bans/ Phusre bans	Bambusa nepalensis Stapleton	Mid Hill	Vegetables
28.	Nepali Peeper	Timur	Zanthoxylum armatum	1100-	Spices/condiments

SN	English name	Nepali name	Scientific name	Distribution	Use value
			DC.	2500m	
29.	Pig Weed	Lude sag	Amaranthus viridis L.	Mid Hill and Tarai	Vegetables
30.	Potato Yam, Air Potato	Gittha	Dioscorea bulbifera L.		
31.	Rhododendron	Lalighuras	Rhododendron arboreum Sm.	Mid to High Hill	Flower juice
32.	Rough lemon	Jyamir	Citrus jambhiri Lush.	Mid Hill	Fruits
33.	See buckthorn	Dale chuk	Hippophae rhamnoides L.	High Hill	Fruits/juice
34.	Sikkim knotweed	Thotne	Polygonum molle D. Don	1200-3500 m	Vegetables
35.	Slender adder's-tongue	Jibresag	Ophioglossum nudicaule L. f.	Mid Hill and Tarai (upto 1800 m)	Vegetables
36.	Stinging nettle	Sisnu	Urtica dioica L.		Tender shoots and leaves cooked as vegetable, also used in maize to make porridge (*khole*)
37.	Water chestnut	Singhada	Trapa bispinosa Roxb.	Mid Hill	Fruits
38.	Water cress	Simsag	Nasturtium officinale R.Br.	Mid Hill	Vegetables
39.	Water Spinach / Swamp cabbage	Kalami sag / karmaiya sag/Ramia/Kerunge	Ipomoea aquatica Forssk.	Mid Hill and Tarai	Vegetables
40.	Wild Edible Yam	Ban tarul	Dioscorea bulbifera L.	Mid Hill	Vegetables
41.	Wild Onion	Jimmu	Allium hypsistum Stearn	High Hill	Spices/condiments
42.	Wood apple	Bel	Aegle marmelos (L.) Corrêa	Low Hill and Tarai	Fruits/juice

Source: Josh et al 2017, Acharya and Niraoula 2014, Shrestha 2008, Upadhyay and Joshi 2003, Khanal et al 2014, Aryal et al 2009, Joshi 2017.

DISTRIBUTION

Such types of plant species are distributed across the country. However, Mid Hill region has higher number of semi-domesticated species (**Table** 1). Most of the household keep such plant species growing in their field without any care and harvest at appropriate time. Such plant species are mostly found around home garden. The populations of such species are generally small in wild state; however, their size is increasingly larger in farming areas depending on their economic value.

USE VALUE

Most of the semi-domesticated plants are used as vegetables (**Table** 1) and some are for fresh fruits. Among the 42 semi-domesticated plant species, one is used as grain, 22 as vegetables, 9 as fruits, 3 as spices and condiments, one for flower juice and 6 others. They grow naturally in the cultivated lands, breed naturally, matured seeds conserved in the fields and very few intervention are applied by farmers to harvest from such plant species. Minor amount of the product are also sold in the market. They are preferred mainly because of having some medicinal values. Consumers also prefer being natural and organic. Farmers are rich in knowledge for their use value.

WAY FORWARD

Farmers and consumers are using APGRs from three stages namely wild, semi domestication and domestication. Wild to semi domestication to domestication is very long process and mainly selection is the major part to accelerate the process. A number of wild edible plants may have potential to grow in human made environment. Farmers are getting benefit from semi-domesticated plant species without giving any inputs and time. Their capacity to adopt adverse conditions and to tolerate stresses should be the future scope in agricultural business. As these crops have importance for the food and nutrition security and have commercial value adding diversity in the market, the technology for their cultivation and use should be developed and delivered. Many systematic studies including nutrient content and diversity assessment are necessary to explore the status and details about these crops. Local farmers, because of their close association with nature and natural environment often developed very practical knowledge system about their use and management (Shrestha and Dhillion 2006), hence exploration of such knowledge and practices can provide very good basis for species domestication. In the other hand, conservation and sustainable use of these plant resources received relatively little attention even by its users and promoters as they perceive these are the free resources getting from the nature (Aryal et al 2013, 2009). Furthermore, these genetic resources are neglected in research and development activities as well as not adequately addressed by policy and program of the country (Aryal et al 2009). Hence an integrated participatory collaborative approach (including the local farmers) is necessary to identify such species having multiple use value for further research and development for the promotion of semi-domesticated plant species for conservation as well as contribution in livelihood of the people.

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Annex 1. Some semi-domesticated plant species

 Gooseberry/ Amala: *Phyllanthus emblica* L.	 Citron /Bimiro: *Citrus medica* L.	 Wood apple/ Bel: *Aegle marmelos* (L.) Corrêa
 Lamb's Quater/ Bethe: *Chenopodium album* L.	 Wild Onion/ Jimmu: ***Allium hypsistum*** Stearn	 See buckthorn/ Dale chuk: *Hippophae rhamnoides* L.
 Garlic pear/ Sipligan*: Crateva religiosa* G.Forst	 Stinging nettle/ Sisnu: *Urtica dioica* L.	 Nepali bamboo/ Tama bans: *Bambusa nepalensis* Stapleton
 Water cress/ Simsag: *Nasturtium officinale* R.Br.	 Amaranthus/ Latte: *Amaranthus tricolor* L.	 Mountain ebony/ Koiralo: *Bauhinia variegata* L.

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Green Manuring Plant Species in Nepal: Diversity and Distribution

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ABSTRACT

Green manuring (GM) plants are rich resources in Nepal. However, their identification, classification and usage are limited. Agro-ecological diversity of Nepal provides favorable growing conditions for both indigenous and introduced GM plants. However, only few are being used as green manure to enhance the soil fertility and plant growth in Nepal. More than 20 indigenous plant species are identified to possess green manuring values in Nepal. Widely, used GM plants in Nepal are *Adhatoda vasica* Nees (Asuro), *Sesbania* spp (Dhaincha), *Artemisia vulgaris* L. (Titepati), *Crotalaria juncea* L. (Sunhemp), and *Azolla* (Jalunyo). In this review, we have summarized the distribution, diversity and benefits of GM plants found in Nepal to enhance agricultural practice.

Keywords: Green manure, legumes, plant diversity, soil fertility

INTRODUCTION

Nepal is an agrarian country located in central part of Himalayan range in between India and China. Nepal has a high degree of agro-ecological diversity owing to variation in topography, slope, aspect and altitude (60-8848 m) that allow range of biological environments, climatic regimes and varied ecosystems. Globally, Nepal harbors 3.2% of flora that includes 5.1% gymnosperms, and 8.2% bryophytes (DPR 2012). Country is rich in diversity of agricultural crops and their wild relatives. A green manure is plant primarily used as a soil amendment and as a nutrient source for subsequent crops. It is an important strategy to maintain and improve soil fertility in organic crop production (Fageria 2007). They can also be a critical nutrient source for smallholder farmers in the tropics who are unable to access adequate quantities of mineral fertilizers (Palm et al 2001). Criteria for selection of green manures include: fleshy and soft plant, fast growing, fast decomposing, leguminous, pest and disease repellent, nutrient provider to soil, and non-invasive. Their benefits are well documented and include greater soil fertility, prevention of soil erosion, reduced nutrient leaching, weed control, increase in microbial biomass and activities, and disease control(Kumar et al 2014, Campiglia et al 2009). In context of Nepal, more than 20 indigenous plant species are identified to have green manuring values and more other closely related species need to be explored for their green manuring values. Wide range of GM plants, either cultivated or grown in wild, are found. GM species are listed under heterosporous fern as *Azolla, or* shrubs/ herbs as *Adhatoda vasica* Nees*, Aeschynomene aspera* L.*, Artemisia vulgaris* L.*, Cucurbita maxima* Duchesne*, Eupatorium adenophorum* Spreng.*, Guizotia abyssinica* (L.f.) Cass.*, Jatropha curcas* L.*,* or leguminous crops as *Crotalaria juncea* L.*, Cicer arietinum* L.*, Pisum sativum* L.*, Sesbania aculeata* (Willd.) Pers.*, Trifolium repens* L.*, Vicia faba* L.*, Vigna sinensis* (L.) Savi ex Hausskn.*,* and *Vigna umbellate* (Thunb.) Ohwi & H.Ohashi or trees as, *Albizia lebbeck* (L.) Benth.*, Albizia odoratissima* (L.f.) Benth.*, Albizia procera* (Roxb.) Benth.*, Ficus clavata* Wall. ex Miq.*, Melia azedarach* L.*, Sapium insigne* (Royle) Trimen*, Schima wallichii* Choisy, and *Trichilia connaroides* (Wight & Arn.) Bentv. Proper documentation of these GM plants used in Nepal should be done to achieve their optimum use and conservation for future.

HISTORY AND TREND ON USING GM PLANTS IN NEPAL

GM is an ancient practice. Farming in Nepal is heavily dependent on forest resources, such as leaf litter, green manure and fodders (Mahat 1987, Kadariya 1992). Various GM plants have been in practices in agricultural system of Nepal since time immemorial. However, there are limited documentation on when, where and how these practices are being carried out. In book "Regenerative agriculture technologies for the hill farmers of Nepal: An information kit (IIRR 1992)" there are description of useful GM plants, their practice and application methods in Nepal. Different NGO's like ICIMOD and Government of Nepal have initiated their work on GM as a part of sustainable agricultural development of Nepal since few decades back. Nepal agriculture research council (NARC) has carried out different studies on few GM plants, and their effect on crop production

(Adhikari 2014). Moreover, *Sesbania rostratra* Bremek. & hutch. and *Sesbania cannabina* (Retz.) Pers. are widely used along with rice and have been found to increase yield significantly (Adhikari 2014). Intercropping of leguminous crop with maize is very common practice in Nepal since long time. It is reported that farmers of Kaski district adopted intercropping of *Crotalaria* with finger millet to improve soil in that region. *Crotalaria* is also intercropped with maize, wheat and rice plants. However, it is reported to be more effective for maize. Dhaincha, another popular GM plant in Nepal, is abundantly used in improving rice and maize production (Basnet 1998, Gurung and Sherchan 1997).

Azolla, a water fern, is mostly used to improve the rice yield. In context of Nepal, azolla is either incorporated into the soil before rice transplanting or grown as a dual crop along with rice. Different researches are being carried out to show its effect on yield and soil quality (Adhikari et al 2014). Now-a-days in Nepal organic farming is flourishing and farmers are willing to switch towards it, and in such context GM plants can have immense value and importance.

DIVERSITY AND DISTRIBUTION OF GM PLANTS AND THEIR BENEFITS

There are wide ranges of GM plants, found in Nepal. Some are cultivated while other grows wild in nature. Their distribution ranges from 250 m to 2200 m altitude. In Nepal, more than 20 indigenous plant species having green manure values have been identified. Additionally, other closely related species of plant could also be explored as a GM species. Highly used species of GM plants in Nepal are listed in **Table** 1 and **Figure** 1. Some GM plants as *Azolla* and *Crotalaria juncea* (sunhemp) are introduced species in Nepal and are widely used as green manure (**Table** 2 and **Figure** 2). Sunhemp is used with wheat, maize, rice and millet (Adhikari 2014 and Grissthi communications) where as *Azolla* has been used for increaing rice yield (Adhikari and Thakur 2013). Different other species of plant found in Nepal can be promoted and utilized as GM plants. Few plant species which are distributed at different part of Nepal are summarized and suggested in **Table** 3, **Figure** 3. Agro-ecologically most of these plants are distributed in Hill regions of Nepal.

Table 1. Diversity and distribution of plants used as green manure in Nepal

SN	Common name	Local name	Scientific name	Origin	Type	Propagation method	Distribution
1.	East Indian walnut	Shirish	Albizia lebbeck (L.) Benth	Native	Wild	Seeds	Tarai and Hill
2.	Malabar nut, adhatoda	Asuro, kalovashak	Adhatoda vasica Nees	Native	Wild	Clonal, stems, micropropagation	Hill
3.	Milk tree	Khirro	Sapium insigne (Royle) Trimen	Native	Wild	Stem cuttings	Hill
4.	Mugwort, Common wormwood	Titepati	Artemisia vulgaris L.	Native	Wild	Seeds	Hill
5.	Oregano	Kanikephool	Sambucus hookeri Rehder	Native	Wild	Stem cuttings	Hill
6.	River hemp	Dhaincha	Sesbania cannabina (Retz.) Pers.	Native	Domestic	Stem cuttings or seeds	Tarai and Hill
7.	River hemp	Dhaincha	Sesbania rostrata Bremek. & Oberm.				
8.	White clover	Beulee	Trifolium repens L.	Native	Wild	Seeds	Hill
9.	Wild marjoram	Raamtulasi	Origanum vulgare L.	Native	Domestic	Stem cuttings	Hill and mountain

Agro-ecological distribution of these plants in Nepal according to range, Mountain >2500 m, Hill 500-2500, Tarai <500.

Table 2. Famous introduced green manuring plant used in Nepal

SN	Common name	Local name	Scientific name	Origin	Type	Propagation method	Distribution
1	Sunhemp	Sanai, Chhinchhine	Crotalaria juncea L.	Cultivated	Domestic	Through seeds	Tarai and Hill
2	Water fern	Jal-unyu	Azolla caroliniana Willd.	Introduced	Wild	Sporocarps	Mountain, Hill and Tarai
3	Water fern	Jal-unyu	Azolla mexicana C. Presl				
4	Water fern	Jal-unyu	Azolla mexicana				

			C. Presl
5	Water fern	Jal-unyu	Azolla pinnata R. Br.

Agro-ecological distribution of these plants in Nepal according to range, Mountain >2500 m, Hill 500-2500, Tarai <500.

Figure 1. Commonly used native green manuring plants in Nepal where a) *Adhatoda vasica,* b) *Albizia lebbeck,* c) *Artemisia vulgaris*, d) *Origanum vulgare,* e) *Sambucus hookeri,* f) *Sapium insigne,* g) *Sesbania* spp., h) *Trifolium repens.*

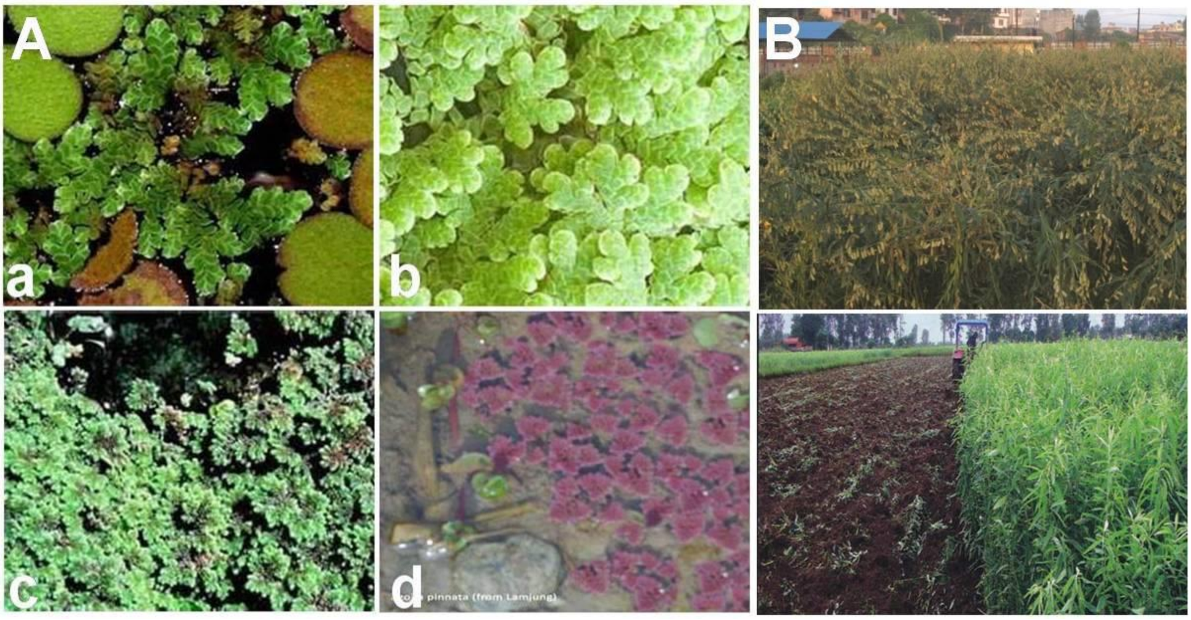

Figure 2. Different species of *Azolla* that are mostly used as green manure in Nepal, where A) *Azolla* spp. a) *Azolla caroliniana* b) *Azolla mexicana,* c) *Azolla mexioana,* d) *Azolla pinnata,* B) *Crotalaria juncea*.

Table 3. Some recommended species of plants as green manures

SN	Common name	Local name	Scientific name	Origin	Type	Propagation method	Distribution
1.		Dhondiya	Aeschynomene aspera L.	Introduced	Domestic		Tarai and Hill
2.		Berulo	Ficus clavata Wall. ex Miq.	Native	Wild	Stem cuttings, seeds	Hill
3.		Aankhatar uwa	Trichilia connaroi des (Wight & Arn.) Bentv.	Native	Wild	Seeds	Hill
4.	Black Siris, ceylon rosewood, fragrant albizia, tea shade tree	Kalo siris, padke	Albizia odoratissima (L.f.) Benth.	Native	Wild	Root cuttings, seeds, micropropagation	Tarai

SN	Common name	Local name	Scientific name	Origin	Type	Propagation method	Distribution
5.	Chickpea	Chana	Cicer arietinum L.	Introduced	Domestic	Stem cuttings, seeds	Tarai and Hill
6.	Chinaberry tree	Bakenu	Melia azedarach L.	Native	Wild	Seeds, micropropagation	Hill
7.	Cow pea, Black-eyed pea	Bodi	Vigna sinensis (L.) Savi ex Hausskn.	Introduced	Domestic	Seeds	Hill
8.	Crofton weed or sticky snakeroot	Banmara, kaljhar	Eupatorium adenophorum Spreng.	Introduced	Wild	Seeds	Hill
9.	English bean, Broad bean	Bakulasimi	Vicia faba L.	Introduced	Domestic	Seeds	Mountain
10.	Garden pea	Kerau	Pisum sativum L.	Introduced	Domestic	Seeds	Hill
11.	Jatropha	Sajiwan	Jatropha curcas L.	Introduced	Domestic	Stem cuttings, seeds	Hill
12.	Needle wood Tree	Chilaune	Schima wallichii Choisy	Native	Wild	Seeds	Hill
13.	Niger seed	Jhusetil	Guizotia abyssinica (L.f.) Cass.	Introduced	Domestic	Seeds	Hill
14.	Pumpkin, winter squash	Mithopharsi	Cucurbita maxima Duchesne	Introduced	Domestic	Seeds	Tarai and Hill
15.	Rice bean	Masyang	Vigna umbellata (Thunb.) Ohwi & H.Ohashi	Introduced	Domestic	Seeds, clonal propagation	Hill
16.	White siris	Setosiris	Albizia procera (Roxb.) Benth	Native	Wild	Stem and root cuttings	Tarai and Hill

Agro-ecological distribution of these plants in Nepal according to range, Mountain >2500 m, Hils 500-2500, Tarai <500.

GM crops such as legumes develop nodules in stem, in roots or both. *Sesbania* sps (Dhaincha), alfalfa, clover, grain legume crops (Soyabean, cowpea, mungbean, blackgram) are legume crops used as green manure. Other green manuring plants grow in wild and are rich in nutrient content such as *Adhatoda vasica* (Asuro), Khirro (*Sapium insigne*), *Eupatorium adenophorum* (Banmara), *Artemisia vulgaris* (Titepati) etc. They can supply plant nutrients after incorporation into the soil (Gurung 1992, ICIMOD 1995). These green manures can be added into the soil in in-situ culture or by bedding them in the soil from outside (ex-situ) and then incorporated (Adhikari 2014).There are two ways of using green manures: When land is unused, or fallow ie, in between crops or while crops are still growing in the field. The use of leguminous green manure crops had been recognized as an important source of N for wetland rice much before the advent of modern agricultural technology (Singh et al 1991). Yet, farmers have not been able to apply it intensively because of the scarcity caused by lack of conservation and promotional efforts (Paudel and Thapa 2001). GM plants contain higher amount of micronutrients as N,P,K that are highly required by plants. Nutritive values of few GM plants are summarized in **Table** 4.

Table 4. Nutrient content of some green manure crops

SN	Common name	Nepali name	Scientific name	Nutrient content (%) on air dry basis			Reference
				N	P	K	
1	East Indian walnut	Shirish	Albizia lebbeck (L.) Benth.	2.9	4.5* 0.65	4.5* 2.6	Joshi 1987
2	Malabar nut	Asuro	Adhatoda vasica Nees	4.30	0.90	4.50	Joshi 1987
3	Milk tree	Khirro	Sapium insigne (Royle) Trimen	2.80	0.80	2.90	Joshi 1987
4	Mugwort, Common wormwood	Titepati	Artemisia vulgaris L.	2.40	0.90	4.90	Joshi 1987
5	Riverhemp	Dhaincha	Sesbania spp	3.50	0.26	1.20	
6	Sunhemp	Sanai, Chhinchhine	Crotalaria juncea L.	3.20	0.22	1.30	Laszlo 2010
7	Water fern	Jal Uniyo	Azolla	2.42	0.56	2.09	
8	Water fern	Jal Uniyo	Azolla pinnata R. Br.	4.50	0.5-0.9	2-4.5	Singh 1979

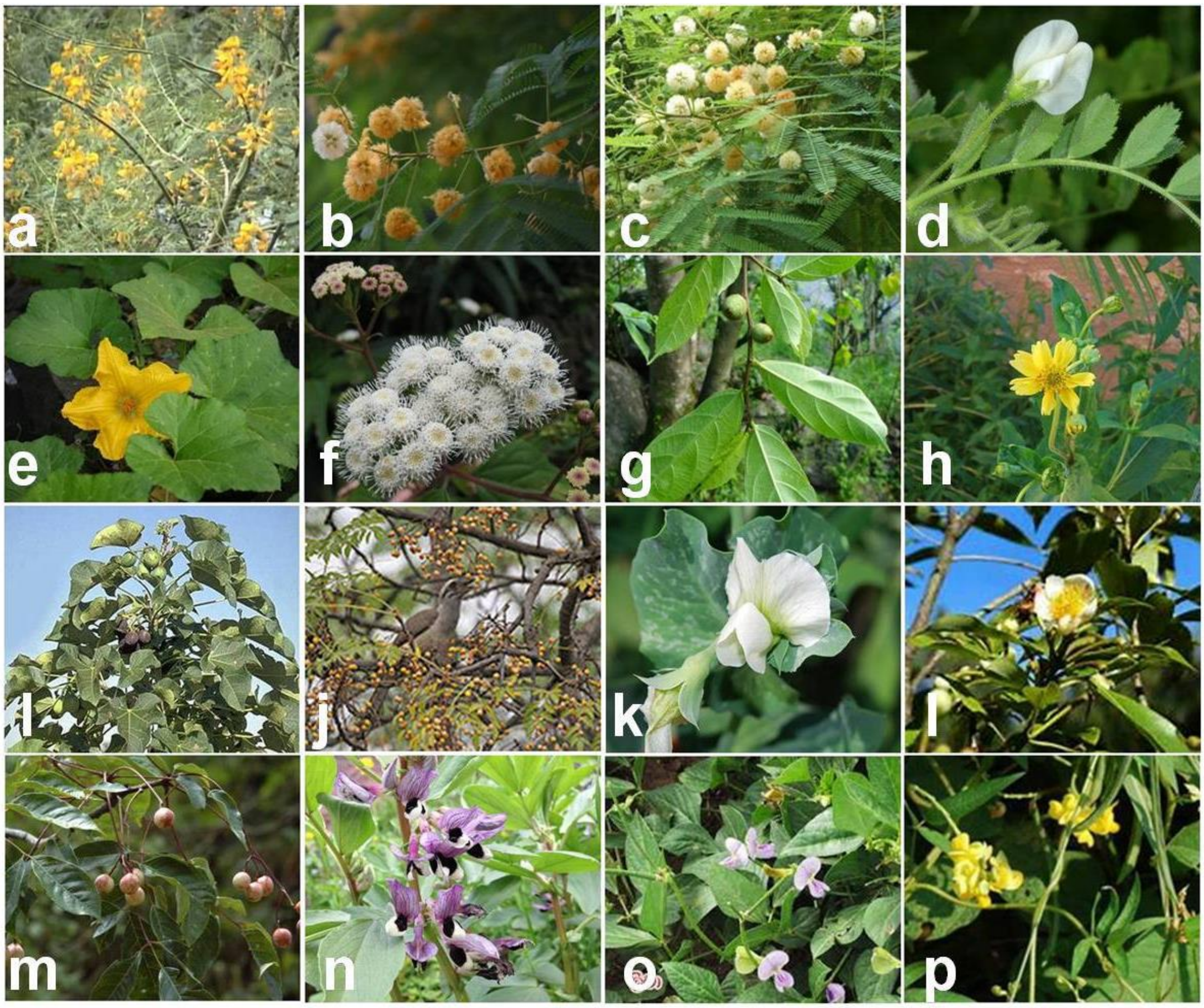

Figure 3. Some recommended species of Nepal which have high potential as green manure in Nepal where a) *Aeschynomene asper,* b) *Albizia odoratissima,* c) *Albizia procera,* d) *Cicer arietinum,* e) *Cucurbita maxima,* f) *Eupatorium adenophorum,* g) *Ficus clavata,* h) *Guizotiaabyssinica,* i) *Jatropha curcas,* j) *Melia azedarach,* k) *Pisum sativum,* l) *Schima wallichii,* m) *Trichilia connaroides,* n) *Vicia faba,* o) *Vigna sinensis* and p) *Vigna umbellate*.

Collectively, GM provides life to soil, regenerating its nutritive values and necessary micronutrients to plants, thus resulting in better growth and yield. Moreover, GM helps in maintaining soil organic matter and reclamation of saline soil (Evans and Rotar 1987). Additionally, it also helps in control of weed (Blackshawet al 2001), disease control against rice blast (Gurung 1992), nematodes (Johnson et al 1992**)** and other plant pathogens (Kumar et al 2014). GM plants have very good ecological impacts on health of soil, plant and human if used continuously on field. For eg, every year farmers use urea for rice, however use of Dhaincha will cut its usage by 50 % saving soil health and money of farmer (Adhikari 2014). Additionally, cutting down use of chemical pesticides and increasing the usage of GM plants to control disease will improve health of human and soil.

WAY FORWARD

GM plants are important resource for sustainable agricultural practice in Nepal. Resource poor farmers can take advantages from this to supplement plant nutritional need instead of expensive chemical fertilizer. Identification, exploration and protection of diverse GM plants are of utmost necessity in Nepal. More researches on the nutritive value of the existing GM plants should be carried out to get the best and effective GM plants. Database, inventory or catalogue of GM plants found in Nepal is the best way to provide information to researchers, students and farmers about them. This in turn would help them to perform the needed research or farming on basis of their needs and properties. Finally, we can conclude that this study will contribute to add a little information on distribution and diversity of GM plants found in Nepal and shed light on future directions in developing and choosing them for sustainable agricultural goals.

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Pesticidal Plant Species: Diversity and Pest Management

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ABSTRACT

Many plant species are reported to have naturally occurring properties of killing, destroying, repelling or mitigating crop pests, these plants are called as pesticidal plants. Botanical pesticides are extracted from these pesticidal plants and are used against crop pests by small holder farmers. Due to raised awareness against chemical pesticides, botanicals are getting attention around the world. Significant research works have been carried out by various research institutions and plenty of research reports are available on botanical pesticides. At least 3,000 plant species have already been studied globally in laboratory tests to determine their effectiveness for controlling plant pests and disease. Farmers in Nepal have been using pesticidal plants to control diseases and insect pests of crops for many years. They have precise knowledge about distribution, abundance, cultural practices, pest management, harvesting, and proper use of these plant resources. Many plant species are used for managing different crop pests in the field and in the storage too. Information on their preparation and use are available from different formal and informal sources. There are quite few scientific publications available. At least 62 pesticidal plants that are commonly used by the Nepali farmers are listed. Thus, many systematic research works is necessary to explore the pesticidal properties of these plants, their efficacy and their proper use against crop pests.

Keywords: Botanical pesticides, diseases, insects, pesticidal plants

INTRODUCTION

Pesticidal plants are the plant species having naturally occurring properties of killing, destroying, repelling, preventing or mitigating pests of the crop plants. Moreover, these plants can also be anti-feedant, growth inhibitors or chemosterilants (Ahmed et al 1984). Botanical pesticides are extracted from pesticidal plants and used against crop pests. Farmers of the resource poor areas are using different parts of the plants for managing the crop pests form hundreds of years. The use of tobacco and chrysanthemum against insect pests of crop plants assumed to be the oldest known practice of the farmers (Okwute 2012). Tobacco was used against insects in 1763 in France, and use of chrysanthemum was started around 1800 in Turkey area (Neupane 2001). Significant research works have been carried out by various research institutions and persons and plenty of research reports are available on botanical pesticides. At least 3,000 plant species have already been studied in laboratory tests to determine their effectiveness for controlling plant pests and disease (Jacobson 1975) and hundreds of plant species have listed having pesticidal properties.

In some parts of Nepal, farmers broadcast ground pulp of *Khirro* leaf for controlling stem borers of wheat and maize (Thapa 1994). Leaves of *Euphorbia* also are being practiced in paddy field for controlling the borers. Farmers are found planting mint and marigold in front of their houses traditionally, farmers use Neem (*Azadirachta indica* A.Juss.), china berry, bojo, timur etc for protecting pests from storage pest (Duwadi et al 1993 and Thapa 1994). It is reported that the extract prepared from the parts of Stinging Nettle (*Urtica* sp.), plants and fruits of Timur (*Zanthoxylum armatum* DC.) plant is used to control many kinds of chewing, biting and cutting insects like the larvae of cabbage butterfly, hairy caterpillar, red ants and termites (Budhathoki et al 1993). Similarly, GC et al (1997) reported that Titepati (*Artemisia vulgaris* L.) and Banmara (*Eupatorium adenophorum* Spreng.) are found effective to control red ants (*Dorylus orientalis*) in the Hills of Nepal.

PESTICIDAL PLANT SPECIES IN NEPAL

Many plant species have been reported having pesticidal properties in Nepal (Neupane 2001). However, not all of these plants are commonly used by the farmers. The plants commonly used by farmers in Nepal have been listed in this review article (**Table** 1).

Table 1. Pesticidal plant species of Nepal

SN	Common name	Nepali/ local name	Scientific name	Parts used	Remarks
1.	Basil	Tulasi	Ocimum sanctum L.	Stem and leaves	Insecticidal
2.	Black pepper	Marich	Piper nigrum L.	Fruits	Insecticidal
3.	Black plum	Jamun	Syzygium cumini (L.) Skeels	Leaves	Insecticidal
4.	Butter tree	Chiuri	Diploknema butyracea (Roxb.) H.J.Lam	Seed cake	Insecticidal
5.	Camphor tree	Kapoor	Cinnamomum camphora (L.) J.Presl	Stem and leaves	Insecticidal
6.	Castor	Ander	Ricinus communis L.	Seed cake	Insecticidal
7.	Catweed/crofton weed	Banmara	Eupatorium adenophorum Spreng.	Stem and leaves	Insecticidal
8.	Century plant	Ketuki/Nalu/Hattibar	Agave americana L.	Leaves	Insecticidal
9.	Chilli	Khursani	Capsicum frutescens L.	Stem, leaves and fruits	Insecticidal
10.	China berry (Persian Lilac)	Bakaino	Melia azedarach L.	Stem, leaves and seeds	Insecticidal
11.	Chiretta	Chiraito	Swertia chirata Buch.-Ham. ex Wall.	Stem and leaves	Insecticidal
12.	Cinnamon	Dalchini	Cinnamomum verum J. Presl.	Leaves and bark	Insecticidal
13.	Common wormwood	Titepati	Artemisia vulgaris L.	Stem and leaves	Insecticidal
14.	Elephant ear	Ajammari/ Hatti kane	Kalanchoe pinnata (Lam.) Pers.	Stem and leaves	Insecticidal
15.	English tobacco	Belayeti surti	Nicotiana rustica L.	Stem and leaves	Insecticidal
16.	Fenugreek	Methi	Trigonella foenum-graecum L.	Seeds	Insecticidal
17.	Garlic	Lasun	Allium sativum L.	Leaves and cloves	Insecticidal
18.	Giant milk weed	Aank	Calotropis gigantea L. Dryand.	Stem and leaves	Insecticidal
19.	Ginger	Aduwa	Zingiber officinale Roscoe	Rhizomes	Insecticidal
20.	Ginger lily	Kewara/Lily	Hedychium coronarium J.Koenig	Leaves	Insecticidal
21.	Goat weed	Gandge Jhar	Ageratum conyzoides (L.) L.	Stem and leaves	Insecticidal
22.	Honey tree/Butter tree	Mauwa	Madhuca indica J.F. Gmel.	Leaves	Insecticidal
23.	Indian heynea	Ankha taruwa	Heynea trijuga Roxb. ex Sims	Stem and leaves	Insecticidal
24.	Indian oleander	Tholo karavir	Nerium odorum Aiton	Stem and leaves	Insecticidal
25.	Indian privet	Simali	Vitex negundo L.	Leaves	Insecticidal
26.	Indian shot	Sarbada	Canna indica L.	Stem and leaves	Insecticidal
27.	Ipil-ipil	Ipil-ipil	Leucaena leucocephala (Lam.) de Wit	Leaves	Insecticidal
28.	Iron wood tree	Nageswar	Mesua ferrea L.	Stem and leaves	Insecticidal
29.	Jerusalem-oak goosefoot	Gandhe bethe	Chenopodium botrys L.	Stem and leaves	Insecticidal
30.	Jimson weed	Dhatura	Datura stramonium L.	Leaves/fruits	Insecticidal
31.	Joint weed	Bisuhari	Persicaria barbata (L.) H.Hara	Stem and leaves	Insecticidal
32.	Lantana	Dhungre phool	Lantana camara L.	Stem and leaves	Insecticidal
33.	Lemon	Nibuwa	Citrus limon (L.) Osbeck	Leaves and fruits	Insecticidal
34.	Malabar nut	Asuro	Adhatoda vasica Nees	Stem and leaves	Insecticidal
35.	Mango	Aanp	Mangifera indica L.	Leaves	Insecticidal
36.	Marigold	Sayapatri	Tagetes patula L., Tagetes erecta L., Tagetes minuta L.	Stem and leaves	Insecticidal/ nematicidal
37.	Marijuana/True hemp	Ganja	Cannabis sativa L.	Stem and leaves	Insecticidal

SN	Common name	Nepali/ local name	Scientific name	Parts used	Remarks
38.	Marsh piper	Pirre	Polygonum hydropiper L.	Stem and leaves	Insecticidal
39.	Mint	Pudina	Mentha arvensis L.	Stem and leaves	Insecticidal
40.	Neem	Neem	Azadirachta indica A.Juss.	Stem, leaves and fruits	Insecticidal
41.	Nepal pepper	Timur	Zanthoxylum armatum DC.	Leaves and fruits	Insecticidal/ bactericidal
42.	Onion	Pyaj	Allium cepa L.	Bulb and leaves	Insecticidal
43.	Papaya	Mewa	Carica papaya L.	Leaves	Insecticidal/ fungicidal
44.	Purging nut	Sajiwan	Jatropha curcas L.	Leaves and fruits	Insecticidal
45.	Purple nutsedge	Mothe	Cyperus rotundus L.	Leaves	Insecticidal
46.	Pyrethrum	Godawari	Chrysanthemum cinerariifolium (Trevir.) Vis.	Stem and leaves	Insecticidal
47.	Royale's spurge	Cactus/Siudi	Euphorbia royleana Boiss.	Stem and leaves	Insecticidal
48.	Sesame	Til	Sesamum indicum L.	Seedcake	Insecticidal
49.	Soap berry	Rittha	Sapindus mukorossi Gaertn.	Leaves and fruits	Insecticidal
50.	Spear mint	Babari	Mentha spicata L.	Stem and leaves	Insecticidal
51.	Spicewood	Siltimur	Lindera neesiana (Wall. ex Nees) Kurz	Leaves and fruits	Insecticidal
52.	Spiked ginger lily	Kewara/Lily	Hedychium spicatum Sm.	Leaves	Insecticidal
53.	Stinging nettle	Sisno	Urtica dioica L.	Stem and leaves	Insecticidal
54.	Sugar apple	Sarifa	Annona squamosa L.	Leaves and fruits	Insecticidal
55.	Sun hemp	Chhinchhine /Sanai	Crotalaria juncea L.	Stem and leaves	Insecticidal
56.	Sweet flag	Bojho	Acorus calamus L.	Rhizomes	Insecticidal
57.	Tasmanian Blue gum	Masala	Eucalyptus globulus Labill.	Bark and leaves	Insecticidal
58.	Tiger's milk spruce	Khirro	Sapium insigne (Royle) Trimen	Stem and leaves	Insecticidal
59.	Tobbaco	Lampate surti	Nicotiana tabacum L.	Stem, leaves and fruits	Insecticidal
60.	Tomato	Golbheda	Solanum lycopersicum L.	Stem and leaves	Insecticidal
61.	Turmeric	Besaar/Haledo	Curcuma domestica Valeton	Rhizomes	Insecticidal/ fungicidal
62.	Wild leek	Chyapi	Allium ampeloprasum L.	Stem and leaves	Insecticidal

Source: Neupane 2001, Bhandari 2007, CWDO 1997, Humagai 2011, Budathoki et al 1993, Thapa 1994.

CONCLUSION AND WAY FORWARD

Due to raised awareness against use of chemical pesticides in crops and their hazardous effect to human, animals and the environment, alternatives of pesticides are being sought around the world. Use of botanical pesticides prepared at home or in the factory could be one of the safe alternatives for agricultural use. This approach is more appropriate to resource poor farmers of subsistence and semi-commercial small holder farmers. Many pesticidal plants of like neem, tobacco, bojho, sisnu, timur, bakaino, Khirro, Ketuke, titepati, etc have shown excellent results against many insect pests of different crops. Most of them have been reported to be effective against pest insects but botanicals against disease pests are not much reported. Thus, many systematic research works is necessary to explore the pesticidal properties of these plants, their efficacy and their proper use against crop pests. Collaborative works need to be initiated with different stakeholders including National Agriculture Research Council, Universities, Department of Agriculture, communities and community based Non Governmental Organizations for effective participatory research and implementation and verification of findings in the field.

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Honeybee and Plant Resources: Diversity, Availability and Significance for Beekeeping in Nepal

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ABSTRACT

Owing to massive geographical variations, Nepal is enriched with immense floral and faunal diversity. Presence of more than 6,900 species of flowering plants fascinates variety of organisms. The mutual interdependence of the anthrophilous insects and entomophilous angiosperms evolved since time immemorial; where the insects utilizes flowering plants for food and shelter and in return pollinate the plants to perpetuate generations. The bees (Apoidae), one of the constant flower visiting insects, constitute a group of more than 20,000 species representing at every level from solitary and non-social to community and truly-social like honeybee genus, *Apis*. Cultivation of honeybees is being one of the promising farming activities nowadays with abundant local as well as export potentiality. The practice of beekeeping not only depends on the better strain of honeybees and management practices, but also on the abundance and occurrence of pollen and nectar sources within the surrounding area. Honeybees obtain nectar, pollen, or both from flowers, which are the mainstay of their life. However, plant types and their flowering duration differ from one place to other due to variation in topography, climate and other cultural and farming practices. The extensive knowledge on type, density and quality of bee flora in a region are prerequisite for successful beekeeping. Such information enable beekeepers to utilize them at the maximum level, so that, they can harvest a good yield of bee products in addition to effective pollination which enhances crop yields. The value of flora in beekeeping has been observed in many parts of the world. But in Nepalese context, few studies are conducted with major emphasis on listing of flowering plants with some botanical features including flowering period and its availability. Honeybee floras of Kathmandu valley, Hindu-Kush Himalayan region, Chitwan, Dolakha, Sarlahi, Kaski districts as well as some generalized studies are some examples. These studies are also concentrated to typical political boundary and are moreover based on secondary information and social surveys. Reviewing these studies, an inventory of 642 number of flowering plans beneficial to honeybees and beekeeping are listed. Still a detailed inventory, domain based floral calendar, carrying capacity, melissopalynological studies and plantation advocacy are missing.

Keywords: Beekeeping, flora diversity, flowering plants, honeybee diversity, toxins

INTRODUCTION

Nepal is characterized by variations in altitude, topography, aspects of the hilly slopes and weather elements within its short North to South span. These conditions have developed smaller ecological domains where diverse nature of floral and faunal communities is present. Nepal occupies 0.09% of the earth surface and with the perspective of species diversity in wild habitats, occupies twenty-sixth and eleventh position on the global and continental levels respectively (MoFS 2009). The species richness among floral diversity comprises more than 6,900 species of flowering plants along with approximately 12,136 species of insects (Insecta: Arthropoda) (Thapa 2015). The mutual interdependence of the anthrophilous insects and entomophilous angiosperms evolved since time immemorial hastening their co-evolution till date; where the insects utilizes flowering plants for food and shelter and in return pollinate the flowering plants to perpetuate generations. The bees (Apoidae), one of the constant flower visiting insects, constitute a group of more than 20,000 species representing at every level from solitary and non-social to community and truly-social like honeybee genus, *Apis*. Flowering plants are the mainstay of honeybees' life and relation between them are considered as an example for co-evolution and mutualism. Nectar, pollen, resin and water are the basic requirements for beekeeping, acquired from floral and extra floral resources of flowering plants and in return plants need honeybees for pollination.

Beekeeping is an agri-horticultural and forest based industry and as such is of great importance for Nepalese farmers. The practice of beekeeping not only depends on the better strain of honeybees and appropriate management practices but also on the abundance and occurrence of pollen and nectar sources within the surrounding area of an apiary. Flowering duration and main blooming period is essential information for sound management of beekeeping. However, flowering plants of several plant families blossom at different time intervals of the year. Depending upon the soil type, climatic factors and the habitat of the vegetation, the time of the flowering may change for even the same nectar plants. The extensive knowledge on type, density and quality of honeybee flora in a region are prerequisites for formation of floral calendar and thereby enhancing the efficiency of beekeeping industry and successful beekeeping. Bee forage calendar for beekeeping is a period that indicates the approximate date and the duration of the blossoming period of the existing honey or pollen plant resources in an area. In addition to the time and duration of blossoms of honey plants, it also involves the mapping of density, distribution and honey potential of the honeybee flora. This information enables the apiculturists to estimate carrying capacity of honeybee colonies in particular region for sustainable utilization of these resources. The bee forage calendar is one of the most useful tools in the sector of the apicultural operations which requires complete observation of the seasonal changes in the floral patterns of an area, the foraging behaviour of the honeybees, and the manner in which the honeybee colonies interact with their floral surroundings.

HONEYBEE DIVERSITY IN NEPAL

In case of honeybee species diversity, Nepal is one of the richest country in the world. Five species of true honeybees and stingless bees are found at different locations. Among these, *Apis florea* Fabricius, *Apis cerana* Fabricius, *Apis dorsata* Fabricius and *Apis laboriosa* Smith are the native honeybee species, whereas *Apis mellifera* Linnaeus is introduced. Also, the stingless bees of Apidae family are found at Nepal.

The Himalayan cliff honeybee, *Apis laboriosa* S., is the largest honeybee of the world which makes a single comb at open place that hangs under the hilly cliffs. Its nests are generally found at high altitudes, at an altitude more than 1200 to 3500-masl, it is reported that this species forages as much as up to 4100 masl (Pratap 1997, Shukla 2000). This species is migratory in behavior and contributes a lot on the conservation of Himalayan vegetation resources. The average honey yield per colony per year from this species is reported as 25 kg (Pokhrel et al 2014) to 60 kg (Gurung et al 2012).

The giant honeybee, *Apis dorsata* F., is common species in Nepal with a single large comb at open places on tall trees, buildings and similar places. This species is distributed from southern lowlands up to 2000-masl (Pratap 1997). These are highly migratory in behavior and make its comb in shaded places during summer and in sunny places during winter. The average honey yield has been reported as 15 kg (Pokhrel et al 2014) to 30 50 kg per colony per year (Gurung et al 2012).

The Asian hive honeybee, *Apis cerana* F., is the only cultivated native species of Nepal and is reared at both indigenous (wall, log, box, etc.) and modern moveable frame (Newton, Godavari, Lumle, top-bar, etc) hives. This species make multiple parallel combs at dark places and are found in wild condition as well. At least three sub-species/ecotypes of *A. cerana* are reported, *Apis cerana indica* in plain areas, *Apis cerana himalaya* in valleys and low to Mid Hill and *Apis cerana cerana* in High Hill (Verma 1992). This species are found throughout Nepal from southern lowlands up to 3,600-masl (Pratap 1997). The honey yield per colony per year ranges from 6 kg (Bista and Shivakoti 2001) to 20-kg (Gurung et al 2012).

The dwarf or little honeybee, *Apis florea* F. builds a single comb nest at open places suspended from the branches of bushes, hedges, trees, caves of buildings, chimneys and so on. This species is distributed from southern plains to Low Hill areas up to 1500 masl. These are also highly migratory honeybees and do not stay at one place for more than six months. Its honey is regarded with high medicinal value, however the honey production is very low, ranging from one to 3 kg per colony per year (Pratap 1997).

The European honeybee, *Apis mellifera* L., originated in Africa and spread to rest of the world was introduced in Nepal during April 1994 and is well-acclimatized at Tarai, inner-Tarai and Foot Hill areas of Nepal (Bista and Shivakoti 2001). It builds multiple parallel combs at dark places and is established up to around 1500 masl (Shukla 2000). With the introduction of this honeybee, commercial beekeeping was initiated in Nepal. This species is cultivated both as stationary as well as migratory practices, so the honey production varies.

The stingless bees, although not referred as true honeybees, also stores honey with high medicinal value and referred as efficient pollinator. These are distributed throughout the southern plains of Nepal below 1000-masl (Pratap 1997). Among the two genuses of stingless bees, *Melipona* and *Trigona*, both genuses are reported from Nepal. The *Trigona* sp. is reported from western and far-western zone (Joshi et al 2000, Bista and Shivakoti 2001) and *Melipona* sp. from Mid Western Nepal (Pratap 1997). These species makes their nests within tree cavities or underground and can also be kept on traditional hive like structures. The stingless bees on log hives could be observed reared by farmers in Dang, Surkhet and Rolpa districts. Its honey is stored in special honey pots kept separately from the brood cells and regarded as high quality medicinal values.

HONEYBEE FLORAL DIVERSITY

Quality honeybee foraging resources is one of the indispensable factor for successful beekeeping development in any area. With variations in habitat and climate, Nepal is rich in floral diversities. But honeybee possesses peculiar foraging preferences and all the flowering plants are not visited. Plants flowering during same period are selected by honeybees for foraging desire. Also, different plant species produce different amount of nectar or pollen during different time of the year. Understanding these floral ecology and having best management practices is vital for the sustainability and growth of the beekeeping industry. This develops the knowledge on potential honey production area, productivity and its value, as well as prediction of resources availability, successful planning for colony placement and capacity, and provides important information for determining habitat and biodiversity management. Hence, the knowledge on honeybee behaviour and foraging activity and their interactions with different flowering plant species are pre-requisite to elucidate on strategy for colony productions and effective crop pollination for different agro-ecological regions.

Beekeeping research and development works in Nepal are mainly concentrated on honeybee species, their management practices and colony products. Research studies on flowering plants, the primary source of honeybee forage and sustainable beekeeping development, are generally neglected. Whatever studies available are also performed with secondary importance; and more focus given towards listing and ranking of honeybee plants according to the quality and quantity of nectar and pollen available from them. The value of honeybee flora in beekeeping has been observed in many parts of the world. But in Nepalese context, scattered studies are conducted with major emphasis on listing of flowering plants in a particular region along with some botanical features including flowering period and its status as nectar or pollen sources. Honeybee flora of Kathmandu valley (Kafle 1984, Maskey 1992), Hindu-Kush Himalayan region (Pratap 1997), Chitwan (Thapa and Dangol 1990, ED 1996, Devkota 2003, DADO 2005, Thapa and Pokhrel 2007), Dolakha (Bista and Shivakoti 2000), Sarlahi (ED 1996) and Kaski (Adhikari and Ranabhat 2011) districts as well as major floral inventory (Pratap 1992, Kafle 1992, Bista 2005, Shukla 2000) are some examples of the studies conducted. These studies are also concentrated to typical political boundary and are moreover based on secondary information and social surveys. Still a detailed inventory, domain based floral calendar, carrying capacity determination, melissopalynological studies and plantation advocacy are missing.

The information provided in this paper has been compiled from different studies made at Nepalese condition. While reviewing the available documents published, most of the studies made concerning with honeybees and beekeeping are concentrated on colony management, incidence of pests and enemies, diversity of honeybee species, colony products, etc. Few research studies are available on honeybee flora and their utilization. Most of the information is mentioned in honeybee related books or reports rather than specific research work based on structured studies. The information provided about scientific name and family of plant resources are contrary among the published studies as the classification of plant details are continuously changing. Whatever facts the authors have provided in their respective publications are mentioned as such in the honeybee floral diversity listing. However the scientific names mentioned are added with recent author citation information, also the family are mentioned as recent classification. The great deals of differences are observed in flowering period of the plants, as the same plant are available in different altitudes and as a result the flowering period also varies. This information is compiled together, thus in some cases the flowering period seems to be longer. Similar case is in the case of nectar and pollen secreting status of the flowers. There are contrasting reports on same plant species reported by different authors, this might be different due to variations in agronomic, climatic or altitudinal factors; these information are also compiled and reported as such. Most of the common and local names mentioned in the table are added by the authors, as this information is missing in most of the published reports. There are some weaknesses regarding availability of flowering plants of same genus, as about thirty species of *Rhododendron* are reported from Nepal, which are one of the major honeybee floral plants, but going through the review, only five species have been reported. This is evident in other genuses as well. However, whatever information available at Nepal till date regarding honeybee flora and their characteristics are of great significance to beekeepers and beekeeping. The compiled inventory of honeybee flora reported from above mentioned sources in Nepal is shown in **Table** 1.

Table 1. Inventory of flowering plants beneficial to honeybees in Nepal

SN	Common name	Local name	Scientific name	Family	Ecological belt *	Type	Flowering period	Status
1.		Angeri	Berchemia edgeworthii Lawson	Rhamnaceae	A, B, C	Shrub	Apr – Jun	N – P
2.		Mirre jhau	***		B,C	Herb	Sep – Nov	N – P
3.	Adam's needle	Ketuki	Yucca smalliana Fernald	Asparagaceae	A, B	Shrub	Feb – Mar	P
4.	Adam's needle	Kettaki	Yucca flaccida Haw.	Asparagaceae	A, B	Shrub	Jun – Sep	N – P
5.	Ajowain	Jwano	Trachyspermum ammi (L.) Sprague	Apiaceae	A, B, C	Tree	Mar – May	N
6.	Albizia	Siris	Albizia chinensis (Osbeck) Merr.	Leguminosae	A, B, C	Tree	May – Jun	N – P
7.	Albizia	Siris	Albizia lebbek (L.) Benth.	Leguminosae	A, B, C	Tree	May – Jun	N – P
8.	Albizia	Siris	Albizia odoratissima (L.f.) Benth.	Leguminosae	A, B, C	Tree	Apr – Jun	N – P
9.	Albizia	Seto siris	Albizia procera (Roxb.) Benth.	Leguminosae	A, B, C	Tree	Apr – May	N – P
10.	Albizia	Siris	Albizia spp.	Leguminosae	A, B, C	Tree	Mar – Jun	N – P
11.	Alder	Uttis	Alnus nepalensis D. Don.	Betulaceae	A, B, C	Tree	Oct – Nov	N – P
12.	Alfa alfa	Leucerne	Medicago sativa L.	Leguminosae	A, B, C	Herb	Aug – Sep	N – P
13.	Almond	Kagagi badam	Prunus amygdalus Batsch	Rosaceae	A, B, C	Tree	Mar – Apr	N – P
14.	Alpine rose	Laligurans	Rhododendron spp.	Ericaceae	B, C	Tree	Spr, Aut	N – P
15.	Alpine strawberry	Bhui ainselu	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	Rosaceae	B, C	Herb	Feb – Jun	N – P
16.	Amaranth	Latte sag	Amaranthus hybridus L.	Amaranthaceae	A, B	Herb	Jul – Aug	N – P
17.	Amaranth	Latte	Amaranthus paniculatus L.	Amaranthaceae	A, B, C	Herb	Jun – Jul	N – P
18.	Ampelocissus	Pureni	Ampelocissus rugose (Wall.) Planch.	Vitaceae	A, B, C	Climber	May – Jun	N – P
19.	Apple	Syawu	Malus domestica Borkh.	Rosaceae	B, C	Tree	Mar – Apr	N – P
20.	Apple	Syawu	Malus pumila Mill.	Rosaceae	B, C	Tree	Mar – Apr	N – P
21.	Apricot	Khurpani	Prunus armeniaca L.	Rosaceae	A, B, C	Tree	Feb – Mar	N – P
22.	Arjun	Arjun	Terminalia arjuna (Roxb. ex DC.) Wight & Arn.	Combretaceae	A, B	Tree	Apr – Jun	N – P
23.	Ash gourd	Kubindo	Benincasa cerifera Savi	Cucurbitaceae	A, B	Climber	Apr – May	N – P
24.	Asparagus	Kurilo	Asparagus officinalis L.	Asparagaceae	A, B, C	Shrub	Jul – Aug	N – P
25.	Asphodelus	Piazi	Asphodelus tenuifolius Cav.	Xanthorrhoeaceae	A, B, C	Herb	Jul – Oct	N – P
26.	Astragalus	Nokyopapu	Astragalus sinicus L.	Leguminosae	A, B, C	Shrub	April	N – P
27.	Astragalus	Thomja	Astragalus spp.	Leguminosae	A, B, C	Shrub	Apr – Jun	N – P
28.	Bael tree	Bel	Aegle marmelos (L.) Corrêa	Rutaceae	A, B	Tree	Mar – May	N
29.	Bahunia	Tanki	Bauhinia malabarica Roxb.	Leguminosae	A, B, C	Tree	Feb – Apr	N – P
30.	Balsam	Seto tiuri	Impatiens glandulifera Royle	Balsaminaceae	A, B, C	Herb	Jul – Sep	N – P
31.	Balsam	Tiwuri	Impatiens sp.	Balsaminaceae	A, B, C	Herb	May – Sep	N – P
32.	Bamboo	Bans	Bambusa bambos (L.) Voss	Poaceae	A, B	Tree	Nov – Dec	N – P
33.	Banana	Kera	Musa paradisiaca L.	Musaceae	A, B, C	Tree	All year	N – P
34.	Banana	Kera	Musa sapientum L.	Musaceae	A, B	Shrub	All year	N – P
35.	Barberry	Chutro	Berberis aristata DC	Berberidaceae	B, C	Shrub	Apr – Jun	N – P
36.	Barberry	Chutro	Berberis asiatica Roxb. ex DC.	Berberidaceae	B, C	Shrub	Mar – May	N – P
37.	Barberry	Ban chutro	Berberis lyceum Royle	Berberidaceae	A, B, C	Shrub	Apr – Jun	N – P
38.	Barberry	Chutro	Berberis macrosepala Hook.f. & Thomson	Berberidaceae	A, B, C	Shrub	Mar – Jun	N – P
39.	Barna		Crateva religiosa G.Forst.	Capparaceae	A, B	Tree	Apr – May	N – P
40.	Barna	Sipligan	Crateva religiosa G.Forst	Capparaceae	A, B, C	Tree	Apr – May	N – P
41.	Barse squash	Pharsi	Cucurbita pepo	Cucurbitaceae	A, B	Climber	Apr – May	N – P
42.	Basak	Asuro	Adhatoda vasica Nees	Acanthaceae	A, B, C	Shrub	Mar – Apr	N – P
43.	Basil	Babari	Ocimum basilicum L.	Lamiaceae	A, B, C	Herb	Aug – Oct	N
44.	Basil	Tulsi	Ocimum basilicum L.	Lamiaceae	A, B, C	Herb	Aug – Oct	N – P
45.	Bayberry	Kafal	Myrica esculenta Buch.-Ham. ex D. Don	Myricaceae	A, B, C	Tree	Spr, Aut	N – P

SN	Common name	Local name	Scientific name	Family	Ecological belt *	Type	Flowering period	Status
46.	Beach launaea	Dhude jhar	Launaea aspleniifolia (Willd.) Hook.f.	Compositae	A, B, C	Herb	May – Jul	P
47.	Bead plum	Hade bayer	Zizyphus spp.	Rhamnaceae	A, B, C	Tree	May – Sep	N – P
48.	Bead tree	Rudrakhsha	Elaeocarpus sphaericus (Gaertn.) K.Schum.	Elaeocarpaceae	A, B	Tree	Mar – Jun	N – P
49.	Bean	Rajma simi	Phaseolus lunatus L.	Leguminosae	A, B	Herb	Oct – Nov	N
50.	Beans	Bodi	Vigna unguiculata (L.) Walp.	Leguminosae	A, B, C	Shrub	Mar – Sep	P
51.	Bermuda grass	Dubo	Cynodon dactylon (L.) Pers.	Poaceae	A, B, C	Herb	May – Sep	P
52.	Betel palm	Supari	Areca catechu L.	Arecaceae	A, B	Tree	Jan – Dec	N
53.	Big leaved rose	Bhainse kanda	Rosa macrophylla Lindl.	Rosaceae	A, B	Shrub	Apr – July	N – P
54.	Bird pepper	Khorsani	Capsicum microcarpum Cav.	Solanaceae	A, B, C	Herb	Jun – Aug	P
55.	Bitter apple	Buja	Citrullus colycynthis (L.) Schrad.	Cucurbitaceae	A, B	Climber	Feb – Mar	N – P
56.	Bitter Gourd	Karela	Momordica charantia L.	Cucurbitaceae	A, B, C	Climber	May – Sep	N – P
57.	Black bondue	Lataa	Caesalpinia decapetala (Roth) Alston	Leguminosae	A, B, C	Shrub	Jul – Sep	P
58.	Black gram	Mash	Phaseolus mungo L.	Leguminosae	A, B, C	Herb	Jul – Sep	N – P
59.	Black henbane	Bazaar bhang	Hyoscyamus niger L.	Solanaceae	C	Herb	May – Sep	N – P
60.	Black mustard	Kalo tori	Brassica nigra (L.) K.Koch	Brassicaceae	A, B, C	Herb	Nov – May	N – P
61.	Black nightshade	Kali bihi	Solanum nigrum L.	Solanaceae	A, B, C	Herb	Feb – Nov	P
62.	Black walnut	Hadey okhar	Juglans nigra L.	Juglandaceae	A, B	Tree	Apr – May	P
63.	Black wattle	Khayer	Acacia mearnsii De Wild.	Leguminosae	A, B	Tree	Mar – Apr	P
64.	Blue Japanese oak	Baanjh	Quercus glauca Thunb.	Fagaceae	A, B, C	Tree	Jan – Mar	N
65.	Blue pine	Raini sallo	Pinus wallichiana A.B.Jacks.	Pinaceae	B, C	Tree	Apr – Jun	N – P
66.	Blue thistle	Nilo phul	Echium vulgare L.	Boraginaceae	A, B, C	Herb	Jan – Jun	N – P
67.	Borage	Borago	Borago officinalis L.	Boraginaceae	A, B	Herb	Feb – Sep	N – P
68.	Bottle brush	Kalki phul	Callistemon citrinus (Curtis) Skeels	Myrtaceae	A, B	Tree	Mar – Oct	N – P
69.	Bottle brush	Kalki phul	Callistemon lanceolatus (Sm.) Sweet	Myrtaceae	A, B	Tree	Feb – Aug	N – P
70.	Bottle gourd	Lauka	Lagenaria siceraria (Molina) Standl.	Cucurbitaceae	A, B, C	Climber	Jul – Oct	N – P
71.	Bottle gourd	Lauka	Lagenaria leucartha (Duchesne) Rusby	Cucurbitaceae	A, B, C	Climber	May – Jul	N – P
72.	Box bean	Pango	Entada phaseoloides (L.) Merr.	Leguminosae	A	Climber	Apr – May	N – P
73.	Brinjal	Bhanta	Solanum melongena L.	Solanaceae	A, B, C	Shrub	All year	N – P
74.	Broad bean	Bakulla	Vicia faba L.	Leguminosae	A, B, C	Shrub	Jan – Apr	N – P
75.	Brocauli	Brocauli	B. oleracea var. italic Plenck	Brassicaceae	A, B, C	Herb	Mar – Apr	N – P
76.	Brown sarson	Sarson	B. campestris var. dichotoma (Roxb.) Watt	Brassicaceae	A, B, C	Herb	Oct – Feb	N – P
77.	Buckwheat	Phapar	Fagopyrum esculentum Moench	Polygonaceae	A, B, C	Herb	Spr, Aut	N – P
78.	Buckwheat	Phapar	Fagopyrum dibotrys (D.Don) H.Hara	Polygonaceae	A, B, C	Herb	Aug – Oct	N – P
79.	Butter cup	Nal kure	Ranunculus spp.	Ranunculaceae	A, B, C	Herb	Apr – Jun	N – P
80.	Butter tree	Chiuri	Aesandra butyracea (Roxb.) Baehni	Sapotaceae	A, B	Tree	Spr, Aut **	N – P
81.	Butter tree	Chiuri	Bassia butyracea Roxb.	Sapotaceae	A, B	Tree	Nov – Feb	N – P
82.	Buttercup	Nak Kure	Ranunculus arvensis L.	Ranunculaceae	A, B, C	Herb	May – Jul	N – P
83.	Butterfly bush	Pati	Buddleja spp.	Scrophulariaceae	A, B, C	Tree	Feb – Mar	N – P
84.	Butterfly bush	Bhimsen pati	Buddleja asiatica Lour.	Scrophulariaceae	A, B, C	Tree	Feb – Mar	N – P
85.	Butterfly pea	Aparajit	Clitoria ternatea L.	Leguminosae	A, B	Shrub	July	N – P
86.	Cabbage	Banda gobi	B. oleracea var capitata L.	Brassicaceae	A, B, C	Herb	Feb – Mar	N – P
87.	Cactus spurge	Siundi	Euphorbia royleana Boiss.	Euphorbiaceae	A, B	Shrub	Apr – Jul	N – P

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88.	Californian poppy		Eschscholzia californica Cham.	Papaveraceae	A, B	Herb	Mar – Jun	N – P
89.	Calliandral	Gunyalo	Calliandra calothyrsus Meisn.	Leguminosae	A, B, C	Tree	Jan – Dec	N – P
90.	Camel's Foot	Bhorla	Bauhinia vahlii Wight & Arn	Leguminosae	A, B, C	Climber	May – Jun	N – P
91.	Candy tuft		Iberis spp.	Brassicaceae	B, C	Herb	Feb – Apr	N – P
92.	Caper bush	Baghnangre	Capparis sepiaria L.	Capparaceae	A, B, C	Climber	Apr – May	N – P
93.	Capsicum	Khursani	Capsicum annuum L.	Solanaceae	A, B, C	Herb	Jun – Sep	N – P
94.	Capsicum	Bhede khorsani	Capsicum frutescens L.	Solanaceae	A, B, C	Herb	Jun – Aug	P
95.	Cardamine	Chamsure	Cardamine spp.	Brassicaceae	A, B	Herb	Jan – Feb	N – P
96.	Carnation	Carnation	Dianthus caryophyllus L.	Caryophyllaceae	A, B, C	Herb	Apr – Jun	N – P
97.	Carrot	Gajar	Dacus carota L.	Apiaceae	A, B, C	Herb	Mar – Jun	N – P
98.	Caryopteris	Ghusere	Caryopetris odorata (D.Don) B.L.Rob.	Lamiaceae	A, B, C	Shrub	Feb – Apr	N – P
99.	Castor oil	Ander	Ricinus communis L.	Euphorbiaceae	A, B	Shrub	Apr – Aug	N – P
100.	Catmint	Potsa	Nepeta sp.	Lamiaceae	A, B, C	Herb	May – Aug	N – P
101.	Cauliflower	Kauli	B. oleracea var. botrytis L.	Brassicaceae	A, B, C	Herb	Feb – Apr	N – P
102.	Cedrela	Tooni	Cedrela toona Roxb. ex Rottler	Meliaceae	A, B, C	Tree	Apr – May	N – P
103.	Century plant	Ketuki	Agave americana L.	Asparagaceae	A	Shrub	Sep – Nov	N – P
104.	Chanlai	Tikui	Wendlandia exserta (Roxb.) DC.	Rubiaceae	A, B	Tree	Nov – Feb	N – P
105.	Chap	Chanp	Michelia champaca L.	Magnoliaceae	A, B	Tree	Mar – Jun	N – P
106.	Chayote	Iskush	Sechium edule (Jacq.) Sw.	Cucurbitaceae	A, B, C	Climber	July – Dec	N – P
107.	Cherry	Cherry	Prunus avium (L.) L.	Rosaceae	A, B, C	Tree	Feb – Mar	N – P
108.	Cherry	Cherry	Prunus nepalensis Hook.f.	Rosaceae	A, B, C	Tree	Feb – Mar	N
109.	Chesnut	Dhale katus	Castanopsis indica (Roxb. ex Lindl.) A.DC.	Fagaceae	A, B, C	Tree	Sep – Nov	N – P
110.	Chestnut	Musure katus	Castanopsis tribuloides (Sm.) A.DC.	Fagaceae	A, B, C	Tree	Sep – Oct	N – P
111.	Chick Pea	Chana	Cicer arietinum L.	Leguminosae	A, B, C	Herb	Feb – Mar	N – P
112.	Chicory	Kansi	Cichorium intybus L.	Compositae	A, B, C	Herb	May – Aug	N – P
113.	Chinese Aster	Gyantaka	Callistephus chinensis (L.) Nees	Compositae	A, B, C	Herb	Apr – May	N – P
114.	Chinese elder	Kanike phul	Sambucus hookerii Rehder	Adoxaceae	A, B, C	Shrub	Apr – Jun	P
115.	Chinese jujube	Bayer	Ziziphus jujuba Mill.	Rhamnaceae	A, B	Tree	Jul – Oct	N – P
116.	Chinese lantern	Ghante phul	Malvaviscus arboreus Cav.	Malvaceae	A, B	Shrub	All Year	N – P
117.	Chinese leek	Lasun	Allium tuberosum Rottler ex Spreng.	Amaryllidaceae	A, B, C	Herb	Apr – Aug	N – P
118.	Chinese rose	Ghanti phool	Hibiscus rosa-sinensis L.	Malvaceae	A, B, C	Shrub	Mar – May	N – P
119.	Chinese wisteria		Wisteria sinensis (Sims) Sweet	Leguminosae	A, B	Shrub	Apr – May	N
120.	Chir pine	Khote salla	Pinus roxburghii Sarg.	Pinaceae	B, C	Tree	Mar – Apr	N – P
121.	Chir pine	Khote salla	Pinus spp.	Pinaceae	B, C	Tree	Mar – Apr	N – P
122.	Chiretta	Chiraito	Swertia spp.	Gentianaceae	B, C	Herb	Aug – Oct	N – P
123.	Chisia	Bilaune	Maesa chisia Buch.-Ham. ex D. Don	Primulaceae	A, B	Tree	Mar – Apr	N – P
124.	Chrysanthemum	Godawari	Chrysanthemum morifolium Ramat	Compositae	A, B, C	Herb	Sep – Oct	N – P
125.	Chrysanthemum	Godavari	Chrysanthemum segetum L.	Compositae	A, B, C	Herb	Jun – Sep	N – P
126.	Cineraria		Cineraria spp.	Compositae	A, B, C	Herb	Feb – Mar	N – P
127.	Cinnamon leaf	Tejpat	Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Lauraceae	A, B, C	Tree	Mar – May	N
128.	Cinnamon leaf	Tejpat	Cinnamomum zeylanicum Blume	Lauraceae	A, B, C	Tree	Mar – Apr	N

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129.	Citron	Bimiro	Citrus medica L.	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
130.	Citrus	Kathe Jyamir	Citrus jambhiri Lush.	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
131.	Clarke	Simal	Schefflera impressa (C.B.Clarke) Harms	Araliaceae	B, C	Tree	Aug – Sep	N
132.	Clarke	Simal	Schefflera octophylla (Lour.) Harms	Araliaceae	A, B	Tree	Oct – Jan	N
133.	Clarke	Kusmiro	Schefflera venulosa (Wight & Arn.) Harms	Araliaceae	A, B, C	Shrub	Jan – May	N
134.	Clematis	Junge laharo	Clematis sp.	Ranunculaceae	A, B	Climber	Mar – May	N – P
135.	Climbing hempvine		Mikania scandens (L.) Willd.	Compositae	A	Climber	Mar – Apr	N – P
136.	Clover	Tinpate	Trifolium repens L.	Leguminosae	A, B, C	Herb	Feb – Jun	N – P
137.	Clover	Pyawali	Trifolium spp.	Leguminosae	A, B, C	Tree	Feb – Jun	N – P
138.	Cluster bean	Gaur	Cyamopsis tetragonoloba (L .) Taub.	Leguminosae	A, B	Climber	Spr, Aut	N
139.	Cluster fig	Pakhuri	Ficus glomerata Roxb.	Moraceae	A, B, C	Tree	Mar – Apr	N
140.	Cobra lily	Sarpa makai	Arisaema sp.	Araceae	A, B, C	Herb	May – Aug	N – P
141.	Cockspur thorn	Damaru	Maclura cochinchinensis (Lour.) Corner	Moraceae	A, B	Shrub	Apr – May	N – P
142.	Coconut	Nariwal	Cocos nucifera L.	Arecaceae	A, B	Tree	Jan – Dec	N
143.	Coffee	Coffee	Coffea arabica L.	Rubiaceae	A, B, C	Shrub	Mar – Apr	N – P
144.	Coks comb	Latte phul	Celosia cristata L.	Amaranthaceae	A, B	Herb	May – Jun	N – P
145.	Coleus	Passan ved	Coleus blumei Benth.	Lamiaceae	A, B, C	Climber	Apr – Sep	N
146.	Colt'sfoot		Tussilago farfara L.	Compositae	A, B, C	Herb	Feb – Jun	N – P
147.	Coral blow	Lwong phul	Russelia equisetiformis Schltdl. & Cham.	Plantaginaceae	A, B	Shrub	All year	N
148.	Coral blow	Lwong phul	Russelia juncea Zucc.	Plantaginaceae	A, B	Shrub	All year	N
149.	Coral tree	Faledo	Erythrina arborescens Roxb.	Leguminosae	A, B, C	Tree	Jul – Sep	N – P
150.	Coral tree	Faledo	Erythrina stricta Roxb.	Leguminosae	A, B, C	Tree	Mar – Apr	N – P
151.	Coral Tree	Faledo	Erythrina suberosa Roxb.	Leguminosae	A, B, C	Tree	Mar – Apr	N – P
152.	Coral vine	Charpate	Antigonon leptopus Hook. & Arn.	Polygonaceae	A	Climber	May – Oct	N – P
153.	Cordia	Bohari	Cordia obliqua Willd.	Boraginaceae	A, B, C	Tree	Mar – Apr	N – P
154.	Cordial	Bohori	Cordia dichotoma G. Frost.	Boraginaceae	A, B, C	Tree	Jul – Aug	N – P
155.	Coriander	Dhaniya	Coriandrum sativum L.	Apiaceae	A, B, C	Herb	Feb – Apr	N – P
156.	Cornflower	Make Phul	Centaurea cyanus L.	Compositae	A, B, C	Herb	Feb – Apr	N – P
157.	Cosmos	Cosmos	Cosmossulphureus Cav.	Compositae	A, B, C	Herb	Aug – Nov	N – P
158.	Cotton	Kapas	Gossypium arboretum L.	Malvaceae	A, B	Herb	Jul – Sep	N – P
159.	Cotton	Kapas	Gossypium sp.	Malvaceae	A, B, C	Herb	Aug – Oct	N – P
160.	Cowpea	Kerau	Vigna sinensis (L.) Savi ex Hausskn.	Leguminosae	A, B, C	Shrub	Aug – Nov	N
161.	Crape myrtle	Asare phul	Lagerstroemia indica L.	Lathyraceae	A, B, C	Tree	Jun – Jul	N – P
162.	Crape myrtle	Asare phul	Lagerstroemia flos-reginae Retz.	Lathyraceae	A, B, C	Tree	May – Jul	N – P
163.	Crape myrtle	Asare	Lagerstroemia parviflora Roxb.	Lathyraceae	A, B, C	Tree	Apr – Jun	N – P
164.	Creeping sorrel	Chari amilo	Oxalis corniculata L.	Oxalidaceae	A, B, C	Herb	Feb – Jul	N – P
165.	Crinum	Hade lasun	Crinum amoenum Ker Gawl. ex Roxb.	Amaryllidaceae	A, B, C	Herb	May – Jul	N – P
166.	Cucumber	Kankro	Cucumis sativus L.	Cucurbitaceae	A, B	Climber	Apr – Sep	N – P
167.	Cuphea	Cuphea	Cuphea micrantha Kunth	Lythraceae	A, B, C	Herb	Feb – Nov	N – P
168.	Curly leaf plant	Mithe neem	Murraya koenigii (L.) Spreng.	Rutaceae	A, B	Shrub	Mar – Apr	N – P
169.	Custard apple	Ram phal	Annona 429eticulate L.	Annonaceae	A, B	Tree	May	N – P
170.	Custard apple	Sarifa	Annona squamosal L.	Annonaceae	A, B	Tree	May	N – P
171.	Cutch tree	Khayer	Acacia catechu (L.f.) Willd.	Leguminosae	A, B, C	Tree	Apr – Jul	N – P
172.	Dahlia	Lahure phul	Dahlia pinnata Cav.	Compositae	A, B, C	Herb	Jul – Jan	N – P
173.	Dahlia	Lhure phul	Dahlia spp.	Compositae	A, B, C	Herb	Spr, Aut	P
174.	Dandelion	Tuki phul	Taraxacum officinale (L.)	Compositae	A, B, C	Herb	Spr, Aut	N – P

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			Weber ex F.H.Wigg.					
175.	Daphne	Kagat pate	Daphne oleoides Schreb.	Thymeliaceae	A, B, C	Shrub	Jul – Sep	N – P
176.	Deadly nightshade	Beladona	Atropa belladonna L.	Solanaceae	B, C	Herb	Aug – Sep	N – P
177.	Deadnettle		Lamium album L.	Lamiaceae	A, B, C	Herb	Apr – Oct	N – P
178.	Decanhemp	Kunjar	Hibiscus cannabinus L.	Malvaceae	A, B	Herb	Jul – Aug	N – P
179.	Dianthus	Dianthus	Dianthus chinensis L.	Caryophyllaceae	A, B, C	Herb	May – Jun	P
180.	Dodder	Aakash beli	Cuscuta reflexa Roxb.	Convolvulaceae	A, B, C	Climber	Jul – Oct	P
181.	Dragon flower	Bhyagute phul	Antirrhinum sp.	Plantaginaceae	B, C	Herb	Feb – Jun	N
182.	Drumstick	Sahijan	Moringa oleifera Lam.	Moringaceae	A, B, C	Tree	Jan – Mar	N – P
183.	Duabanga	Pampatc	Duabanga grandiflora (DC.) Walp.	Lythraceae	A	Tree	Apr – Apr	N – P
184.	Duranta	Nilkanda	Duranta erecta L.	Verbenaceae	A, B, C	Shrub	Jun – Aug	P
185.	Egyptian clover	Pyauli	Trifolium alexandrinum L.	Leguminosae	A, B, C	Herb	May – Jun	N – P
186.	Egyptian cotton	Kapas	Gossypium barbadense L.	Malvaceae	A, B, C	Herb	Sep – Oct	N – P
187.	Elsholtzia	Silam	Elsholtzia bodinieri Vaniot	Lamiaceae	A, B, C	Herb	Nov – Dec	N – P
188.	Elsholtzia	Ban silam	Elsholtzia cyprianii (Pavol.) C.Y.Wu & S.Chow	Lamiaceae	B, C	Herb	Sep – Oct	N – P
189.	Elsholtzia	Ban silam	Elsholtzia densa Benth.	Lamiaceae	A, B, C	Herb	Aug – Sep	N – P
190.	Elsholtzia	Ban silam	Elsholtzia fruticose (D.Don) Rehder	Lamiaceae	B, C	Herb	Sep – Oct	N – P
191.	Elsholtzia	Ban silam	Elsholtzia rugulosa Hemsl.	Lamiaceae	B, C	Herb	Oct – Dec	N – P
192.	Elsholtzia	Ban silam	Elsholtzia splendens Nakai ex F.Maek.	Lamiaceae	B, C	Herb	Sep – Oct	N – P
193.	Elsholtzia	Ban silam	Elsholtzia ciliate (Thunb.) Hyl.	Lamiaceae	A, B, C	Herb	Oct – Nov	N – P
194.	Elsholtzia	Ban silam	Elsholtzia blanda (Benth.) Benth.	Lamiaceae	B, C	Herb	Sep – Oct	N – P
195.	Engelhardtia	Mauwa	Engelhardia spicata Lesch ex Blume	Juglandaceae	B, C	Tree	Mar – May	N – P
196.	Erodium		Erodium sp.	Geraniaceae	A, B, C	Herb	Apr – Jun	N – P
197.	Eucalyptus	Masala	Eucalyptus camaldulensis Dehnh.	Myrtaceae	A	Tree	May – Jun	N – P
198.	Eucalyptus	Masala	Eucalyptus citriodora Hook.	Myrtaceae	A	Tree	Jun – Jul	N – P
199.	Eucalyptus	Masala	Eucalyptus exserta F.Muell.	Myrtaceae	A	Tree	May – Jul	N – P
200.	Eucalyptus	Masala	Eucalyptus globulus Labill.	Myrtaceae	A, B	Tree	Sep – Oct	N – P
201.	Eucalyptus	Masala	Eucalyptus grandis W.Hill	Myrtaceae	A, B	Tree	Jun – Aug	N – P
202.	Eucalyptus	Masala	Eucalyptus melliodora A.Cunn. ex Schauer	Myrtaceae	A, B	Tree	Oct – Dec	N – P
203.	Eucalyptus	Masala	Eucalyptus robusta Sm.	Myrtaceae	A, B	Tree	Jun – Jul	N – P
204.	Eucalyptus	Masala	Eucalyptus spp.	Myrtaceae	A, B	Tree	Spr, Aut	N – P
205.	Euphorbia	Siundi	Euphorbia sp.	Euphorbiaceae	A, B	Shrub	Apr – Jul	N – P
206.	False acacia		Robinia pseudoacacia L.	Leguminosae	A, B, C	Tree	Mar – May	N – P
207.	Fennel	Swonp	Foeniculum vulgare Mill.	Apiaceae	A, B, C	Herb	Aug – Sep	N – P
208.	Fenugreek	Methi	Trigonella foenum-graecum L.	Leguminosae	A, B, C	Herb	Spr, Aut	N
209.	Fetter bush	Lek angeri	Pieris formosai (Wall.) D. Don	Ericaceae	C	Shrub	Mar – Apr	N
210.	Field bindweed	Tonbe	Convolvulus arvensis L.	Convolvulaceae	A, B, C	Climber	Apr – Sep	N – P
211.	Field thistle	Dhade kanda	Cirsium sp.	Compositae	A, B	Herb	Mar – Jun	N – P
212.	Field thistles	Dhade kanda	Cirsium verutum (D.Don) Spreng.	Compositae	A, B	Herb	Mar – Jun	N – P
213.	Field thistles	Khalvun	Cirsium wallichii DC.	Compositae	A, B, C	Herb	Apr – May	N – P
214.	Fig	Bar	Ficus benghalensis L.	Moraceae	A, B, C	Tree	Feb – Apr	N – P
215.	Fig	Pakhuri	Ficus glaberrima Blume	Moraceae	A, B, C	Tree	Feb – Apr	N – P
216.	Fig	Khasreto	Ficus hispida L.f.	Moraceae	A, B, C	Tree	Feb – Apr	N – P
217.	Fig	Kavro	Ficus lacor Buch.-Ham.	Moraceae	A, B, C	Tree	Feb – Apr	N – P

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218.	Fig	Dumri	Ficus racemose L.	Moraceae	A, B, C	Tree	Feb – Apr	N – P
219.	Fig	Pipal	Ficus religiosa L.	Moraceae	A, B, C	Tree	Feb – Apr	N – P
220.	Fig	Swami	Ficus rumphii Blume	Moraceae	A, B, C	Tree	Feb – Apr	N – P
221.	Fig	Ber	Ficus spp.	Moraceae	A, B, C	Tree	Feb – Apr	N – P
222.	Figwort	Mokhi ghans	Scrophularia sp.	Scrophulariaceae	A, B, C	Herb	May – Sep	N – P
223.	Finger millet	Kodo	Eleusine coracana (L.) Gaertn.	Poaceae	A, B, C	Shrub	Sep – Oct	P
224.	Fire flame bush	Dhaiyaro	Woodfordia fruitcosa (L.) Kurz	Lythraceae	A, B, C	Shrub	Mar – Apr	N – P
225.	Fire thorn	Ghangharu	Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	Rosaceae	A, B, C	Tree	Apr – May	N – P
226.	Forest flame	Bhujetro	Butea minor Baker	Leguminosae	A, B, C	Shrub	Apr – May	N – P
227.	Forest flame	Palas	Butea monosperma (Lam.) Taub.	Leguminosae	A, B, C	Tree	Jan – Feb	N – P
228.	Foxglove	Dijitalis	Digitalis purpurea L.	Plantaginaceae	B	Herb	Jun – Sep	P
229.	Foxtail millet	Kaguno	Setaria italica (L.) P.Beauv.	Poaceae	A, B, C	Herb	Sep – Oct	P
230.	Gaania		Gazania sp.	Compositae	B, C	Herb	Jan – Aug	P
231.	Garden amaranth	Latte phool	Amaranthus cruentus L.	Amaranthaceae	A, B	Herb	Aug – Sep	N – P
232.	Garden cress	Chamsur	Lepidium sativum L.	Brassicaceae	A, B, C	Herb	Jan – Feb	N
233.	Garlic	Lasun	Allium sativum L.	Amaryllidaceae	A, B, C	Herb	Feb – Jun	N – P
234.	Gartic pear	Siplikan	Crateva unilocularis Buch - Ham	Capparaceae	A, B, C	Shrub	Apr – May	N – P
235.	Gayo	Gayo	Bridelia retusa (L.) A.Juss.	Phyllanthaceae	A, B, C	Tree	Aug – Oct	N – P
236.	Gentiana	Gyanjak	Gentiana pedicellata (D.Don) Wall.	Gentianaceae	B, C	Herb	Apr – Jul	N – P
237.	Geranium	Chunetro ghas	Geranium spp.	Geraniaceae	A, B, C	Herb	May – Jul	N – P
238.	Globe thistle	Kande	Echinops echinatus Roxb.	Compositae	B, C	Herb	May – Jun	N – P
239.	Goat weed	Gandhe jhar	Ageratum conyzoides (L.) L.	Compositae	A, B	Herb	Feb – Nov	N – P
240.	Golden rod	Bakhra kane	Senecio longiflorus (DC.) Sch.Bip.	Compositae	A, B, C	Herb	Jun – Sep	N – P
241.	Golden rod		Solidago longifolia Schrad.	Compositae	A, B, C	Herb	Sep – Oct	N – P
242.	Goose berry	Aamala	Phyllanthus acidus (L.) Skeels	Phyllanthaceae	A, B	Tree	Apr – Jun	N – P
243.	Goose berry	Aamala	Phyllanthus emblica L.	Phyllanthaceae	A, B	Tree	Apr – Jun	N – P
244.	Goose berry	Bhuin amala	Phyllanthus virgatus G.Forst.	Phyllanthaceae	A, B, C	Tree	Jul – Sep	N – P
245.	Goose foot	Bethe	Chenopodium album L.	Amaranthaceae	A, B, C	Herb	Feb – May	N – P
246.	Goose foot	Bethe	Chenopodium ambrosioides L.	Amaranthaceae	A, B, C	Herb	Jan – Mar	N – P
247.	Gooseberry	Aamala	Emblica officinalis Gaertn.	Phyllanthaceae	A, B	Tree	Mar – May	N – P
248.	Gourd	Pate ghiraula	Luffa acutangula (L.) Roxb.	Cucurbitaceae	A, B, C	Climber	May – July	P
249.	Gourd	Barela	Momordica balsamina L.	Cucurbitaceae	A, B, C	Climber	Feb – Mar	N – P
250.	Gourd	Chaatel	Momordica cochinchinensis (Lour.) Spreng.	Cucurbitaceae	A, B, C	Climber	Feb – Mar	N – P
251.	Grape	Aangur	Vitis vinifera L.	Lamiaceae	A, B, C	Climber	Feb – Jun	N – P
252.	Grape	Pureni	Vitis virgata	Lamiaceae	A, B, C	Climber	Mar – May	P
253.	Green briers	Kukur daino	Smilax ovalifolia Roxb. ex D.Don	Smilacaceae	A, B, C	Climber	Apr – May	N – P
254.	Grewia	Syal phusro	Grewia optiva J.R.Drumm. ex Burret	Malvaceae	A, B, C	Tree	Apr – Jun	N – P
255.	Guava	Aamba	Psidium guajava L.	Myrtaceae	A, B, C	Tree	Apr – Jun	N – P
256.	Gulmohr	Gulmohar	Delonix regia (Hook.) Raf.	Leguminosae	A, B, C	Tree	May – Jun	N – P
257.	Gum arabic tree	Khayer	Acacia arabica (Lam.) Willd.	Leguminosae	A, B, C	Tree	May – Jul	N – P
258.	Gum arabic tree	Khayer	Acacia modesta Wall.	Leguminosae	A, B, C	Tree	May – Jul	N – P
259.	Haldu	Kadam	Adina cordifolia (Roxb.)	Rubiaceae	A, B, C	Tree	Jun – Jul	N – P

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			Benth. & Hook.f. ex B.D.Jacks.					
260.	Hazelnut	Dante ookhar	Corylus jacquemontii Decne.	Betulaceae	A, B	Tree	Mar – May	N – P
261.	Headache tree	Gideri	Premna integrifolia Willd.	Lamiaceae	A, B	Tree	Apr – Jun	N – P
262.	Hemp	Ganja, Bhang	Cannabis himalensis	Cannabaceae	A, B, C	Herb	Jun – Sep	N – P
263.	Hemp	Ganja, Bhang	Cannabis sativa L.	Cannabaceae	A, B, C	Herb	Feb – Apr	N – P
264.	Hemp	Bhang	Cannabis sativa L.	Cannabaceae	B, C	Herb	Feb – Mar	N – P
265.	Himalayan cedar	Devader	Cedrus deodara (Roxb. ex D.Don) G.Don	Pinaceae	B, C	Tree	Sep – Oct	N – P
266.	Himalayan cherry	Painyu	Prunus cerasoides Buch.-Ham. ex D.Don	Rosaceae	A, B, C	Tree	Sep – Nov	N – P
267.	Himalayan cherry	Cherry	Prunus cornuta (Wall. ex Royle) Steud.	Rosaceae	A, B, C	Tree	Jan – Apr	N – P
268.	Himalayan Fir	Gobre sallo	Abies spectabilis (D.Don) Mirb.	Pinaceae	B, C	Tree	Apr – Jul	N – P
269.	Himalayan indigo	Mirmire	Indigofera spp.	Leguminosae	A, B, C	Shrub	Jun – Aug	N – P
270.	Himalayan labrum	Parwal simi	Sophora mollis (Royle) Baker	Leguminosae	A, B, C	Tree	Mar – Jul	N – P
271.	Himalayan rose	Jangali gulaf	Rosa sericea Wall. ex Lindl.	Rosaceae	A, B	Shrub	May – Aug	N – P
272.	Himalayan spurce	Jule sallo	Picea smithiana (Wall.) Boiss.	Pinaceae	B, C	Tree	May – Jul	N – P
273.	Himilayan ash	Lankuri	Fraxinus floribunda Wall	Oleaceae	A, B, C	Tree	Apr – May	N – P
274.	Himlayan fritillary	Kakoli	Fritillaria cirrhosa D.Don	Liliaceae	B, C	Herb	Jan – Apr	N
275.	Hiude squash	Pharsi	Cucurbita maxima Duchesne	Cucurbitaceae	A, B, C	Climber	Apr – Aug	N – P
276.	Hog plum	Lapsi	Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill	Anacardiaceae	A, B	Tree	Mar – May	N – P
277.	Hog plum	Amaro	Spondias pinnata (L. f.) Kurz	Anacardiaceae	A, B	Tree	Feb – Apr	N
278.	Hog plum	Amaro	Spondias axillaris Roxb.	Anacardiaceae	A, B	Tree	Mar – May	N
279.	Hogweed	Pakhi	Heracleum sp.	Apiaceae	A, B, C	Herb	May – Jul	N – P
280.	Holboellia	Gulfo	Holboellia latifolia Wall.	Berberidaceae	A, B, C	Climber	Apr – May	N – P
281.	Hollyhock	Gulaph	Althaea rosea (L.) Cav.	Malvaceae	A, B, C	Shrub	Apr – Jun	N – P
282.	Holy tree	Puwanle	Ilex excels (Wall.) Voigt	Aquifoliaceae	A, B, C	Herb	Apr – May	N – P
283.	Honey suckle	Masino kanike	Lonicera sempervirens L.	Caprifoliaceae	A, B	Climber	May – Aug	N – P
284.	Honey suckle	Masino kanike	Lonicera ligustrina Wall.	Caprifoliaceae	A, B	Climber	Mar – May	P
285.	Honey Suckle	Badru	Lonicera sp.	Caprifoliaceae	A, B	Climber	May – Jun	N – P
286.	Horse chestnut	Lekhpangra	Aesculus indica (Wall. ex Cambess.) Hook.	Sapindaceae	A, B	Tree	May – Jun	N – P
287.	Hounds tongue	Kuro	Cynoglossum amabile Stapf & J.R.Drumm.	Boraginaceae	A, B, C	Herb	Jul – Aug	N – P
288.	Hounds tongue	Kuro	Cynoglossum glochidiatum Wall. ex Benth.	Boraginaceae	A	Herb	Jul – Sep	N – P
289.	Hounds tongue	Kanike kuro	Cynoglossum sp.	Boraginaceae	A, B	Herb	May – Aug	N – P
290.	Hounds tongue	Jibre jhar	Cynoglossum sp.	Boraginaceae	A, B	Herb	Jul – Sep	N – P
291.	Hypericum	Aareli	Hypericum cordifolium L.	Hyperaceae	A, B, C	Shrub	Aug – Oct	N – P
292.	Hypericum	Pyauli phul	Hypericum sp.	Hyperaceae	A, B, C	Shrub	All year	N – P
293.	Indian butter tree	Mahuwa	Madhuca latifolia (Roxb.) J.F.Macbr.	Sapotaceae	A, B	Tree	Feb – Mar	N – P
294.	Indian jujube	Bayer	Ziziphus mauritiana Lam.	Rhamnaceae	A, B	Tree	Aug – Oct	N – P
295.	Insect flower	Godavari	Chrysanthemum cinerarIlfolium (Trevir.) Vis.	Compositae	A, B, C	Herb	Jul – Nov	N
296.	Intermedia	Ban kanyu	Wendlandia tinctoria (Roxb.) DC.	Rubiaceae	A, B	Tree	Feb – Apr	N – P

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297.	Ipil ipil	Ipil ipil	Leucaena leucocephala (Lam.) de Wit	Leguminosae	A, B, C	Tree	Sep – Oct	N – P
298.	Ipil ipil	Epil ipil	Leucaena trichodes (Jacq.) Benth.	Leguminosae	A, B, C	Tree	Sep – Oct	P
299.	Ironweed	Rahune jhar	Veronica spp.	Plantaginaceae	A, B, C	Herb	Apr – Sep	N – P
300.	Ivory weed	Seto lodo	Ehretia acuminate R.Br.	Boraginaceae	A, B, C	Tree	Mar – Apr	N – P
301.	Jacaranda	Nilmohar	Jacaranda mimosifolia D.Don	Bignoniaceae	A, B	Tree	May – Jun	N – P
302.	Jack fruit	Rukh katahar	Artocarpus integer (Thunb.) Merr.	Moraceae	A, B	Tree	Feb – Mar	P
303.	Jackfruit	Rukh katar	Artocarpus heterophyllus Lam.	Moraceae	A, B	Tree	Apr – May	N – P
304.	Jackfruit	Rukh katar	Artocarpus integer (Thunb.) Merr.	Moraceae	A, B	Tree	Feb – Mar	N – P
305.	Jambolan	Kyamun	Syzygium operculatum (Roxb.) Nied.	Myrtaceae	A, B	Tree	Apr – Jul	N – P
306.	Jambolan	Jamun	Syzygium cumini (L.) Skeels	Myrtaceae	A, B	Tree	Spr, Aut	P – N
307.	Jamun	Thulo jamun	Eugenia Formosa Wall.	Myrtaceae	A, B	Tree	Jan – Mar	N – P
308.	Jasmine	Beli	Jasminum sambac (L.) Aiton	Oleaceae	B, C	Shrub	Aug – Nov	N
309.	Jujube	Bayer	Ziziphus incurva	Rhamnaceae	A, B	Tree	Jun – Jul	N – P
310.	Jujube	Bayer	Ziziphus nummularia (Burm.f.) Wight & Arn.	Rhamnaceae	A, B	Shrub	Apr – Jun	N – P
311.	Jujube	Jangali bayer	Ziziphus oxyphylla Edgew.	Rhamnaceae	A, B	Shrub	Jun – Sep	N – P
312.	Juniper	Dhupi	Juniperus spp.	Cupressaceae	A, B, C	Tree	Apr – Jun	N – P
313.	Kanthar	Junge lahara	Capparis himalensis Jafri	Capparaceae	A, B, C	Climber	Apr – May	N – P
314.	Karambal		Odina wodier Roxb.	Anacardiaceae	A, B	Tree	Feb – Apr	N – P
315.	Karandas	Paner	Carissa carandas L.	Apocynaceae	A, B, C	Shrub	Apr – May	N – P
316.	Khol rabi	Gyanth kobi	B. oleracea var. gongylodes L.	Brassicaceae	A, B, C	Herb	Feb – Apr	N – P
317.	Kidney bean	Ghiu simi	Phaseolus vulgaris L.	Leguminosae	A, B, C	Shrub	Spr, Aut	N – P
318.	Laburnum	Rajbriksya	Cassia fistula L.	Leguminosae	A, B, C	Tree	May – July	N – P
319.	Laburnum	Rajbriksya	Cassia floribunda Collad.	Leguminosae	A, B, C	Tree	May – July	N – P
320.	Laburnum	Rajbriksya	Cassia mimosoides L.	Leguminosae	A, B, C	Tree	May – July	N – P
321.	Lady's finger	Bhindi	Abelmoschus esculentus (L.) Moench	Malvaceae	A,B,C	Herb	Mar – Sep	N – P
322.	Larkspur	Bikhadi ghans	Delphinium roylei Munz	Ranunculaceae	A, B	Herb	Mar – May	N – P
323.	Lemon	Nibuwa	Citrus limon (L.) Osbeck	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
324.	Lentil	Musuro	Lens culinaris Medik.	Leguminosae	A, B, C	Herb	Sep – Nov	N – P
325.	Lespedeza	Bhaisano	Lespedeza cuneata (Dum.Cours.) G.Don	Leguminosae	A, B, C	Herb	Jun – Jul	N
326.	Lespedeza	Bhaisano	Lespedeza gerardiana Maxim.	Leguminosae	A, B, C	Herb	Aug – Oct	N
327.	Lettuce	Jiri ko sag	Lactuca sativa L.	Compositae	A, B, C	Herb	Apr – Aug	N – P
328.	Leucosceptrum	Bhusure	Leucosceptrum canum Sm.	Lamiaceae	A, B, C	Shrub	Feb – Apr	N – P
329.	Leucosceptrum	Kanike phul	Leucosceptrum nepalense	Lamiaceae	A, B, C	Shrub	Feb – Mar	N – P
330.	Ligustrum	Kanike Phul	Ligustrum indicum (Lour.) Merr.	Oleaceae	A, B, C	Tree	Jun – Jul	N – P
331.	Lime	Kagati	Citrus aurantifolia (Christm.) Swingle	Rutaceae	A, B, C	Tree	Feb – Apr	N – P
332.	Lime basswood		Tilia spp.	Malvaceae	A, B, C	Tree	Jun – Aug	N
333.	Linseed	Aalas	Linum sp.	Linaceae	A, B, C	Herb	Feb – Mar	N – P
334.	Linseed	Alas	Linum usitatissimum L.	Linaceae	A, B, C	Herb	Feb – Mar	N – P
335.	Litchi	Litchi	Litchi chinensis Sonn.	Sapindaceae	A, B, C	Tree	Feb – Apr	N – P
336.	Lodh tree	Kholme	Symplocos paniculata (Thunb.) Miq.	Symplocaceae	A, B, C	Tree	Apr – May	N – P

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337.	Loquat	Louquat	Eriobotrya japonica (Thunb.) Lindl.	Rosaceae	A, B	Tree	Spr, Aut	N – P
338.	Loquat	Tindu	Eriobotrya sp.	Rosaceae	B, C	Tree	May – Jul	N – P
339.	Lucerne	Leucern	Medicago falcate L.	Leguminosae	A, B, C	Herb	Feb – Apr	N – P
340.	Lucerne	Leucern	Medicago laciniata (L.) Mill.	Leguminosae	A, B, C	Herb	Mar – Apr	N – P
341.	Lucerne	Leucern	Medicago lupulina L.	Leguminosae	A, B, C	Herb	Apr – May	N – P
342.	Maesa	Bhagate	Maesa macrophylla C.B.Clarke	Primulaceae	A, B, C	Shrub	Feb – Apr	N – P
343.	Mahagony	Hallongra	Chukrasia tabularis A.Juss.	Meliaceae	A, B	Tree	Apr – May	N
344.	Mahonia	Jaman mandro	Mahonia napaulensis DC.	Berberidaceae	A, B, C	Tree	Nov – Feb	N – P
345.	Maize	Makai	Zea mays L.	Poaceae	A, B, C	Shrub	All year	P
346.	Malabar nut	Aasuro	Justicia adhatoda L.	Acanthaceae	A, B, C	Shrub	Mar – May	N – P
347.	Malabar nut	Aasuro	Justicia procumbens L.	Acanthaceae	A, B, C	Shrub	Jul – Aug	N
348.	Malabur nut	Bankas	Justicia pubigera (Nees) C.B. Clarke	Acanthaceae	B, C	Herb	Aug – Oct	N – P
349.	Malabur nut	Kalo asuro	Justicia gendarussa Burm.f.	Acanthaceae	A, B, C	Herb	Mar – May	N
350.	Mallow	Lafe sag	Malva sylvestris L.	Malvaceae	A, B	Herb	June – Oct	N – P
351.	Mandarin orange	Suntala	Citrus reticulate Blanco	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
352.	Mango	Aamp	Mangifera indica L.	Anacardiaceae	A	Tree	Feb – Apr	N – P
353.	Maple	Phirphire	Acer acuminatum Wall. ex D.Don	Sapindaceae	B, C	Tree	Mar – Apr	N – P
354.	Maple	Phirphire	Acer caesium Wall. ex Brandis	Sapindaceae	B, C	Tree	Mar – May	N – P
355.	Maple	Phirphire	Acer negundo L.	Sapindaceae	B, C	Tree	Apr – May	N – P
356.	Maple	Phirphire	Acer oblongum Wall. ex DC.	Sapindaceae	B, C	Tree	Feb – Apr	N – P
357.	Maple	Phirphire	Acer pentapomicum Stewart ex Brandis	Sapindaceae	B, C	Tree	Mar – Apr	N – P
358.	Maple	Phirphire	Acer pictum Thunb.	Sapindaceae	B, C	Tree	Mar – Apr	N – P
359.	Margosa	Neem	Azadirachta indica A.Juss.	Meliaceae	A	Tree	Apr – May	N – P
360.	Marigold	Asarphi ful	Calendula officinalis L.	Compositae	A, B	Herb	Feb – Apr	N – P
361.	Marigold	Sayapatri	Tagetes erecta L.	Compositae	A, B, C	Herb	All year	N – P
362.	Marigold	Sayapatri	Tagetes patula L.	Compositae	A, B, C	Herb	Sep – Dec	N – P
363.	Marking nut tree	Kag bhalayo	Semecarpus anacardium L.f.	Anacardiaceae	A, B, C	Tree	Apr – May	N – P
364.	Marsh marigold		Caltha spp.	Ranunculaceae	C	Herb	Apr – Jul	N – P
365.	Marvel of Peru	Lankeshori	Mirabilis jalapa L.	Nyctaginaceae	A, B, C	Herb	Jun – Jul	N
366.	Maule's quince		Chaenomeles japonica (Thunb.) Lindl. ex Spach	Rosaceae	B, C	Shrub	Jan – Sep	P – N
367.	Mazus	Tapre jhar	Mazus sp.	Phrymaceae	A, B	Herb	Jul – Oct	N – P
368.	Meda	Kutmero	Litsea monopetala (Roxb.) Pers.	Lauraceae	A, B, C	Tree	Jan – Feb	N – P
369.	Meda	Kutmero	Litsea polyantha Juss.	Lauraceae	B, C	Tree	Dec – Jan	N – P
370.	Medlar	Jure kaphal	Eriobotrya dubia (Lindl.) Decne.	Rosaceae	A, B	Tree	Spr, Aut	N – P
371.	Mellilot	Ran methi	Melilotus sp.	Leguminosae	A, B, C	Herb	Jun – Jul	N – P
372.	Milkweed	Macha Phul	Asclepias curassavica L.	Apocynaceae	B, C	Shrub	Apr – Jun	N – P
373.	Mint	Pudina	Mentha spicata L.	Lamiaceae	A, B, C	Herb	Jun – Sep	N
374.	Mint	Babari	Mentha viridis (L.) L.	Lamiaceae	A, B, C	Herb	Jul – Oct	N – P
375.	Molucca bean	Karanj	Caesalpinia sp.	Leguminosae	A, B, C	Tree	Nov – May	N – P
376.	Monkshood	Bikh	Aconitum spp.	Ranunculaceae	A, B	Herb	Jun – Sep	N – P
377.	Mother wort		Leonurus cardiaca L.	Lamiaceae	A, B, C	Herb	Jun – Aug	N – P
378.	Mother wort		Leonurus heterophullus Sweet	Lamiaceae	A, B, C	Herb	Jun – Jul	N – P
379.	Mountain ebony	Koiralo	Bauhinia variegata (L.) Benth.	Leguminosae	A, B, C	Tree	Sep – Nov	N – P
380.	Mugwort	Titepati	Artemisia indica Willd.	Compositae	A, B, C	Herb	Sep – Nov	N – P

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381.	Mugwort	Titepati	Artemisia spp.	Compositae	A, B, C	Herb	Aug – Oct	N – P
382.	Mulberry	Kimbu	Morus alba L.	Moraceae	A, B, C	Tree	Feb – Mar	N – P
383.	Musk thistles		Carduus onopordioides Fisch. ex M.Bieb.	Compositae	A, B, C	Herb	May – Aug	N – P
384.	Mussoorie berry	Machhaino	Coriaria nepalensis Wall.	Coriariaceae	B, C	Tree	Mar – Apr	N – P
385.	Mustard	Rayo	Brassica juncea (L.) Czern.	Brassicaceae	A, B, C	Herb	Jan – Apr	N – P
386.	Mustard	Tori	Brassica campestris L.	Brassicaceae	A, B, C	Herb	Dec – May	N – P
387.	Myrobalan	Harro	Terminalia chebula Retz.	Combretaceae	A, B	Tree	Apr – May	N – P
388.	Myrobolon	Barro	Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	A, B	Tree	Apr – May	N – P
389.	Needle wood	Chilaune	Schima wallichii Choisy	Theaceae	A, B	Tree	Mar – Jun	N – P
390.	Nepal iris	Padam puskar	Iris nepalensis Wall. ex Lindl.	Iridaceae	B, C	Herb	Apr – May	N – P
391.	Nepal loquat	Loquat	Eriobotrya elliptica Lindl.	Rosaceae	A, B	Tree	Feb – Apr	N – P
392.	Nepal pepper	Timbur	Zanthoxylum armatumi DC.	Rutaceae	B, C	Shrub	Mar – May	N – P
393.	Nepal sumac	Bhalayo	Rhus spp.	Simaroubaceae	A, B, C	Tree	Spr, Aut	N – P
394.	Nepal sumac	Bhalayo	Rhus wallichii Hook. f.	Simaroubaceae	A, B	Tree	Apr – Jun	N – P
395.	Nepali paper plant	Lokta	Daphne sp.	Thymeliaceae	A, B, C	Shrub	Jul – Sep	N – P
396.	Niger	Jhuse til	Guizotia abyssinica (L.f.) Cass.	Compositae	A, B, C	Herb	Aug – Nov	N – P
397.	Night jasmine	Parijat	Nyctanthes arbor-tristis L.	Oleaceae	A, B, C	Tree	May – Oct	N – P
398.	Night shade	Bihi	Solanum indicum L.	Solanaceae	A, B, C	Herb	Jun – Jul	P
399.	Oak	Baanjh	Quercus spp.	Fagaceae	A, B, C	Tree	Apr – Jul	P
400.	Oat	Jou	Avena sativa L.	Poaceae	A, B, C	Shrub	Feb – Apr	P
401.	Oleaster	Madilo	Elaeagnus angustifolia L.	Elaeagnaceae	A, B, C	Tree	Mar – Jun	N – P
402.	Oleaster	Ghuenli	Elaeagnus parvifolia Wall. ex Royle	Elaeagnaceae	A, B, C	Shrub	Mar – Jun	N – P
403.	Onion	Piyaj	Allium cepa L.	Amaryllidaceae	A, B, C	Herb	Apr – May	N – P
404.	Opium poppy	Aphim	Papaver somniferum L.	Papaveraceae	A, B, C	Herb	Mar – May	P
405.	Osbeckia	Chuleshi	Osbeckia stellata Buch.-Ham. ex Ker Gawl.	Melastomataceae	A, B, C	Shrub	Jul – Nov	N – P
406.	Osmanthus	Jhigani	Eurya alata Kobuski	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
407.	Osmanthus	Jhigani	Eurya brevistyla Kobuski	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
408.	Osmanthus	Jhigani	Eurya chinensis R.Br.	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
409.	Osmanthus	Jhigani	Eurya groffi Merr.	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
410.	Osmanthus	Jhigani	Eurya muricata Dunn	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
411.	Osmanthus	Jhigani	Eurya nitida Korth.	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
412.	Osmanthus	Jhingani	Eurya sp.	Pentaphylacaceae	A, B	Tree	Sep – Nov	N – P
413.	Oval leaf lyonia	Angeri	Lyonia ovalifolia (Wall.) Drude	Ericaceae	B, C	Tree	Feb – Apr	N – P
414.	Pagoda tree	Parwal simi	Sophora viciifolia Hance	Leguminosae	A, B, C	Shrub	Mar – Apr	N – P
415.	Papaya	Mewa	Carica papaya L.	Caricaceae	A, B	Tree	Apr – Jun	N – P
416.	Paper chase	Dhobini	Mussaenda roxburghii Hook.f.	Rubiaceae	A, B, C	Shrub	May – Aug	N – P
417.	Paper flower		Helichrysum arenarium (L.) Moench	Compositae	A, B	Shrub	Feb – Jun	N – P
418.	Parthenium	Congres jhar	Parthenium hysterophorus L.	Compositae	A, B	Herb	May – Dec	P
419.	Paulownia	Paulownia	Paulownia elongate S.Y. Hu	Paulowniaceae	A, B	Tree	Feb – Mar	N – P
420.	Pea	Kerau	Pisum sativum L.	Leguminosae	A, B, C	Herb	Mar – Apr	N – P
421.	Peach	Aaru	Prunus persica (L.) Batsch	Rosaceae	A, B, C	Tree	Jan – Mar	N – P
422.	Pear	Naspati	Pyrus communis L.	Rosaceae	A, B, C	Tree	Feb – Mar	N – P
423.	Pearl millte	Bajra	Pennisetum typhoides (Burm.f.) Stapf & C.E.Hubb.	Poaceae	A, B, C	Shrub	Sep – Oct	P
424.	Pearly everlasting	Seto ekli ghas	Anaphalis busua (Buch.-Ham.) DC.	Compositae	A, B, C	Shrub	Jun – Aug	P
425.	Perilla	Silam	Perilla frutescens (L.)	Lamiaceae	A, B, C	Herb	Aug – Nov	N – P

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			Britton					
426.	Persean lilac	Bakaino	Melia azedarach L.	Meliaceae	A, B, C	Tree	Mar – Apr	N – P
427.	Persian acacia	Rato siris	Albizia julibrissin Durazz.	Leguminosae	A, B, C	Tree	Apr – Jun	N – P
428.	Persian clover	Pyauli	Trifolium resupinatum L.	Leguminosae	A, B, C	Herb	Apr – Jun	N – P
429.	Persimmon	Halwabed	Diospyros kaki L.f.	Ebenaceae	B, C	Tree	Mar – Apr	N – P
430.	Persimmon	Halwabed	Diospros virginiana L.	Ebenaceae	B, C	Tree	Mar – Apr	N – P
431.	Peru apple	Poke chinek	Nicandra physalodes (L.) Gaertn.	Solanaceae	A, B, C	Herb	Mar – Nov	N – P
432.	Petha	Kubindo	Benincasa hispida (Thunb.) Cogn.	Cucurbitaceae	A, B	Climber	Apr – May	N – P
433.	Phlogacanthus	Choyua	Phlogacanthus pubinervius T. Anderson	Acanthaceae	A, B	Shrub	Mar – Jul	N – P
434.	Phlogacanthus	Choyuu	Phlogacanthus thyrsiflorus Nees	Acanthaceae	A, B	Shrub	Sep – Nov	N – P
435.	Physic nut	Sajiba	Jatropha curcas L.	Euphorbiaceae	A, B	Shrub	Apr – Jul	N – P
436.	Piegon pea	Rahar	Cajanus cajan (L.) Millsp.	Leguminosae	A, B, C	Shrub	Feb – Oct	N – P
437.	Pigweed	Lunde	Amaranthus spp.	Amaranthaceae	A, B, C	Herb	Jun – Aug	N – P
438.	Pink bahunia	Tanki	Bauhinia purpurea L.	Leguminosae	A, B, C	Tree	Mar – Apr	N – P
439.	Pink balsam	Rato tiuri	Impatiens balsamina L.	Balsaminaceae	A, B, C	Herb	Apr – Aug	N – P
440.	Pioinsettia	Lalupate	Poinsettia pulcherrima Willd. ex Klotzsch) Graham	Euphorbiaceae	A, B	Shrub	Jan – Feb	N – P
441.	Plantago	Nashe jhar	Plantago spp.	Plantaginaceae	A, B, C	Herb	Mar – Sep	N – P
442.	Plum	Arubokhar	Prunus cerasifera Ehrh.	Rosaceae	A, B, C	Tree	Feb – Mar	N – P
443.	Plum	Aaru bakhada	Prunus communis (L.) Arcang.	Rosaceae	A, B, C	Tree	Feb – Mar	N – P
444.	Plum	Aru bakhada	Prunus domestica L.	Rosaceae	A, B, C	Tree	Feb – Mar	N – P
445.	Poet's daffodil	Gun keshari	Narcissus poeticus L.	Amaryllidaceae	A, B, C	Herb	Mar – May	P
446.	Pogostemon	Rudilo	Pogostemon glaber Benth.	Lamiaceae	A, B, C	Shrub	Spr, Aut	N – P
447.	Poinsettia	Lalupate	Euphorbia pulcherrima Willd. ex Klotzsch	Euphorbiaceae	A, B, C	Shrub	Spr, Aut	N – P
448.	Polygonum	Thotne	Polygonum spp.	Polygonaceae	A, B, C	Herb	May – Sep	N – P
449.	Pomogranate	Anar	Punica granatum L.	Lythraceae	A, B, C	Tree	Mar – May	N – P
450.	Poppy	Aphim	Papaver rhoeas L.	Papaveraceae	A, B, C	Herb	Mar – May	N – P
451.	Poppy	Aphim	Papaver spp.	Papaveraceae	A, B, C	Herb	Dec – Feb	P
452.	Porana	Aakash beli	Porana grandiflora Wall.	Convolvulaceae	A, B, C	Climber	Aug – Oct	N – P
453.	Pot marjorma	Ram tulasi	Origanum vulgare L.	Lamiaceae	A, B	Herb	Aug – Sep	N – P
454.	Potato	Aalu	Solanum tuberosum L.	Solanaceae	A, B, C	Herb	All year	N – P
455.	Prickly pear	Siundi	Opuntia monacantha (Willd.) Haw.	Cactaceae	A, B, C	Shrub	Feb – Mar	N – P
456.	Prickly Pear	Siundi	Opuntia sp.	Cactaceae	A, B, C	Shrub	Feb – Mar	N – P
457.	Prickly poppy	Thaakal	Argemone mexicana L.	Papaveraceae	A, B	Herb	May – Jul	P
458.	Primula	Medosero	Primula sp.	Primulaceae	A, B, C	Herb	May – Sep	N – P
459.	Prinsepia	Dhatelo	Prinsepia utilis Royle	Rosaceae	A, B, C	Herb	Oct – Nov	N – P
460.	Privet	Simali	Vitex negundo L.	Lamiaceae	A, B, C	Shrub	Apr – Oct	N – P
461.	Pumelo	Bhogate	Citrus grandis (L.) Osbeck	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
462.	Pumelo	Bhogate	Citrus paradisi Macfad.	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
463.	Pumpkin	Pharsi	Cucurbita moschata Duchesne	Cucurbitaceae	A, B	Climber	Mar – Sep	N – P
464.	Purslana	Nun dhiki	Portulaca grandiflora Hook.	Portulacaceae	A, B, C	Herb	Jun – Sep	N – P
465.	Radish	Mula	Raphanus sativus L.	Brassicaceae	A, B, C	Herb	Feb – Mar	N – P
466.	Ragwort	Bakhra kane	Senecio scandens Buch.-Ham. ex D.Don	Compositae	A, B, C	Herb	Jun – Sep	N – P
467.	Ragwort	Bakhra kane	Senecio densiflorus Wall.	Compositae	A, B, C	Herb	Feb – Mar	P
468.	Railway creeper		Ipomoea pulchella Roth	Convolvulaceae	A, B, C	Herb	Aug – Nov	N – P
469.	Rangoon creeper	Brahma beli	Quisqualis indica L.	Combretaceae	A, B, C	Climber	Aug – Oct	N – P
470.	Rape	Tori	Brassica napus var. glauca (Roxb.) O. E. Schulz	Brassicaceae	A, B, C	Herb	Dec – Mar	N – P

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471.	Rape	Tori	Brassica napus var. toria	Brassicaceae	A, B, C	Herb	Dec – Mar	N – P
472.	Raspberry	Ainselu	Rubus ellipticus Sm.	Rosaceae	A, B, C	Shrub	Feb – Apr	N – P
473.	Raspberry	Rukh ainselu	Rubus paniculatus Sm.	Rosaceae	A, B, C	Shrub	Apr – May	N – P
474.	Raspberry	Aainselu	Rubus setchuenensis Bureau & Franch.	Rosaceae	A, B, C	Shrub	Jul – Aug	N – P
475.	Raspberry	Ainselu	Rubus spp.	Rosaceae	A, B, C	Shrub	Spr, Aut	N – P
476.	Raspberry	Aainselu	Rubus ulmifolius Schott	Rosaceae	A, B	Shrub	Sep – Oct	N – P
477.	Red bean	Masyang	Phaseolus calcaratus Roxb.	Leguminosae	A, B, C	Herb	Oct – Nov	N – P
478.	Red bean	Masyang	Vigna umbellate (Thunb.) Ohwi & H.Ohashi	Leguminosae	A, B, C	Herb	Oct – Nov	N – P
479.	Red cedar	Tooni	Toona ciliata M.Roem.	Meliaceae	A, B, C	Tree	Jul – Aug	N – P
480.	Red clover	Pyauli	Trifolium pratense L.	Leguminosae	A, B, C	Herb	Apr – Sep	N – P
481.	Rhododendron	Angeri	Melastoma malabathricum L.	Melastomataceae	B, C	Shrub	Mar – Jun	N – P
482.	Rhododendron	Angeri	Melastoma normale D. Don	Melastomataceae	B, C	Shrub	Mar – Jun	N – P
483.	Rhododendron	Laligurans	Rhododendron arboreum Sm.	Ericaceae	B, C	Tree	Feb – Mar	N – P
484.	Rhododendron	Sunpati	Rhododendron anthopogon D. Don	Ericaceae	C	Shrub	May – July	N – P
485.	Rhododendron	Chimaal	Rhododendron ponticum L.	Ericaceae	B, C	Shrub	May – Oct	N
486.	Rice	Dhan	Oryza sativa L.	Poaceae	A, B, C	Herb	Jul, Oct	P
487.	Ripple grass	Ishabgol	Plantago major L.	Plantaginaceae	A, B, C	Herb	Mar – Sep	N – P
488.	Rocket Salad	Sarsuyn	Eruca sativa Mill.	Brassicaceae	A, B, C	Herb	Feb – Mar	N – P
489.	Rose	Gulaf	Rosa hybrida Vill.	Rosaceae	A, B, C	Shrub	Apr – Jun	N – P
490.	Rose	Jangali gulaf	Rosa spp.	Rosaceae	A, B, C	Shrub	Apr – Jun	N – P
491.	Rose apple	Ban jamun	Syzygium jambos (L.) Alston	Myrtaceae	A, B	Tree	Spr, Aut	N – P
492.	Rosemary		Rosmarinus officinalis L.	Lamiaceae	A, B	Shrub	Apr – Jun	N – P
493.	Rough lemon	Kalo Jyamir	Citrus junos Siebold ex Tanaka	Rutaceae	A, B, C	Tree	Feb – Mar	N
494.	Rubber tree	Rabar	Hevea brasiliensis (Willd. ex A.Juss.) Müll.Arg.	Euphorbiaceae	A	Tree	Mar – Jul	N – P
495.	Rungia	Ukche jhar	Rungia parviflora Nees	Acanthaceae	A, B	Herb	Jul – Aug	N – P
496.	Sacbiosa		Scabiosa speciosa Royle	Caprifoliaceae	A, B, C	Herb	May – Jul	N – P
497.	Safflower	Kusum	Carthamus tinctorius L.	Compositae	A, B, C	Herb	Feb – Mar	N – P
498.	Saffron	Keshar	Crocus sativus L.	Iridaceae	A, B, C	Herb	Jan – May	N – P
499.	Sal	Sal	Shorea robusta Gaertn.	Dipterocarpaceae	A, B	Tree	Feb – Apr	N – P
500.	Salvia	Bishnu phul	Salvia coccinea Buc'hoz ex Etl.	Lamiaceae	A, B	Herb	Jan – Dec	N – P
501.	Salvia	Ram tulasa	Salvia sp.	Lamiaceae	A, B, C	Herb	All year	N – P
502.	Samphire	Kan pake	Inula cappa (Buch.-Ham. ex D.Don) DC.	Compositae	A, B, C	Herb	Sep – Feb	N – P
503.	Santonica	Kirmane jwanu	Artemisia maritima L.	Compositae	A, B	Herb	Aug – Oct	N – P
504.	Sarson	Sarson	B. campestris var. sarson Prain	Brassicaceae	A, B, C	Herb	Sep – Mar	N – P
505.	Sauauia	Gogan	Saurauia napaulensis DC.	Actinidiaceae	A, B	Tree	Sep – Oct	N – P
506.	Saw thistle	Dudhe bhalayo	Sonchus asper (L.) Hill	Compositae	A, B, C	Herb	Jun – Oct	N – P
507.	Scabious		Scabiosa speciosa Royle	Caprifoliaceae	A, B, C	Herb	May – Jul	N – P
508.	Scarlet sage	Lwang phul	Salvia splendens Sellow ex Schult.	Lamiaceae	A, B, C	Herb	All Year	N – P
509.	Sensitive plant	Lazzawati	Mimosa pudica L.	Leguminosae	A, B, C	Herb	May – Nov	N – P
510.	Sensitive plant	Lazzawati	Mimosa rubicaulis Lam.	Leguminosae	A, B, C	Herb	May – Jul	P
511.	Sesame	Til	Sesamum indicum L.	Pedaliaceae	A, B, C	Herb	Jul – Oct	N – P
512.	Sesame	Til	Sesamum orientale L.	Pedaliaceae	A, B, C	Herb	Apr – May	N – P
513.	Shain		Plectranthus coetsa Buch.-Ham. ex D.Don	Lamiaceae	B, C	Shrub	Aug – Nov	N – P
514.	Shain		Plectranthus gerardianus Benth.	Lamiaceae	B, C	Shrub	Aug – Sep	N – P

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515.	Shain		Plectranthus rugosus Wall. ex Benth.	Lamiaceae	B, C	Shrub	Aug – Oct	N – P
516.	Shain	Charpate	Plectranthus sp.	Lamiaceae	B, C	Shrub	Aug – Nov	N – P
517.	Sickle pod	Tapre	Cassia tora L.	Leguminosae	A, B, C	Tree	Jun – Aug	N – P
518.	Silk cotton	Simal	Bombax ceiba L.	Malvaceae	A, B, C	Tree	Feb – Mar	N – P
519.	Silk cotton	Simal	Bombax malabaricum DC	Malvaceae	A, B	Tree	Mar – Apr	N – P
520.	Silky oak	Kangiyo	Grevillea hirtella (Benth.) Olde & Marriott	Proteaceae	B, C	Shrub	Sep – Oct	N – P
521.	Silky oak	Kangiyo	Grevillea robusta A.Cunn. ex R.Br.	Proteaceae	A, B	Tree	Mar – May	N – P
522.	Silverweed	Bajra danti	Potentilla spp.	Rosaceae	A, B	Herb	Jun – Aug	N – P
523.	Sissoo	Sissoo	Dalbergia sissoo DC.	Leguminosae	A, B	Tree	Mar – May	N – P
524.	Small rhododendron	Sanno chimaal	Rhododendron cinnabarinum Hook. f.	Ericaceae	C	Shrub	Mar – May	N
525.	Smart weed	Pirre	Persicaria capitata (Buch.-Ham. ex D.Don) H.Gross	Polygonaceae	A, B, C	Herb	Mar – Nov	N – P
526.	Snake gourd	Chichindo	Trichosanthes anguina L.	Cucurbitaceae	A, B, C	Climber	Jun – Sep	N – P
527.	Snake weed	Dudhe jhar	Euphorbia hirta L.	Euphorbiaceae	A, B, C	Herb	All year	P
528.	Soapnut	Rittha	Sapindus detergens Roxb.	Sapindaceae	A, B, C	Tree	May – Jun	N – P
529.	Soapnut	Rittha	Sapindus mukorossi Gaertn.	Sapindaceae	A, B, C	Tree	Apr – Jun	N – P
530.	Sorghum	Junelo	Shorghum vulgare Pers.	Poaceae	A, B, C	Herb	May – Jun	P
531.	Sorghum	Junelo	Sorghum sp.	Poaceae	A, B, C	Herb	May – Jun	P
532.	Sorrel	Chari amilo	Oxalis acetosella L.	Oxalidaceae	A, B, C	Herb	Feb – Apr	N
533.	Sorrel	Halhale	Rumex spp.	Polygonaceae	A, B, C	Herb	Jun – Oct	N – P
534.	Soyabean	Bhatmas	Glycine max (L.) Merr.	Leguminosae	A, B, C	Herb	Jul – Sep	N – P
535.	Spanish needle	Kuro	Bidens sp.	Compositae	A, B, C	Herb	Sep – Dec	N – P
536.	Spanish needle	Kalo kuro	Bidens pilosa L.	Compositae	A, B, C	Herb	Jun – Aug	P
537.	Spinach	Palungo	Spinacea oleracea L.	Amaranthaceae	A, B, C	Herb	Feb – May	N – P
538.	Spiny amaranth	Lunde kanda	Abelmoschus esculentus (L.) Moench	Malvaceae	A, B, C	Herb	Jun – Aug	N – P
539.	Spiny poppy	Kyashar	Meconopsis sp.	Papaveraceae	B, C	Herb	Jun – Aug	N – P
540.	Sponge gourd	Ghiroula	Luffa cylindrica (L.) M.Roem.	Cucurbitaceae	A, B, C	Climber	Jul – Oct	N – P
541.	Squash	Kharbuzza	Cucumis melo L.	Cucurbitaceae	A, B	Shrub	Apr – Jun	N – P
542.	Squirell's tail	Ghursul	Colebrookea oppositifolia Sm.	Lamiaceae	B,C	Shrub	Dec – Apr	N – P
543.	Starwort	Ankhe phul	Aster spp.	Compositae	A, B, C	Herb	Sep – Nov	N – P
544.	Stitch wort	Tike jhar	Stellaria vestita Kurz	Caryophyllaceae	A, B, C	Herb	Sep – Nov	N – P
545.	Strawberry	Ainselu	Fragaria vesca L.	Rosaceae	A, B	Herb	Feb – May	N – P
546.	Strawberry	Ainselu	Fragaria indica Jacks.	Rosaceae	A, B	Herb	Feb – Apr	N – P
547.	Strobilanthes	Kibbu	Strobilanthes wallichii Nees	Acanthaceae	A, B, C	Herb	Aug – Oct	N – P
548.	Sumac	Dudhe bhalayo	Rhus javanica L.	Simaroubaceae	A, B, C	Tree	Sep – Oct	N – P
549.	Sumac	Rani bhalayo	Rhus succedanea L.	Simaroubaceae	B, C	Tree	May – Jun	N – P
550.	Sumac	Bhalayo	Rhus verniciflua Stokes	Simaroubaceae	A, B	Tree	May – Jun	N – P
551.	Summer savoury		Calamintha spp.	Lamiaceae	B, C	Herb	Sep – Oct	P
552.	Sunflower	Suryamukhi	Helianthus annuus L.	Compositae	A, B, C	Shrub	Jul – Sep	N – P
553.	Sunhemp	Sanai	Crotalaria juncea L.	Leguminosae	A, B, C	Shrub	Jul – Sep	N – P
554.	Supota	Supota	Parkia roxburghii G.Don	Leguminosae	A, B, C	Tree	Oct – Dec	N – P
555.	Sweer chestnut	Katus	Castanea sativa Mill.	Fagaceae	A, B, C	Tree	Apr – Sep	N – P
556.	Sweet broomweed	Mithi jhar	Scoparia dulcis L.	Plantaginaceae	A, B, C	Herb	May – July	P
557.	Sweet lemon	Chakshi	Citrus limetta Risso	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
558.	Sweet lime	Chaksi	Citrus limettioides Yu.Tanaka	Rutaceae	A, B, C	Tree	Feb – Apr	N
559.	Sweet orange	Mausum	Citrus sinensis (L.) Osbeck	Rutaceae	A, B, C	Tree	Mar – Apr	N – P
560.	Sweet potato	Karmi sag	Ipomoea aquatic Forssk.	Convolvulaceae	A, B, C	Shrub	Jul – Sep	P

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561.	Sweet potato	Baguwa	Ipomoea carnea Jacq.	Convolvulaceae	A, B, C	Shrub	Apr – Sep	P
562.	Sweet potato	Sakharkhand	Ipomoea batatas (L.) Lam.	Convolvulaceae	A, B, C	Shrub	Aug – Nov	N – P
563.	Symphytum		Symphytum peregrinum Ledeb.	Boraginaceae	A, B	Herb	Jun – Sep	N – P
564.	Symplocos	Kholme	Symplocos spp.	Symplocaceae	A, B, C	Tree	Apr – May	N – P
565.	Symplocos	Kholme	Symplocos sumuntia Buch.-Ham. ex D. Don	Symplocaceae	A, B, C	Tree	Sep – Oct	N – P
566.	Tallow	Khirro	Sapium discolori (Champ. ex Benth.) Müll.Arg.	Euphorbiaceae	A, B	Tree	May – Jun	N – P
567.	Tallow	Khirro	Sapium insigne (Royle) Trimen	Euphorbiaceae	A, B	Tree	May – Jul	N – P
568.	Tallow	Khirro	Sapium sebiferum (L.) Roxb.	Euphorbiaceae	A, B	Tree	Jul – Aug	N – P
569.	Tallow	Khirro	Sapium spp.	Euphorbiaceae	A, B	Tree	Nov – May	N – P
570.	Tamarind	Imili	Tamarindus indica L.	Legumnosae	A, B	Tree	Apr – Jun	N – P
571.	Tatary buckwheat	Phapar	Fagopyrum tartaricum (L.) Gaertn.	Polygonaceae	A, B, C	Herb	Aug – Oct	N – P
572.	Tea	Chiya	Camellia oleifera Abel	Theaceae	A, B	Tree	Oct – Nov	N – P
573.	Tea	Chiya	Camellia sinensis (L.) Kuntze	Theaceae	A, B	Shrub	Oct – Nov	N – P
574.	Teak	Tick	Tectona grandis L.f.	Lamiaceae	A, B	Tree	Mar – May	N – P
575.	Temple tree	Golaichi	Plumeria rubra L.	Apocynaceae	A, B	Herb	May – Oct	N – P
576.	Terminalila	Saj	Terminalia alata Wall.	Combretaceae	A, B	Tree	Apr – May	N – P
577.	Tesael	Mulapat	Dipsacus inermis Wall.	Caprifoliaceae	A, B, C	Herb	Jul – Oct	N – P
578.	Thistle	Dhade kanda	Cirsium arvense (L.) Scop.	Compositae	A, B	Herb	Mar – Jun	N – P
579.	Thistle	Khalbum	Cirsium wallichi DC.	Compositae	A, B	Herb	Apr – May	N – P
580.	Thomson's aster		Aster thomsonii C.B.Clarke	Compositae	C	Herb	Sep – Nov	P
581.	Thorn apple	Dhaturo	Datura metel L.	Solanaceae	A, B, C	Herb	Jan – Mar	P
582.	Thorn apple	Dhatura	Datura stramonium L.	Solanaceae	A, B, C	Herb	Jun – Sep	P
583.	Three leaved caper	Sipligan	Crateva unilocularis Buch.-Ham.	Capparaceae	A, B, C	Tree	Apr – May	N – P
584.	Through wort	Banmara	Eupatorium adenophorum Spreng.	Compositae	A, B, C	Shrub	Mar – Jun	N – P
585.	Through wort	Seto banmara	Eupatorium glandulosum Michx.	Compositae	A, B, C	Herb	Mar – Apr	N – P
586.	Through wort	Nilo banmara	Eupatorium odoratum L.	Compositae	A, B, C	Herb	Apr – Aug	N – P
587.	Throughwort	Banmara	Eupatorium sp.	Compositae	A, B, C	Herb	Spr, Aut	N – P
588.	Thumbe	Gumpate	Leucas lanatai Benth.	Lamiaceae	A, B, C	Shrub	Jan – Apr	N – P
589.	Thyme	Aakhano	Thymus sp	Lamiaceae	A, B, C	Shrub	May – Oct	N – P
590.	Tick clover	Bakhre ghans	Desmodium oojeinense (Roxb.) H.Ohashi	Leguminosae	A, B	Tree	May – Jun	N – P
591.	Tobacco	Surti	Nicotiana tabacum L.	Solanaceae	A, B, C	Herb	Sep – Oct	P
592.	Tomato	Golvenda	Lycopersicon esculentum Mill.	Solanaceae	A, B, C	Herb	Feb – Oct	N – P
593.	Trailing eclipta	Bhringe raj	Eclipta prostrata (L.) L.	Compositae	A, B	Shrub	Jul – Oct	P
594.	Translucent honey suckle	Kanike	Lonicera quinquelocularis Hard.	Caprifoliaceae	B, C	Shrub	Mar – Jul	N
595.	Trichilia	Aankha taruwa	Trichilia connaroides (Wight & Arn.) Bentv.	Meliaceae	A, B, C	Tree	Apr – May	N – P
596.	Trumpet vine	Pushpa lata	Campsis grandiflora (Thunb.) K.Schum.	Bignoniaceae	A, B	Climber	May – Aug	N – P
597.	Tulasi	Tulsi	Ocimum sanctum L.	Lamiaceae	A, B, C	Herb	Aug – Oct	N – P
598.	Tulasi	Tulsi	Ocimum tenuiflorum L.	Lamiaceae	A, B, C	Herb	Aug – Oct	N – P
599.	Turnip	Salgam	Brassica rapa var. rapa L.	Brassicaceae	A, B, C	Herb	Feb – Apr	N – P
600.	Umbrella tree	Sigane	Schisandra grandiflora (Wall.) Hook.f. & Thomson	Schisandraceae	A, B, C	Shrub	Jan – Dec	N – P
601.	Verbana	Galaicha phul	Verbena hybrid Groenl. & Rumpler	Verbenaceae	A, B, C	Herb	All year	N – P
602.	Verbana	Galicha phul	Verbena officinalis L.	Verbenaceae	A, B, C	Herb	Apr – Jul	N – P
603.	Vikurum	Ghode khari	Viburnum spp.	Adoxaceae	A, B, C	Shrub	May – Jun	N – P

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604.	Voilet	Ghate phul	Viola odorata L.	Violaceae	A, B, C	Herb	Jun – Aug	N – P
605.	Voilet	Ghate phul	Viola tricolor L	Violaceae	A, B, C	Herb	Jun – Sep	N – P
606.	Walnut	Dante okhar	Juglans regia L.	Juglandaceae	A, B	Tree	Feb – May	P
607.	Water banyan	Kyamuna	Cleistocalyx operculatus (Roxb.) Merr. & L.M.Perry	Myrtaceae	A, B	Tree	Mar – Apr	N – P
608.	Water pennywort	Ghottapre	Hydrocotyle nepalensis Hook.	Araliaceae	A, B, C	Shrub	Jul – Sep	N – P
609.	Watermelon	Tarbuja	Citrullus vulgaris Schrad.	Cucurbitaceae	A, B	Climber	Mar – May	N – P
610.	Weeping willow	Bainsh	Salix babylonica L.	Salicaceae	A, B, C	Tree	Jan – Mar	N – P
611.	White melilot	Methi jhar	Melilotus alba Ledeb	Leguminosae	A, B, C	Herb	Mar – May	N – P
612.	White willow	Bainsh	Salix alba L.	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
613.	Wild amaranth	Latte	Amaranthus lividus L.	Amaranthaceae	A, B	Herb	Jul – Aug	N – P
614.	Wild cinchona	Kadam	Anthocephalus chinensis (La m.) Hassk.	Rubiaceae	A, B	Tree	Oct – Nov	N – P
615.	Wild date palm	Khajur	Phoenix sp.	Arecaceae	A, B	Shrub	May – Jul	N – P
616.	Wild osmanthus	Jhigani	Eurya accuminata DC.	Pentaphylacaceae	A, B	Shrub	Sep – Oct	N – P
617.	Wild pear	Mayal	Pyrus pashia Buch.-Ham. ex D.Don	Rosaceae	A, B, C	Tree	Feb – Apr	N – P
618.	Wild pomogranate	Darim	Punica nana L.	Lythraceae	A, B, C	Tree	Apr – Jun	N – P
619.	Wild rose	Gulaph	Rosa brunonii Lindl.	Rosaceae	A, B	Shrub	Apr – Jun	N – P
620.	Wild rose	Jangali gulaf	Rosa laevigata Michx.	Rosaceae	A, B	Shrub	Apr – Jun	N – P
621.	Wild rose	Jangali gulaf	Rosa moschata Herrm.	Rosaceae	A, B	Shrub	Jun – Jul	N – P
622.	Wild rose	Jangali gulaf	Rosa spp.	Rosaceae	A, B, C	Shrub	All year	N – P
623.	Wild turmeric	Ban haledo	Curcuma aromatica Salisb.	Zingiberaceae	A, B, C	Herb	Jun – Jul	N – P
624.	Willow	Bainsh	Salix acmophylla Boiss.	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
625.	Willow	Bainsh	Salix calyculatai Hook. f. ex Andersson	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
626.	Willow	Bainsh	Salix elegans Besser	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
627.	Willow	Bainsh	Salix excelsa S.G.Gmel.	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
628.	Willow	Bainsh	Salix fragilis L.	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
629.	Willow	Bainsh	Salix sikkimensis Andersson	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
630.	Willow	Bainsh	Salix spp.	Salicaceae	A, B, C	Tree	Feb – May	N – P
631.	Willow	Banish	Salix wallichiana Andersson	Salicaceae	A, B, C	Tree	Feb – Mar	N – P
632.	Willow Herb	Kupate jhar	Epilobium sp.	Onagraceae	A, B, C	Herb	Jun – Sep	N – P
633.	Winter green	Machino	Gaultheria fragrantissima Wall.	Ericaceae	B, C	Shrub	Apr – Jun	N – P
634.	Wondwort		Stachys melissifolia Benth.	Lamiaceae	A, B, C	Shrub	Jun – Sep	N – P
635.	Wooly oak	Baanjh	Quercus lanuginosa Lam..	Fagaceae	A, B, C	Tree	Jan – Apr	N
636.	Yellow flax	Pyawali	Reinwardtia indica Dumort.	Linaceae	A, B, C	Shrub	Nov – May	N – P
637.	Yellow melilot	Methi jhar	Melilotus parviflora Des f.	Leguminosae	A, B, C	Herb	May – Jul	N – P
638.	Yellow oleander	Pahelo kaner	Thevetia peruviana (Pers.) K.Schum.	Apocynaceae	A, B	Shrub	All year	N – P
639.	Yupland cotton	Kapas	Gossypium hirsutum L.	Malvaceae	A, B, C	Herb	Sep – Oct	N – P
640.	Zinnia	Taramukhi	Zinnia elegans L.	Compositae	A, B, C	Herb	Jun – Sep	N – P

** A: Sub-Tropical; B: Sub-Temperate; C: Temperate; ** Spr, Aut: Spring, Autumn; N: Source of nectar; P: Source of pollen. Sources: Kafle 1984, Thapa and Dangol 1990, Maskey 1992, Pratap 1992, Kafle 1992, ED 2001, Pratap 1997, Shukla 2000, Bista and Shivakoti 2000, Adhikari and Ranabhat 2011, DADO 2005, Bista 2005, Thapa and Pokhrel 2007.*

PLANT SOURCES PRODUCING HONEYDEWS BENEFICIAL TO HONEYBEES

Honeybee produces honey from the nectar collected from various plant resources. Generally honeybee forages on three types of plant sources to gather nectar: floral and extra-floral nectarines produced by flowering plants and honeydew, produced by some sucking insects from the plants. Honeydew is the sweet nutritious substances deposited at plant parts from the secretion by small plant-sucking insects. The plants sucking insects like, aphids, psyllids, scales, mealy bugs, etc puncture on phloem sap of plants, extract and feed the nutrients they require; while the reminder of the substances passes through their body to be deposited on plants' surface in small droplets. These deposited honeydew substances contain different sugars and other nutritious contents, which are utilized by different organisms, including honeybees. The honeydews having strong flavor, attract honeybees for foraging especially during the period when good source of nectar plants are not available. According to the studies, most of the honeys produced at higher altitudes contain higher composition of honeydews than at the lower altitudes (Joshi et al 2000). Most of the research works on honeydew plants are carried out at developed countries, while the plant sources and insect species mentioned on those studies are also available at Nepal. The authors as well as other researchers (Pratap 1997, Joshi et al 2000, Shukla 2000, Bista 2005, Adhikari and Ranabhat 2011, Pokhrel et al 2014) have also observed honeydew produced in many plant resources (especially in trees and large shrubs) at different parts of Nepal, but the insect species associated with production of honeydew are yet to be studied in detail. The compiled list of honeydew producing plant resources and the insect species related to it are presented in **Table** 2.

Table 2. Plant sources producing honeydew beneficial to honeybees along with associated insect species

SN	Common name	Scientific name	Family	Ecological belt (m)	Insect species associated for producing honeydew	Occurrence period
1.	Apple	Malus domestica Borkh.	Rosaceae	B, C	Aphis pomi De Geer (Aphididae)	Apr – Jul
					Psylla mali Schmidberger (Psyllidae)	Apr – Jul
					Macrosiphum rosae (L.) (Aphididae)	Apr – Jul
2.	Ash tree	Fraxinus floribunda Wall.	Oleaceae	B, C	Unidentified insect	Apr – May
3.	Barberry	Berberis aristata DC.	Berberidaceae	B, C	Unidentified insect	Mar – May
4.	Common larch	Larix decidua Mill.	Pinaceae	C	Cinara cuneomaculata (del Guer.) (Aphididae)	Jul – Oct
					Cinara kochiana (Borner) (Aphididae)	Jun – Nov
					Cinara laricis (Hartig) (Aphididae)	Jul – Oct
5.	Common oak	Quercus robur L.	Fagaceae	B, C	Kermes querus (L.) (Kermesidae)	April – Jun
					Lachnus iliciphilus (del Guericio) (Aphididae)	June
					Lachnus roboris (L.) (Aphididae)	May – July
					Thelexes dryiphila (Schrank) (Thelaxidae)	May – Oct
					Tuberculatus annulatus (Hartig) (Aphididae)	June – July
6.	False acacia	Robinia pseudoacaciai L.	Leguminosae	B, C	Aphis medicaginis Koch. (Aphididae)	Apr – Jul
					Parthenolecanium corni (Bouche) (Coccidae)	Apr – Jul
7.	Gooseberry	Phyllanthus emblica L.	Phyllanthaceae	A, B	Unidentified insect	Apr – Jun
8.	Himalayan cedar	Cedrus deodara (Roxb. ex D.Don) G.Don	Pinaceae	B, C	Unidentified insect	May – Jul
9.	Himalayan fir	Abies spectabilis (D.Don) Mirb.	Pinaceae	B, C	Unidentified insect	Apr – Jul
10.	Himalayan Hemlock	Tsuga dumosa (D.Don) Eichler	Pinaceae	B, C	Unidentified insect	May – Jul
11.	Himalayan Pine	Pinus wallichiana A.B.Jacks.	Pinaceae	B, C	Cinara eastopi (Pintera) (Aphididae)	Mar – May
12.	Himalayan spurce	Picea smithiana (Wall.) Boiss.	Pinaceae	C	Cinara comater (Doncaster) (Aphididae)	May – Jul
					Cinara sp. (Aphididae)	May – Jul
13.	Jambolan	Syzygium cumini (L.) Skeels	Myrtaceae	A, B, C	Unidentified insect	Apr – May
14.	Jerusalem pine	Pinus halepensis Mill.	Pinaceae	A, B	Marchalina hellenica (Genna.) (Margarodidae)	Jun – Mar
15.	Juniper	Juniperus sp.	Cupressaceae	B, C	Unidentified insect	Apr – Jun
16.	Maize	Zea mays L.	Poaceae	A, B, C	Unidentified insect	Jul – Aug

SN	Common name	Scientific name	Family	Ecological belt (m)	Insect species associated for producing honeydew	Occurrence period
17.	Mango	Mangifera indicia L.	Rosaceae	A, B	Unidentified insect	Feb – Apr
18.	Pine	Pinus roxburghiii Sarg.	Pinaceae	B, C	Unidentified insect	Feb – Apr
19.	Poplar	Populus alba L.	Salicaceae	B, C	Chaitophorus populeti (Panzer) (Aphididae)	May – Jun
					Pterocomma salicia (L.) (Aphididae)	May – Jun
					Pachypappa vesicalis Koch. (Aphididae)	May – Jun
20.	Poplar	Populus nigra L.	Salicaceae	B, C	Chaitophorus populeti (Panzer) (Aphididae)	May – Jun
					Pterocomma salicia (L.) (Aphididae)	May – Jun
					Pachypappa vesicalis Koch. (Aphididae)	May – Jun
21.	Poplar	Populus tremula L.	Salicaceae	B, C	Chaitophorus populeti (Panzer) (Aphididae)	May – Jun
					Pterocomma salicia (L.) (Aphididae)	May – Jun
					Pachypappa vesicalis Koch. (Aphididae)	May – Jun
22.	Raspberry	Rubus ellipticus Sm.	Rosaceae	A, B, C	Unidentified insect	Feb – Apr
23.	Scotch pine	Pinus sylvestris L.	Pinaceae	B, C	Cinara cembrae (Seitner) (Aphididae)	Jul – Sept
					Cinara nuda (Mordvilko) (Aphididae)	Jun – Jul
					Cinara pinea (Mordvilko) (Aphididae)	Jun – Jul
					Marchalina hellenica (Genna.) (Margarodidae)	Jun – Mar
					Schizolachnus pineti F. (Aphididae)	Jun – Mar
24.	Sugarcane	Saccharum officinarum L.	Poaceae	A, B	Melanaphis sacchari (Zehntner) (Aphididae)	Sept – Oct
					Perkinsiella saccharicida Kirkaldy (Delphacidae)	Sept – Oct
					Unidentified insect	Sept – Oct
25.	Tallow	Sapium insigne (Royle) Trimen	Salicaceae	A, B, C	Unidentified insect	May – Jul
26.	White willow	Salix alba L.	Salicaceae	B, C	Tuberolachnus salignus (Gmelin.) (Aphididae)	Apr – Jul
					Pterocomma salicia (L.) (Aphididae)	Apr – Jul

** A: Sub-Tropical; B: Sub-Temperate; C: Temperate. Sources: Pratap 1997, Joshi et al 2000, Shukla 2000, Bista 2005, Adhikari and Ranabhat 2011, Pokhrel et al 2014.*

PLANT SOURCES PRODUCING TOXIC NECTAR AND POLLEN UTILIZED BY HONEYBEES

Honeybees obtain nectar, pollen or both from flowers which is necessary for their survival. They continuously visit the flowers as long as these are available in nature. The visit of most of the insects including honeybees is governed by certain behavioral cues, by which they are attracted to flowers, whatever the status of nectar may be. But the entire flowers that honeybee visit may not be beneficial to them. Nectar or pollen of certain flowers may be poisonous to honeybees or degrade the quality of honey they process. Sometimes considerable numbers of dead or paralyzed honeybees are observed at the field, which resembles with pesticide poisoning, but that may be due to toxicity of nectar or pollen that honeybees forages upon. This poisoning is caused by certain sugar constituents (especially mannose) that the honeybees can absorb but their body system is unable to metabolize. Honeybees often display flower fidelity character, by which they tends to forage on same flower species. In such situation, the toxic substances accumulate above the critical level which ceases the flight activities of honeybees and ultimately caused death. Similarly, in some cases, the honeybees' forages on some plant species secreting poisonous nectar, which are not harmful to honeybees, but this nectar degrade the honey quality and cause toxicity to human beings. The commonly known grayanotoxin (caused by andromedotoxin, acetylandromedol, rhodotoxin) toxicity instigated by the nectar of certain species of *Rhododendron*, *Kalmia* genuses plants are some of the examples. There are other plant genuses as well which are reported to be poisonous to livestock, but their toxicity to honeybee and honey are unknown. Some of the plant sources secreting toxic nectar in varying degree are mentioned by various authors (Kafle 1992, Pratap 1997, Bista and Shivakoti 2000, Shukla 2000, Bista 2005, Adhikari and Ranabhat 2011, Adhikari 2012, Pokhrel et al. 2014) in their studies, but the amount of substances and their nature of toxicity are yet to be analysed. The list of plant sources producing nectar or pollen toxic to honeybees and human beings are given in Table 3.

Table 3. Plant sources producing toxic nectar or pollen utilized by honeybees

SN	Common name	Scientific name	Family	Ecological belt (m)	Flowering period	Poisoning substance
Plant sources producing nectar or pollen toxic to honeybees						
1	Black henbane	Hyoscyamus niger L.	Solanaceae	C	May – Sep	Alkaloids: Hyocyamine, Hyoscine, Atropine
2	Black nightshade	Solanum nigrum L.	Solanaceae	A	May – Oct	Solanine toxin in pollen
3	Foxglove	Digitalis purpurea L.	Plantaginaceae	B	Jun – Sep	Pollen poisonous
4	Marsh marigold	Caltha palustris L.	Ranunculaceae	B, C	May – Aug	
5	Monkshood	Aconitum spp.	Ranunculaceae	A, B, C	Jun – Sep	Diterpenoid alkaloids - Aconitine
6	Opium poppy	Papaver somniferum L.	Papaveraceae	A, B, C	Apr – May	Stigmatal exudate
7	Tea	Camellia oleifera Abel	Theaceae	A, B, C	Sep – Nov	Nectar toxic
8	Tobacco	Nicotiana tabacum L.	Solanaceae	A, B, C	Jul – Sep	Nicotine, Nornicotine, Basine
Honey produced from plant sources toxic to human beings						
1		Maesa chisia Buch.-Ham. ex D. Don	Primulaceae	A, B, C	Mar – Apr	
2	Alpine rose	Rhododendron anthopogon D. Don	Ericaceae	C	May – July	Andromedotoxin, Acetylandromedol, Rhodotoxin
3	Alpine rose	Rhododendron cinnabarinum Hook. f.	Ericaceae	C	May – Jun	Andromedotoxin, Acetylandromedol, Rhodotoxin
4	Alpine rose	Rhododendron ponticum L.	Ericaceae	B, C	May – Oct	Andromedotoxin, Acetylandromedol, Rhodotoxin
5	Cactus spurge	Euphorbia royleana Boiss.	Euphorbiaceae	A, B, C	Apr – Jul	Diterpene esters
6	Deadly nightshade	Atropa belladonna L.	Solanaceae	B, C	Aug – Sep	Atropine (Alkaloid)
7	Himalayan pieris	Pieris formosa (Wall.) D. Don	Ericaceae	B, C	Mar – May	
8	Horse chestnut	Aesculus indica (Wall. ex Cambess.) Hook.	Sapindaceae	A, B, C	May – Jun	Saponins
9	Lyonia	Lyonia ovalifolia (Wall.) Drude	Ericaceae	B, C	Feb – Apr	Luteolin, Apigenin
10	Monkshood	Aconitum sp.	Ranunculaceae	B, C	Jun – Sep	Aconitine
11	Mountain laurel	Kalmia latifolia L.	Ericaceae	B, C	May – Oct	Andromedotoxin, Acetylandromedol, Rhodotoxin
12	Opium poppy	Papaver sp.	Papaveraceae	A, B, C	Apr – May	
13	Prickly poppy	Argemone mexicana L.	Papaveraceae	A, B, C	May – Jun	Berlambine, Neprotin
14	Prinsepia	Prinsepia utilis Royle	Rosaceae	B, C	Oct – Nov	Prinsepoil
15	Strawberry tree	Arbutus unedo L.	Ericaceae	C	Autumn	Arbutin (glucoside)

**A: Sub-Tropical; B: Sub-Temperate; C: Temperate. Sources: Kafle 1992, Pratap 1997, Bista and Shivakoti 2000, Shukla 2000, Bista 2005, Adhikari and Ranabhat 2011, Pokhrel et al 2014.*

WAY FORWARD

The inventory of flowering plants mentioned as honeybee flora in this report is only a preliminary effort compiled from different published documents; however there are far more number of flowering plants available at Nepal at different altitudes and ecological zones, which are more likely to be beneficial for honeybees and beekeeping. The availability of these resources in particular region is very important, and the research studies should be directed towards this. The findings will be of great help in sustainable utilization of these natural resources. Also, some of the useful plants may be endangered or in the verge of extinction due to injudicious use by local users. Generally the economically important resources in particular places are declining in number due to over exploitation, and also the habitats of some of these plants are continuously destroyed knowingly or unknowingly leading to extinction. This may be obvious because of high grazing by domesticated or wild animals, deforestation, forest fire, ignorance of local people, etc. This will also lead to less number of pollinating organisms including honeybees in any habitat which in return will negatively affect the fertilization process of plant resources. Research studies are the only means to identify these issues at local level and could uncover the awareness strategies for conservation programs, and by which these gaps could be addressed by the policy makers and planners at the national level to solve the problems. Some of the example as plantation programs with multipurpose plant resources at road-side, community or religious forests or even at rural or urban areas can be one of the models.

The availability of flowering plants in a region and their maximum utilization by honeybees is the major aspect for successful beekeeping. The flowering plants secret nectar or pollen (also resin, honeydews as minor source) for particular days and also during the specific time of the day. There may be hundreds of flower visitors ranging from different insect species to other arthropods to birds to higher mammals like bats relying upon these resources. Honeybees are also one of them, and their visits depend upon various factors like their foraging behavior, availability and quality of the resources, climatic conditions, etc. Also the foraging range and preferences by honeybees are important. All the flowering plants are not visited by honeybees and they show particular floral preferences as per the quality of the resources secreted by the flowers. Also, the hive bees prefer to forage on flowering plants closer to their colonies (normally 300 to 800 m) as the nectar or pollen from distant sources will have less value for honeybees and beekeeping. However, the honeybees being a highly social organism, utilize these resources for themselves as well as to carry on their generation, while most of other flower visitors utilizes for individual survival. The detail studies on the existing flowering plants in a region are imperative to harness these natural resources for the development of beekeeping and also to conserve the plant resources in natural conditoin. The knowhow on botany of the flowering plants, quality and quantity of nectar and pollen produced as well as their availability in different time of the day could be utilized to prepare a honeybee floral calendar of particular region. This information will be helpful for determining the carrying capacity of the particular region, colony migration planning and preparing advocacy for plantation programs.

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Status of Invasive Alien Plant Species in Nepal

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ABSTRACT

Biological invasion, a major component of human-induced global environmental changes, is a direct outcome of human movement and trade across continents. With globalization of trade and human movement, the number of alien species has been increasing in all continents and climatic regions. The negative impacts of biological invasion have been considered significant in countries from under-developed to developed economy. In Nepal at least 179 alien plant species has established their self-replacing population (ie naturalized), and among them 26 species, mostly native of tropical Americas, has been reported to be invasive with negative impacts on environment including agriculture production. Four of them (*Lantana camara, Mikania micrantha, Chromolaena odorata* and *Eichhornia crassipes*) are among the 100 of the world's worst invasive alien species. The number of invasive alien plant species (IAPS) is lower in western Nepal than in central and eastern Nepal. Tarai, Siwalik and Middle Mountain (Mid Hill) regions harbor high number of IAPS. A few species are also found in High Mountain while none of the IAPS has been reported from High Himal. The number of IAPS decline with increasing elevation. *Ageratina adenophora*, *Lantana camara, Chromolaena odorata* and *Mikania micrantha* are most problematic in forests and shrublands; *Parthenium hysterophorus* in grasslands and residential areas; *Ageratum houstonianum* and *Alternanthera philoxeroides* in agroecosystems; and *Eichhornia crassipes* in wetlands. The negative impacts of biological invasion appear to be increasing in Nepal but the national policy and management responses seem inadequate. There is a need to prepare a National Strategy for the Management of Invasive Alien Species to effectively harmonize sectoral and cross-sectoral programs for the timely management of this emerging problem.

Keywords: Elevation gradient, land use types, naturalized species

INTRODUCTION

Biological invasion, a major component of human-induced global environmental changes, is a direct outcome of human movement and trade across continents. It is one of the leading causes of biodiversity loss (population decline to species extinction) (Bellard et al 2016, Downey and Rirchardson 2016) and economic damages (Born et al 2005). Generally dispersal of organism is prevented by natural biogeographical barriers such as ocean, large desert, high mountains etc. For example dispersal of terrestrial organisms from Americas to Asia is naturally impossible due to presence of vast expanse of ocean between these two continents. Such natural biogeographic barriers have been overcome by intentional and accidental introduction of organisms from one continent to another by human (Boivin et al 2016). A large number of plants (agricultural and ornamental plants) and animals (livestock and pet animals) have been introduced outside their native distribution range intentionally by humans for centuries where they are considered as 'alien'. Fortunately, majority of these introduced plants and animals have not spread beyond cultivation and domestication; these alien species are considered as 'casual' (Pysek et al 2004). However, a small number of these organisms, together with similar fraction of accidentally introduced organisms (eg weeds contaminating grain lots, rat hitch-hiked by sheep) have escaped to the nature and established self-replacing populations; they are considered as 'naturalized' (Pysek et al 2004). A subset of naturalized species has spread so rapidly and extensively that they have imparted significant negative impacts on biodiversity, ecosystem, infrastructure, human health and economy in the introduced range; these species are called invasive alien species (Pysek et al 2004).

With increasing globalization of trade and human movement, the number of alien species has been increasing in all continents and climatic regions without any sign of saturation (Seebens et al 2017), including in high mountains and polar regions (Pauchard et al 2016). At least 13,168 species of plants have become naturalized elsewhere in the world outside their native distribution range (van Kleunen et al 2015). Similar data for animals and other taxonomic groups is, however, lacking. With worldwide increase in the number of naturalized species, the negative impacts of biological invasion has been considered equally significant in countries with under-developed to developed economy. For example, agriculture sector of USA and China is under high threat of invasion by insect pests and pathogens with high economic cost in absolute term while the developing countries like Nepal, Bangladesh are also among the countries with high risk of biological invasion in agriculture sector (Paini et al 2016).

Biological invasion in Nepal has also emerged as a challenging problem in biodiversity conservation, ecosystem services flow, and agriculture production (MoFSC 2014). Physiographic and climatic diversity of Nepal is not only supporting wide spectrum of organisms and ecosystems but also providing potential suitable habitats for the species native to anywhere in the world.Furthermore, there is huge imbalance in Nepal's international trade with import to export ratio at about 11 (calculated for fiscal year 2015/2016 from the data available from Trade and Export Promotion Center – www.tepc.gov.np; retrieved on 3 June 2017). Food security and agriculture sector is also increasingly more dependent on imported agriculture products, seeds and seedlings/plantlets. Due to these scenarios, Nepal's agriculture sector has been ranked third among the most threatened countries out of the 124 countries assessed (Paini et al 2016). To address the emerging threat of invasive alien species, Nepal's National Biodiversity Strategy and Action Plan 2014-2020 has targeted a number of activities including impact assessments of selected invasive alien plant species (IAPS) and release of biological control agents against IAPS (MoFSC 2014). In this communication, we are presenting a brief overviewof the diversity and distribution of IAPS in Nepal.

STATUS

Scientific documentation of invasive alien plant species (IAPS) in Nepal dates back to 1958 when ML Banerji published a paper 'Invasion of *Eupatorium glandulosum* in east Nepal' (Poudel and Thapa 2012). Since then, nearly a dozen of research works were undertaken until 2000 which were mostly focused on ecology of a few IAPS. In this period, there was no effort to document the diversity of IAPS in Nepal. The first nation-wide assessment of the IAPS was undertaken by IUCN Nepal which led to a publication in 2005 with a risk assessment of 21 IAPS and a list of 166 alien species naturalized in Nepal (Tiwari et al 2005). This publication stimulated interest on biological invasion among researchers, managers and policy makers. In recent years, the lists of IAPS and naturalized species have been frequently updated based on publications and field researches (Siwakoti 2012, Shrestha 2016).

The numbers of invasive and naturalized plant species have been reported variously in scientific publications. This has created a lot of confusions among researchers, managers and policy makers. For example, all 'naturalized' plant species has been defined as 'invasive plant species' by Bhattarai et al (2014) without considering a well-established notion that only a subset of naturalized species are invasive (Pysek et al 2004). Many of the species of 'pantropical distribution' have been included in the list of naturalized plant species of Nepal by Tiwari et al (2005) and Siwakoti (2012). Since exact native distribution range of such species is currently unknown, their inclusion in the list of naturalized plant species of Nepal is ambiguous unless there is clear evidence that they were introduced by human. Considering above mentioned limitations, an effort has been made to update the list of naturalized plant species of Nepal which is going to be published soon by Global Register of Introduced and Invasive Species (www.griis.org). According to this updated list, at least 179 species of alien plants have been naturalized in Nepal (unpublished data, BB Shrestha). Majority of naturalized plant species are native of Americas (74%) followed by Europe (8%) (Bhattarai et al 2014).

The list of IAPS has been also updated periodically. Tiwari et al (2005) reported 21 plant species as invasive in Nepal. Recently, Shrestha (2016) has reported 25 species as invasive with the addition of four species to the list of Tiwari et al (2005). Further review of literature (Ranjit et al 2010) and field observations by one of the authors (Jagat D Ranjit) revealed that another alien plant species *Spergula arvensis* has been spreading rapidly in hill agriculture of the central Nepal (eg Parbat, Baglung, Kaski, Myagdi) increasing labor input to weeding and reducing wheat, winter vegetable and legume production. A native of Europe (http://www.brc.ac.uk/plantatlas/index.php?q=node/386; accessed on 4 June 2-17), herbarium specimen of this weed was first collected in Nepal from west in 1952 and reported by Hara and Williams (1979). Therefore, *S. arvensis* can also be considered as 'invasive' and we have included this weed in the list of IAPS in Nepal (**Table** 1).

Table 1. Invasive alien plant species (IAPS) in Nepal

SN	Common name	Local name	Name of IAPS	Family	Native range	First Report
1.	Alligator weed	Jala jambhu,	Alternanthera	Amaranthaceae	South America	1994

SN	Common name	Local name	Name of IAPS	Family	Native range	First Report
		Patpate	philoxeroides (Mart.) Griseb.			
2.	Billygoat	Raunne/Gandhe	Ageratum conyzoides (L.) L.	Asteraceae	C & S America	1910
3.	Black jack/Hairy Beggar-tick	Kalokuro	Bidens pilosa L.	Asteraceae	Tropical America	1910
4.	Blue Billygoat Weed	Nilogandhe	Ageratum houstonianum Mill.	Asteraceae	Mexico & C America	?
5.	Broadleaf bottonweed	Alu Pate Jhar	Spermacoce alata Aubl.	Rubiaceae	West Indies and Tropical America	
6.	Bush morning-Glory	Besaram	Ipomoea carnea ssp. fistulosa (Mart. ex Choisy) D.F. Austin	Convolvulaceae	Mexico, C & S America	1966
7.	Bushmint	TulsiJhar	Hyptis suaveolens (L.) Poit.	Lamiaceae	Tropical America	1956
8.	Coffee Senna	Panwar	Senna occidentalis (L.) Link.	Caesalpiniaceae	Tropical America	1910
9.	Corn spurry	Thangnejhar	Spergula arvensis L.	Caryophyllaceae	Europe	1952
10.	Crofton weed	KaloBanmara	Ageratina adenophora L.	Asteraceae	Mexico	1952
11.	Karwinsky's Fleabane	PhuleJhar	Erigeron karvinskianus DC.	Asteraceae	Mexico & C America	?
12.	Lantana	Kirnekanda	Lantana camara L.	Verbenaceae	C & S America	1848
13.	Mexican poppy	Thakal	Argemone mexicana L.	Papaveraceae	Tropical America	1910
14.	Mile-a-minute weed	Laharebanmara	Mikania micrantha Kunth	Asteraceae	C & S America	1963
15.	Parrot's feather		Myriophyllum aquaticum (Vell.) Verdc.	Holaragaceae	South America	?
16.	Parthenium	Patijhar	Parthenium hysterophorus L.	Asteraceae	Southern USA to S America	1967
17.	Purple wood sorel	Chari amilo	Oxalis latifolia Kunth	Oxalidaceae	C and S America	1954
18.	Rough cockle-Bur	Bhede kuro	Xanthium strumarium L.	Asteraceae	America	1952
19.	Sensitive plant	Lajjawati	Mimosa pudica L.	Mimosaceae	Mexico to S America	1910
20.	Shaggy Soldier	JhuseChitlange	Galinsoga quadriradiata Ruiz & Pav.	Asteraceae	Mexico	?
21.	Siam weed	SetoBanmara	Chromolaena odorata (L.) R.M.King & H.Rob.	Asteraceae	Mexico, C & S America	1825
22.	Sickle pod senna	Tapre	Senna tora (L.) Roxb.	Caesalpiniaceae	South America	1910
23.	Southern Cut grass	Karaute ghans, Navo dhan	Leersia hexandra Sw.	Poaceae	Tropical America	1820
24.	Spiny pigweed	Kandelude	Amaranthus spinosus L.	Amaranthaceae	Tropical America	1954
25.	Water hyacinth	Jalkumbhi	Eichhornia crassipes (Mart.) Solms	Pontederiaceae	South America	1966
26.	Water lettuce	Kumbhika, Panibanda	Pistia stratiotes L.	Araceae	South America	1952

Four of the 26 species of IAPS (*Lantana camara, Mikania micrantha, Chromolaena odorata* and *Eichhornia crassipes*) are among the 100 of the world's worst invasive alien species (Lowe et al 2000). This list of 100 species also includes *Leucaena leucocephala* (Lam.) de Witt (common name: leucaena, wild tamarind; local name: Ipillpil) which was introduced as fodder plant to tropical region worldwide including Nepal (Jackson 1994). A tree native to Mexico region, it has escaped to natural ecosystem in the introduced range (eg Asia, Australia) and can form mono-specific stands replacing other species (Sankaran and Suresh 2013). At the sites of introductions in Nepal, this alien tree is regenerating well with high chances of being invasive to natural ecosystems in near future (BB Shrestha, personal observation 2017).

Ageratum houstonianum Mill. (Nilo gandhe)

Alternanthera philoxeroides (Mart.) Griseb. (Patpate)

Erigeron karvinskianus DC. (Phule jhar)

Oxalis latifolia Kunth (Chari amilo jhar)

Parthenium hysterophorus L. (Pati jhar)

Spergula arvensis L. (Thangne jhar)

Figure 1. Emerging invasive alien plant species of agro-ecosystems in Nepal (Photo: *Alternanthera philoxeroides* by Kusum Pokharel, *Spergula arvensis* by JD Ranjit, all others by BB Shrestha).

DISTRIBUTION

Distribution pattern of naturalized and invasive alien plant species (IAPS) in Nepal appears to be linked with climate of their native region and routes of international trades of Nepal. With majority of the IAPS being native of tropical Americas, their number is also high in the southern lowland (Tarai and Siwalik) with tropical to subtropical climate (Tiwari et al 2005, Shrestha et al 2016). Middle Mountain region with subtropical to temperate climate also has high number of IAPS. Only a few IAPS (eg *Ageratina adenophora* (Spreng.) R.M.King & H.Rob., *Galinsoga quadriradiata* Ruiz & Pav.) has been reported from High Mountains while the High Himal region has remained free from IAPS until now (Shrestha et al 2016, Siwakoti et al 2016). Species richness of IAPS across vegetation types also decline with increasing elevation and the species reaching to the highest elevation (>3000 masl) is *Ageratina adenophora* (BB Shrestha, personal communication 2017). Number of both naturalized species and IAPS are higher in eastern and central Nepal than in west (Bhattarai et al 2014). At least a few IAPS first invaded eastern Nepal and they are gradually spreading westward. For example, *Mikania micrantha* (L.) Willd. is absent and *Chromolaena odorata* (L.) R.M.King & H.Rob. is present only at a few locations in western Nepal (Poudel 2016) whereas both these species are major invasive weeds in eastern and central Nepal (Tiwari et al 2005).

Majority of the IAPS are already widespread while a few are still confined to a limited geographic area (eg *Myriophyllum aquaticum* only in Kathmandu valley, Tiwari et al 2005). They are invading a wide range of land use types (**Table** 2). *Ageratina adenophora*, *Lantana camara, Chromolaena odorata* and *Mikania micrantha* are the most problematic in forests and shrublands; *Parthenium hysterophorus* in grasslands and residential areas; *Ageratum houstonianum* and *Alternanthera philoxeroides* in agroecosystems; and *Eichhornia crassipes* in wetlands.

Table 2. Major invasive alien plant species invading different land use types

Land use types	**Major invasive alien plant species**
Forests and shrublands	Ageratina adenophora, Chromolaena odorata, Hyptis suaveolens, Lantana camara, Mikania micrantha
Grasslands and residential areas	Amaranthus spinosus, Bidens pilosa, Parthenium hysterophorus, Senna tora, S. occidentalis, Spermacoce alata, Xanthium strumarium
Agroecosystems	Ageratum houstonianum, A. conyzoides, Alternanthera philoxeroides, Argemone mexicana, Erigeron karvinskianus, Galinsoga quadriradiata, Mimosa pudica, Oxalis latifolia, Parthenium hysterophorus, Spergula arvensis
Wetlands	Alternanthera philoxeroides, Eichhornia crassipes, Ipomoea carnea spp. fistulosa, Leersia hexanda, Myriophyllum aquaticum, Pistia stratiotes

Agroecosystem has relatively a high number of invasive alien plant species. Some species like *Ageratum conyzoides, Galinsoga quadriradiata, Mimosa pudica* and *Bidens pilosa* are palatable to livestock, and therefore these species are not being considered as problematic by farmers in subsistence farming systems in which farming is integrated with livestock rearing. Species having toxicity and/or low palatability, such as *Ageratum houstonianum*, *Alternanthera philoxeroides*, *Erigeron karvinskianus*, *Oxalis latifolia*, *Parthenium hysterophorus*, *Pistia stratiotes*, etc have been considered highly troublesome by farmers (Ranjit et al 2013, Ranjit 2013, ICIMOD 2016, Siwakoti et al 2016). These species can easily over-compete the crops if there is no weeding frequently (**Figure** 2).

A.

B.



C.


D.

Figure 2. Croplands invaded by invasive alien plant species. A) Paddy field invaded by *Alternanthera philoxeroides* in Khumaltar, Lalitpur (Photo: JD Ranjit), B) Black gram field in Kaski invaded by *Ageratum houstonianum* (Photo: BB Shrestha) C) Wheat field invaded by *Spergula arvensis* in Phalebas, Parbat (Photo: JD Ranjit) D), Rice field invaded by *Pistia stratoites* in Dhikure, Nuwakot (Photo: JD Ranjit)

CONCLUSION AND WAY FORWARD

At least 179 species of alien plant species are naturalized in Nepal and 26 of them have become invasive with negative impacts on environment and economy. There is a need to prepare a national working list of naturalized and invasive alien plant species to avoid existing ambiguity on defining them. The number of invasive alien plant species decline from east to west and from lowland to high mountains. Most of the land use types in Tarai, Siwalik and Middle Mountain regions are being invaded by some invasive alien plant. The negative impacts of biological invasion on biodiversity, natural ecosystems, agriculture and economy appear to be increasing in Nepal but the national policy and management responses seem to be inadequate.

The biological invasion is likely to increase continuously in foreseeable future with increasing volume and diversity of merchandise being imported into Nepal. Due to open border and less effective quarantine (weed pest) in Nepal-India border, any exotic species established in India can spread into Nepal sooner or later. Therefore, though prevention is the first line of defense against invasive alien species, it is less likely to be achieved. Practical approaches for management of invasive alien plant species, particularly in agriculture sector, may include 1) periodic assessment of naturalized plant species for their invasiveness and preparation of prioritized list of invasive alien species for management; 2) early detection and eradication of populations of new invasive alien plant species; 3) preparation of field guide and public education materials for identification; 4) preparation of species-specific weed management guidelines for priority species; and 5) economic assessment of the impact and management of invasive alien species. At the top of these activities, there is a need to prepare a National Strategy for the Management of Invasive Alien Species to effectively harmonize sectoral and cross-sectoral programs including release of biological control agents for high-risk species. Management could be effective when community become aware to those species and take preventive measures.

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Host Plant Species: Diversity, Distribution and Importance in Crop Pest Epidemiology

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ABSTRACT
The damage of pests on major host is significantly higher than in minor host. In the absence of host plants, pathogen may survive in alternative host, in alternate host, as resting spores, or in the host parts. Depending on pathogen species and ecological conditions, an alternate host may have different functions for the plant disease epidemics and pathogen variations. The role of alternate host for diseases epidemiology in Nepal is under study. Similarly, there have a number of key insect pests in vegetable, cereal, commercial and fruit crops have been listed in wide range of host plant as major, minor and alternate host depending upon their survival in different climatic condition. For diseases/pest management, eradication of alternate host plants works best in such regions where alternate hosts are essential for the diseases but like Nepal where alternate hosts are native and major member of plantations, eradication may not be feasible and ecologically sound and may apply other means of diseases management such as fungicide application on alternate hosts around the hosts plants or cultivation of resistant variety around the alternate hosts.

Keywords: Alternate host, epidemiology, major host, minor host

INTRODUCTION

Any plant species that is invaded by a parasite from which the parasite obtains nutrients are called host plants (Agrios 2005). In the absence of host plants, pest may survive in alternative host, in alternate host, as resting spores, or in the host parts. Alternative hosts are other plants that can become infected with the same pathogen, but are not required completing the pathogen's life cycle but alternate host is a plant other than the principal host, that is needed for a pathogen to complete its life cycle. The roles of the alternate hosts in disease epidemiology and pathogen variation vary greatly from species to species and from region to region because of different climatic and cropping conditions (Zhao et al 2016) Most of the insects are polyphagous. If they do not find major host or if the host is not available they feed on the crops found in the vicinity. Major host is more preferable to the plant than the minor hosts.

HOST PLANT SPECIES IN NEPAL

An attempt is made to explore information about economically important few agricultural pests of crops and their host in Nepal. Although it is difficult to distinguish the major and minor hosts of insect pests, they are broadly categorized based on the information found in literature.

Major and Alternate Hosts ff Disease

Different plants may serve as an alternate host for different pathogen such as *Berberis* spp., is an alternate host for wheat yellow and black rust as well as barley black rust; *Thalictrum* spp. and *Isopyrum* spp. are the alternate host of wheat leaf rust; *Ornithogalum* spp., *Dipcadi* spp. and *Leopoldia* spp. are the alternate host of barley leaf rust and *Oxalis* spp. is an alternate host of maize common rust (Table 1).

Table 1. Name of crop diseases with their major host and alternate host

SN	Disease	Pathogen Name	Major host	Alternate host
1	Black rust	Puccinia triticiana Erikss	Wheat (*Triticum aestivum* L.) (Mahto 2015)	*Berberis* spp. (Schumann and Leonard 2000)
2	Black rust	Puccinia graminis Pers	Barley (*Hordeum vulagare* L.) (Manandhar et al 2016)	*Berberis* spp. (Schumann and Leonard 2000)
3	Common rust	Puccinia sorghi Pers	Maize (*Zea mays*) (Subedi 2015)	*Oxalis spp.* (Upadhyay et al 2009)
4	Leaf rust	Puccinia recondita f.sp. tritici. Erikss & Henn	Wheat (*Triticum aestivum L.*) (Neupane et al 2013)	*Thalictrum speciosissimum* and *Isopyrum fumaroides* (Bolton et al 2008)

SN	Disease	Pathogen Name	Major host	Alternate host
5	Leaf rust	Puccinia hordei G.H. Otth	Barley (*Hordeum vulagare* L.) (Amgai et al 2016)	*Ornithogalum brachystachys*, *O. trichophyllum*, *Dipcadi erythraeum* and *Leopoldia eburnean* (Guerra 2016)
6	Yellow rust	Puccinia striiformis f. sp. tritici (Pst) Westend	Wheat (*Triticum aestivum L.*) (Sharma et al 2015)	*Berberis* or *Mahonia* spp. (Chen et al 2014)

Figure 1. *Barberis* plant

Figure 2. Aecial cup formaion on *Barberis* leaf

Figure 3. *Mahonia* spp.

Figure 4. *Mahonia* spp.

Figure 5. Oxalis spp.

Higher diversity and distribution of *Berberis spp*., *Mohania* spp. (NEHHPA 2017), *Thalictrum* spp., *Oxalis* spp. (Dangol 2017) etc were reported in Nepal. In Nepal, 32 species and more than 8 varieties of Berberis are found from 600 to 3000 masl (NEHHPA 2017) but the role of alternate host for diseases epidemiology in the contest of Nepal is under study. In general, an alternate host enables a rust pathogen to survive winter, provides inoculums to initiate disease development on cereal crops, generates new races, and diversifies rust populations (Zhao et al 2016). A single barberry plant can produce as many as 64 billion aeciospores and have chance to create genetic variations in the fungal population by completing the sexual cycle whereas barberry eradication has had significant positive effects on the control of stem rust epidemics in USA (Schumann and Leonard 2000) but it is not feasible because of the loss of biodiversity.

Major and Minor Hosts of Insect Pests

There are a number of key pests which causes major economic damages to our crops. Some of the key pests of major agricultural pests and their major and minor hosts are given in the **Table** 2.

Table 2. List of major and minor hosts of some key insect pests of Nepal.

SN	Pests	Major hosts	Minor/Alternate hosts
1	Yellow rice stem borer *Scirpophaga incertulas* Walker	*Oryza sativa* L. (Paneru and Giri 2011)	*Oryza nivara* Sharma & Shastry, *O. rufipogon* (Chen and Romena 2016)
2	Chafer beetle *Phylophaga rugosa* Harris	*Sorghum bicolor* L., *Eleusine coracana* Gaertn, *Oryza sativa* L. (CABI 2006)	*Pennisetum purpureum* Schumach (CABI 2006)
3	Tomato fruit worm *Helicoverpa armigera* Hubner	*Abelmoschus esculentus* L., *Arachis hypogaea* L., *Cajanus cajan* L., *Lycopersicon esculentum* L., *Solanum melongena* L. , *Vigna unguiculata* L. and *Zea mays* Grassenfamilie (CABI 2007).	*Vitis vinifera* L., *Amaranthus spp* L., *Datura spp* L. (Voros 1996)
4	Cucumber fruit fly (*Bacterocera cucurbitae* Coquillett*)*	*Lagenaria siceraria* Standl, *Trichosanthes cucumerina var. anguina* L., *Cucumis sativus, Cucurbita moschata* L., *Momordica charantia* L., *Prunus persica* L. and *Psidium guajava* L. (Cheraghian 2014)	*Cyphomandra betacea* Sendtn, *Lycopersicon esculentum* L., *Mangifera indica* L., *Artocarpus heterophyllus* Lam. (Cheraghian 2014)
5	Brinjal fruit and shoot borer *Leucinoides orbonalis* Guenee	*Solanum melongena* L. (Paneru and Giri 2011)	*Solanum nigrum* L., *S. indicum* L., *S. torvum* L., *S. myriacanthum* L. *and solanum tuberosom* L. (Isahaque and Chaudhuri 1983)

WAY FORWARD

For diseases management, eradication of alternate host plants works best in such regions where alternate hosts are essential for the diseases but like in Nepal where alternate hosts are native and major member of plantations, eradication may not be feasible and ecologically sound. Thus one may apply other means of diseases management such as fungicide application on alternate hosts around the host plants or cultivation of resistant variety around the alternate hosts.

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Discussion Session

Documented by Hari Bahadur KC, Shanta Karki and Mahadev Paudel

Workshop title: *2nd National Workshop on Conservation and Utilization of Agricultural Plant Genetic Resources (CUAPGR) in Nepal*
Total participants: *75*
Theme: *Agrobiodiversity for securing our lives*

A. Technical Session 1: Conservation and Utilization

The first technical session was chaired by the Joint Secretary Mr Suresh Babu Tiwari. In this session ten papers were presented as per the program schedule. This session was mainly focussed on the principles and practices of the conservation and utilization of APGRs in Nepal. This session also highlighted the status of conservation and utilization of APGRs in Nepalese agricultural development. The papers also highlighted the experiences of DoA, Genebank, LI-BIRD, etc on the conservation and utilization activities in Nepalese context.

List of presentations

1. Bal K. Joshi: Agrobiodiversity conservation options and status
2. Suroj Pokhrel: Utilization of APGRs in breeding, nutrition, production, research and distribution
3. Anil K. Acharya: Landraces as geographical indicators
4. Umesh Acharya: Nepalese APGRs outside the country
5. Tek P. Gotame: Introduced agricultural plant genetic resources (APGRs)
6. Bharat Bhandari: Custodian farmers and community seed banks
7. Ramita Manandhar: Community and public orchards in Nepal
8. Mina N. Paudel: Plant genetic resources for food and nutritional security: Global importance and Nepal's role in their management and conservation
9. Dila Ram Bhandari: Government farms and agricultural plant genetic resources
10. Shanta Karki: Minor fruits, their utilization and conservation practices

Discussion on the first technical session

Comments, questions and suggestions

Altogether 4 participants took part on the discussion of the first technical session. Most of them gave suggestions for further work on the conservation and utilization of APGRs. Mr Indraraj Pande, a freelance Vegetable expert shed light on the necessity to conduct study on pumpkin biodiversity, evaluation of the diverse characters and register them. As several landraces of pumpkins are found around the country, this will be a pioneering work. He suggested the linking of community seed bank facilitated by LIBIRD's to local government and DADOs. He also suggested the revitalization and conservation of community orchards should get attention on coming Fruits Decade 2074/75-2083/84 and Fruits Year. He added the importance of minor fruits and suggested to work on the saplings productions to make them available in the country.

Dr DR Sharma, the Program Director of Plant Protection Directorate made suggestions to 6 paper presenters. He questioned the incoming of 73% of germplasm of Nepal from outside countries and also asked the route of the entry. He suggested that all the germplasm coming or going out should come under the system of plant quarantine. He also highlighted the post arrival testing of APGRs in the country. He also suggested the easy process for the international transfer of APGRs to the scientific communities. He added that all germplasm of the county and coming from outside should be preserved in the Genebank and post entry quarantine procedure should strictly be followed. Furthermore, he explained the importance of pest surveillance and designing appropriate pest management standards for in situ conservation of the APGRs in the government farms and communities.

Mr Lekhnath Acharya, Joint Secretary of MoAD suggested for the availability of quality mother plants which is declining especially for introduced varieties. He also suggested maintaining the specific data of the exotic germplasms in the system. The details lists of all wilds, semi-domesticated landraces including domesticated (minors, majors) and commercial cultivars with clearly demarcated groups with their scientific, common and local names should be produced and updated regularly.

Dr Ananda Gautam, Planning Director of NARC suggested linking the importance of local landraces with the Vaidic literature. He also mentioned that the fruit orchards have important role in carbon sequestration which is yet neglected, so the incentives coming to Nepal because of carbon sequestration should also come to agricultural sector. He also suggested analysing and making the inventory of carbon sequestration by agricultural crops.

B. Technical Sessions 2: Accelerators for APGRs management and Technical Session 3: Status of Agronomic Crops

These both technical sessions were chaired by Executive Director of NARC Dr YR Pandey. The second session was concentrated on accelerators of APGRs management in which four papers were presented whereas the third session was focused on the status of agronomic crops in which four papers were presented.

List of presentations

11. Bal K. Joshi: Use of Biotech, GIS and CAT for management of APGRs
12. Devendra Gauchan: Agrobiodiversity index and genetic erosion: We need to measure to manage agrobiodiversity
13. Devendra Gauchan: National and international policy and incentive mechanism on agrobiodiversity
14. Bal K. Joshi: Education system on agrobiodiversity
15. Madan R. Bhatta: Cereals and Pseudo-cereals
16. Krishna H. Ghimire: Status of millets genetic resources in Nepal
17. Ram Krishna Neupane: Grain legumes
18. Tara Ghimire: Oilseed crops

Discussion on technical sessions 2 and 3

Comments, questions and suggestions

Altogether 6 participants took part in discussion on the presented papers. Most of them have suggestions and information to improve the full paper.

Mr IR Pande suggested having the mechanism to produce Nepalese rice in Nepalese name. He mentioned that Nepalese paddy is going to India and coming in the brand of Indian rice in Nepal. Dr Binod Saha mentioned the importance of safflower and its high scope in Nepal.

Mr Govinda Sharma of HASERA has the fear of genetic pollution in Nepalese agriculture due to the overflow of exotic genetic resources and also shared the chances of genetic erosion on the indigenous genetic resources.
Dr Ananda Gautam suggested using local weather data of Nepal on CAT to have the precise results. He suggested documenting quantitative and qualitative characterizations of APGRs. He mentioned the poor utilization of APGRs in the country and pointed to analyse this situation.

Dr Mahendra Khanal of Seed Quality Control Centre (SQCC) informed that the Seed Regulation has the provision for the conservation and promotion of the local landraces. We did not care much on this aspect.

Dr Bhim Khatri of National Potato Research Program informed that sometimes the introduced germplasm is referred to as “local” as in case of potato. He questioned, is this correct as these species has originated in other countries? Should this be linked with centre of diversity? Thus he suggested genotypic characterization of local landraces to delineate the duplication.

Finally session chair Dr Pande in his closing remarks committed to enhance research activities on the conservation and utilization of APGRs in NARC. He informed that in recent days many varieties are coming in line for releasing process which will add varietal diversity. He suggested to focus on the market demand/consumers demand while developing the new varieties.

C. Technical Session 4: Status of Horticultural Crops, Forages and CWR

This session was chaired by Mr Dila Ram Bhandari, Director Gneral of DOA. The session was focussed on the status of horticultural crops, forages and crop wild relatives. Altogether 9 papers were presented in this session spread over two days.

List of presentations

19. Indra R. Pandey: Vegetables (Leafy and stem, Fruit, Legume)
20. Bhim Khatri: Root and Tuber vegetables
21. Mohan B Thapa: Tropical and Sub tropical fruits
22. Gopal P Shrestha: Temperate fruits
23. Budhi Prakash Sharma: Spices
24. Krishna B. Thapa: Sugar (Sugarcane)
25. Lok Nath Paudel: Forages (Grass, Tree and Legume)
26. Deepa Singh: Crop wild relatives
27. Anil K. Acharya: Wild edible plants

Discussion on technical session 4

Comments, questions and suggestions

This session had received quite rigorous discussion. Altogether 18 participants took part in the discussion. Most of them were suggestions where as some of them were clarifications.

A participant form Department of Plant Resources has asked to go for PGRs rather than APGRs because plenty of them are duplicated in both categories. For example, flowers, medicinal and forest genetic resources are not covered in this workshop. He pointed out that phenotypic characterization is not enough we have to develop the facilities and capacity for genetic characterizations. For all these to happen, a strong collaboration and co-ordination among the stakeholders working on this sector should be developed.

Mr Gopal Shrestha, Senior Horticulturist suggested preparing an action plan of conservation and utilization of individual sector. The action plan should be implemented effectively in co-ordinated way.

Mr Dharma Datta Baral, Chief of SQCC informed that SQCC will work as watch dog for registration activities. Pro-active registration and release of variety needed, SQCC willing to help. He suggested the presentations on documentation system, its strength, weakness and recommendation could have been included in the program. All plants should enter through registration process.

Mr Bharat Babu Shrestha discussed the biological invasion and threats of biological invasions on APGRs. Thus risk assessment should be addressed prior to introduction of any species.

Dr Bhim Khatri informed that farms under DoA and NARC have many local and exotic germplasms, they should be registered and make inventory of farm materials. Wild edible fruits are found in command area of NARC research stations, they need to be identified and utilized. If there is problem on identification of APGRs in farms, they should utilize knowledge bank (experts who have retired but are active and very willing to share their knowledge) available in the country. He also suggested accessing indigenous knowledge to document and manage indigenous germplasm. He mentioned the problem on indigenous variety registration system which needs pedigree records. How to get pedigree for local germplasm if they are not from breeding programs?

On the later question on the need of pedigree records for indigenous variety registration, Dr M. Khanal of SQCC clarified that there is no need of pedigree for indigenous materials, so the process is easy.

Dr Umesh Acharya of NARC informed the participants that there are literatures available on Himali jeera, Soff and Saffron.

Mr Rewati Paudel of Directorate of Training, DoA pointed that benefits from local landraces should be harnessed. Example: Kande makai from Mustang, seed of local apricot used as an anti-carcinogenic material, bhojo chiya which is richly scented and beneficial for sugar patients. The social, economic and cultural benefits should also be explored.

Dr Mina Nath Paudel from Genebank stated the selection and cultivation of local landraces is essential. He suggested the indigenous and wild vegetables like sisno, nyuro, bhyakur, tree tomato, tite phapar should also be considered because these have special bond with the culture of indigenous communities.

Ms Deepa Singh from Genebank clarified that Genebank has functional collaboration with Department of Plant Resources for taxonomic works.

Mr Parashuram Adhikari from MoAD also highlighted the inclusion of other genetic resources too like aquatic diversity which is also in agricultural sector. He pointed to domesticate well preferred wild vegetables like Nyuro and promote the exportable semi-domesticated spice crop Timur in the national and international markets. He also suggested to rehabilitation/restoration possibilities of deteriorated public orchards in the country.

Dr Hari B KC, Program Director of VDD suggested for the proper recording and inventory of the hybrids vegetable varieties coming from outside. He also pointed the inclusion of the diversity, conservation and utilization of mushrooms, flowers, medicinal herbs, microbes, pests and natural enemies and pollinators may be in next such type of workshop. The clear demarcation of different categories of APGRs (wild, crop wild relatives, semi-domesticated and domesticated) is must for further planning of conservation and utilization activities. He informed that the government farms are instructed to establish the Biodiversity Park of the mandated crop. And for this human resource development is very crucial. Finally he suggested for the review of full papers.

Dr Pralhad Thapa from IUCN informed that National Planning Commission has prepared a Nature Conservation Strategy which will be very informative for biodiversity conservation planning. He committed for any type of capacity development activities necessary in this sector.

Dr Mahendra Khanal replied to Dr Bhim Khatri that the Seed Regulation has not made records of pedigree mandatory to register local germplasm.

Dr BK Joshi from Genebank informed the participants that the proceedings will be published soon and kept in the website. Moreover, he informed the grouping of the APGRs will be discussed in another workshop which will be organized by Genebank.

Dr Mahadeb Paudel informed that there are still some fruit trees not identified in the fruit orchards of Marpha and Phaplu. This type of forum could form an expert committee (think tank) to identify ancient varieties, unidentified plants in the farms.

Mr Basanta Dhungana from Organic Certification Nepal (OCN) suggested the role of PPP, universities and private sectors for the conservation and utilization of APGRs.

Finally Session Chair Mr Dilaram Bhandari gave the final remarks. He highlighted the importance of minor crops for food security in the country and suggested for team spirit and commitment of all sectors. He admitted that fruit sector is neglected in the country due to several reasons thus it needs effective extension system for fruits and root and tuber crops. He emphasized the popularity of local landraces in local markets thus it needs to link with nutritional aspects too. Spices provide more energy, increase their consumption. He suggested for the need of uniform nomenclature system and apply DNA finger printing technique to clarify confusion. Finally he wished for the well documentation of the information in the form of proceedings and sharing to all.

D. Poster Session

Altogether following 6 posters were presented covering different groups of APGRs in the workshop. As there were no oral presentations on these topics, these added more information on APGRs of Nepal. Participants enjoyed the posters and information on it and interacted with the authors. One poster entitled Bee flora: Diversity and abundance by Sanjya Bista was not posted.

- Semi domesticated plant genetic resources of Nepal. **Hari Bahadur KC**, Bal K Joshi, Anil K Acharya and Kamal Aryal
- Green manuring plant species: Diversity and distribution. **Anupama Shrestha**, Renuka Shrestha, Byung Taek Oh, S. Kamala Kannan
- Pesticidal plant species: Diversity and distribution. **Basanta Ranabhat**, Govinda Sharma and Bal Krishna Joshi

- Invasive plant species: Diversity and distribution. **Bharat Babu Shrestha**, Mohan Siwakoti, Jagad Devi Ranjit
- Host plant species: Diversity and distribution. **Ajaya Karkee**, Suraj Baidya and Sushil Gaire
- Diversity rich solution and climate smart crop varieties for secured crop harvest. **Bal Krishna Joshi**

Group Recommendations

Three groups were formed on three different topics.
Group 1: Future strategies for conservation of APGRs (Team leader: Dr Hari Bahadur KC)
Group 2: Utilization strategies for conservation of APGRs (Team leader: Mr Anil K Acharya)
Group 3: Access and benefit sharing mechanism (Team leader: Dr Devendra Gauchan)

Group 1: Future strategies for conservation of APGRs

- NARC should prepare the inventory of Indigenous APGRs and prioritize them for research activities
- With the selection process they may come to commercial level
- Provide sufficient budget for these works to NARC and Genebank
- Collaboration with private organizations and universities will be fruitful
- Government farms under DoA should be given specific crop mandate and both research and extension activities should be focused on the resource centre development
- Proper identification and characterizations of all APGRs with the collaboration of concern institutions with the involvement of expert team. Local special landraces should be conserved at community level
- Online catalogue along with all information should be created
- IT and bioinformatics should be incorporated to create database of these resources
- A collaborative action plan should be developed and delivered to the government for effective implementation. Correct identification and tagging of trees
- Rajikot farm should be mandated for high altitude APGRs conservation and maintenance
- Mustang farm should also be utilized for research works. Co-ordination and collaboration is must
- Request the seniors worked to establish the farms for correct identification of trees (Mr PP Shrestha to Jumla and Trishuli, Mr Ram Badal Saha to Sarlahi and Palpa for mango and citrus, Mr Buddhi Ratna Sherchan to Mustang)
- Commodity Research programs should be mandated for all varietal listing and conservation. Registration of local landraces should be speed up
- The identification catalogues should be developed and be easily available
- Research needs to verify nutritional contents to link with health benefit so that utilization and conservation will be encouraged
- Give responsibility and ownership to local community for conservation and utilization of APGRs
- Reward the community for their efforts after certain period of time

Group 2: Utilization strategies for conservation of APGRs

- Tie-up with medicinal values and markets so that the utilization with get accelerated.
- The local APGRs should be built-in to extension activities with appropriate incentive mechanisms.
- Local landraces should also go for multi-location trials before registration.
- For processing purpose, the DFTQC and NARC should also work on local APGRs.
- Mass cultivation of the local APGRs which are tested as high value commodity and have high market demand should be promoted.
- The custodian farmers should be empowered with technology and incentive packages.
- The detail information about the APGRs should be collected, characterized and conservation and utilization activities should be conducted in collaboration with private sectors.

Group 3: Access and benefit sharing mechanism

- Creation of enabling policy environment for access and benefit sharing (ABS) of APGRs
- Analyse legal status and barriers for access, exchange and benefit sharing of APGRs
- Assess legal provisions and barriers for APGR import and export
- Harmonization of polices for APGRs with forest genetic resources including overall agricultural policies such as right to food and food security policies
- Develop mechanisms for sharing benefits for conservation and ownership of APGRs

- Develop incentives mechanisms for conservation and use of local APGRs
- Need to review and anayse perverse incentives for conservation of local APGRs
- Need to have guidelines for conservation of rare and endangered crops and cultivars
- Recognition and reward for custodian farmers conserving unique landraces
- Develop incentives for cultivation and conservation of rare and unique crop varieties
- Promote conservation of hotspots of traditional APGRs
- Development of value chain and marketing of APGRs linking with agroecotourism
- Create awareness of the value of local unique indigenous nutrient rich APGRs
- Private sector engagement for processing, value addition, marketing and benefit sharing
- Conservation of rare and unique APGRs on fallow /abandoned public for enhanced ABS

Action Plan

SN	Activity	Responsible organization
1.	Study on pumpkin biodiversity, evaluation of the diverse characters and registration	LIBIRD, CEAPRED, NARC, DADO,SQCC
2.	Revitalization and conservation of community orchards to support on Fruits Decade 2074/75-2083/84 and Fruits Year	LIBIRD, CEAPRED, NARC, DADO, Govt.Farms, FDD
3.	Promotion of minor fruits through their saplings productions and expanding the area	LIBIRD, CEAPRED, DADO, FDD
4.	All germplasm of the county and coming from outside should be preserved in the Genebank and post entry quarantine procedure should strictly be followed. Risk assessment should be addressed prior to introduction of any species	Genebank, NARC, NPQP, DoA, MoAD
5.	Maintaining the specific data of both the indigenous and exotic germplasms in the system. Online catalogue along with all information should be created IT and bioinformatics should be incorporated to create database of these resources.	Genebank, NARC, NPQP, DoA, MoAD
6.	Lists of all wilds, semi-domesticated landraces including domesticated (minors, majors) and commercial cultivars with clearly demarcated groups with their scientific, common and local names should be produced and updated regularly.	Genebank, NARC, LIBIRD, CEAPRED, VDD, FDD, DoA, MoAD
7.	As Nepalese paddy is going to outside of the country and coming in the brand of other name of rice in Nepal, the mechanism should develop to produce Nepalese rice by Nepalese name.	NARC, LIBIRD, CEAPRED, CDD, SQCC
8.	Promotion of safflower due to its importance and high scope in Nepal	NARC, ORP, LIBIRD, DFTQC, DoA, MoAD
9.	Study on genetic pollution in Nepalese agriculture due to the overflow of exotic genetic resources and also shared the chances of genetic erosion on the indigenous genetic resources	NARC, LIBIRD, CEAPRED, BI, ICIMOD, IUCN, FAO, DoA, MoAD
10.	Enhance research activities on the conservation and utilization of APGRs focusing on the market demand/consumers demand while developing the new varieties	NARC, LIBIRD, CEAPRED
11.	Develop the facilities and capacity for genetic characterizations of local landraces with a strong collaboration and co-ordination among the stakeholders working on this sector. The need of uniform nomenclature system and apply DNA finger printing technique to clarify confusion	Genebank, NARC, MoAD, FAO, ICIMOD, IUCN
12.	Farms under DoA and NARC have many local and exotic germplasms, they should be registered and make inventory of farm materials. Registration of local landraces should be speed up	NARC, VDD, FDD, DoA, LIBIRD, CEAPRED
13.	Wild edible fruits are found in command area of NARC and DoA farms, they need to be identified and utilized through the utilization of knowledge bank (experts who have retired but are active and very willing to share their knowledge) and accessing indigenous knowledge	NARC, VDD, FDD, DoA
14.	Benefits from local landraces, such as Kande makai from Mustang, seed of local apricot used as an anti-carcinogenic material, bhojo chiya which is richly scented and beneficial for sugar patients, should be harnessed and their social, economic and cultural benefits should also be explored	Genebank, NARC, LIBIRD, CEAPRED, VDD, FDD, DoA, MoAD
15.	Indigenous and wild vegetables, like sisno, nyuro, bhyakur, Timur, tree tomato, tite phapar have special bond with the culture of indigenous communities, should explore and promote such semi-domesticated crops in the national and international markets.	NARC, LIBIRD, CEAPRED, BI, ICIMOD, IUCN, FAO, DoA, MoAD
16.	Government farms, both of NARC and DoA, should establish the Biodiversity Park or field genebank, crop specific parks in their vicinity areas	NARC, VDD, FDD, DoA
17.	Human resource development/capacity building programs	NARC, DoA, MoAD,

SN	Activity	Responsible organization
		LIBIRD, CEAPRED, BI, ICIMOD, IUCN, FAO
18.	Adoption of PPP model including universities and private sectors for the conservation and utilization of APGRs	NARC, MoAD
19.	Local landraces should be conserved at community level through giving responsibility and ownership to local community for their conservation and utilization. The custodian farmers should be empowered with technology and incentive packages for cultivation and conservation of those rare and unique crop varieties	NARC, DoA, MoAD, LIBIRD, CEAPRED, BI, ICIMOD, IUCN, FAO
20.	Guidelines preparation for conservation and utilization of rare and endangered crops and cultivars	NARC, DoA, MoFSC, MoAD, IUCN, ICIMOD, FAO, BI
21.	Development of value chain and marketing of APGRs linking with agroecotourism	NARC, LIBIRD, CEAPRED, DoA, MoAD
22.	Recognition and reward for the community and custodian farmers for conserving unique landraces	NARC, LIBIRD, CEAPRED, DoA, MoAD
23.	Rajikot and Mustang farm should be mandated for high altitude APGRs conservation and maintenance	NARC, DoA, MoAD
24.	Research needs to verify nutritional contents to link with health benefit so that utilization and conservation will be encouraged and create awareness of the value of local unique indigenous nutrient rich APGRs.	NARC, DoA, MoAD, LIBIRD, CEAPRED, BI, ICIMOD, IUCN, FAO
25.	For value addition of local unique indigenous nutrient rich APGRs, DFTQC and NARC should prioritize on such local APGRs.	DFTQC, NARC
26.	Creation of enabling policy environment for access and benefit sharing (ABS) of APGRs and development of mechanisms for sharing benefits of the APGRs	NARC, MoFSC, MoAD, IUCN, ICIMOD, FAO, BI
27.	Harmonization of polices for APGRs with forest genetic resources including overall agricultural policies such as right to food and food security policies	NARC, MoFSC, MoAD, IUCN, ICIMOD, FAO, BI
28.	Analyse legal status and barriers for access, exchange and benefit sharing of APGRs and assess legal provisions and barriers for APGRs import and export	NARC, LIBIRD, CEAPRED, DoA, MoAD, IUCN, ICIMOD, FAO, BI
29.	Conservation of rare and unique APGRs on fallow /abandoned public land for enhanced ABS	NARC, MoFSC, MoAD, IUCN, ICIMOD, FAO, BI

Workshop Detail

Workshop title: 2nd National Workshop on Conservation and Utilization of Agricultural Plant Genetic Resources (CUAPGR) in Nepal
Theme: Agrobiodiversity for securing our lives
Date: 22-23 May 2017 (8-9 Jestha 2074)
Venue: Mirabel Hotel and Resort, Dhulikhel, Nepal
Organizers: National Agriculture Genetic Resources Center (NGRC), www.narc.gov.np; Fruit Development Directorate (FDD), www.fdd.gov.np; Department of Agriculture (DoA), www.doanepal.gov.np; Ministry of Agricultural Development (MoAD), www.moad.gov.np

Workshop Introduction

Agriculture research has contributed significantly for generating information, securing food and advancing crop and animal husbandry. Agricultural plant genetic resources (APGRs) are the core part of agriculture and agrobiodiversity and they are critical for continuing production and minimizing the risks of food and nutrition insecurity. Importance of agrobiodiversity is well known, however, genetic erosion is rapidly expanding to locations and crop species. A large number of wild relatives of important food crops are also likely to disappear over the next decades due to climate change and *ad hoc* commercialization. Realizing the importance of APGRs as national property, Convention on Biological Diversity (CBD 1992) has been evolved for better managing and utilizing APGRs. This policy has provided sovereign rights to each country to manage, use and control the APGRs under its territory. This has resulted in the restriction on germplasm exchange and flows. Later it is realized the necessity of free exchange of germplasm for global food security. Therefore International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA 2001) has been in action for strengthening national food security, reducing poverty and addressing biotic and abiotic stresses.

The Biodiversity Profiles Project (1995) ranked Nepal as having the tenth richest flowering plant diversity in Asia and 31st on a world scale. Three agro-ecological zones of Nepal (Tarai, Mid Hill and High Hill) experience a wide range of climate from sub tropical to temperate and alpine cold semi desert, resulting in the evolution and maintenance of diverse crop gene pools. The availability of crop gene pool is a fundamental requirement for achieving further productivity increase and higher nutritional values through plant breeding. For this, it is crucial to conserve and use the existing crop diversity and to allow agricultural researchers, breeders and farmers for easy access to it.

Collective efforts are necessary to conserve and utilize APGRs more effectively and efficiently. The state of the art of agrobiodiversity needs to be developed and scientific system of APGRs handling needs to be established. Farmers and agriculturists should know the APGRs conservation systems and facilitate the conservation works. With the objectives of strengthening, encouraging and establishing APGRs management system in Nepal, 1st national workshop was organized on 28 Nov-1 Dec 1994 in Kathmandu. Over all status of APGRs has been documented in the proceedings of this first national workshop. After a long gap, 2nd national workshop in this area is planned with the following objectives.

Scope

- Diversity and utilization status, agrobiodiversity conservation and utilization
- Angiosperms, agricultural plant genetic resources (APGRs)
- National and international policies

Objectives

- Update and share on conservation and use of APGRs, status of diversity and policy on APGRs in Nepal
- Prepare list of i. Existing APGRs including cultivated, wild relatives and wild edible plants, ii. Lost APGRs, iii. Agrobiodiversity rich farmers (custodian farmers) and hotspots of agrobiodiversity, iv. Rare, endangered and unique APGRs, v. APGRs originated in the regions, vi. Organizations involved in the APGRs conservation
- Enhance the capacity of agriculturists on management, conservation and utilization of APGRs
- Establish linkage among diverse sectors and stakeholders for the management of APGRs
- Accelerate the conservation and utilization of APGRs
- Sharing and collecting feedbacks on ITPGRFA-MLS Implementation Strategy and Action Plan (IMISAP)

Organizing Committee

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Program

MC: Deepa Singh and Krishna H. Ghimire

Rapporteurs: Dr Hari B. KC, Dr Shanta Karki, Dr Mahadev Paudel

Program title	Time and facilitator
Departure from Singhadurbar Gate	1st Day: 22 May at 6:45 am. Contact: Parashuram Adhikari (9841 5648 04), Mahadev Paudel (9845 6848 96), Anil K. Acharya (9841 7145 54)
Breakfast and Registration	7:30-8:00 Suryanath Yogi, Ashok Basnet, Arjun Prasad Baral
Opening session	
Chair: Dr Suroj Pokhrel, Secretary, MoAD	
Chief Guest: Hon. Minister, Gauri Shanker Chaudhary, MoAD	
Welcome and rationale plus objectives of the 2nd National Workshop on CUAPGR	8:05-8:20; Suresh Babu Tiwari, MoAD
Key note: DG, DoA, Lalitpur	8:20-8:25; Dila Ram Bhandari
Key note: FAO	8:25-8:30; Bidno Saha
Key note: ED, NARC, Kathmandu	8:30-8:40; Yama Raj Pandey
Chief guest remarks	8:40-8:50
Session closing: Secretary, MoAD, Kathmandu	8:50-9:05
Poster session (observation and feedback)	***9:05-9:30***
Coffee Break	**9:30-10:00**
Technical Session 1: Conservation and Utilization	***Presentation and interaction: 15 minutes each***

Chair: Joint Secretary; Food Security, Agri- business Promotion and Environment Division	10:00-10:05
1. Agrobiodiversity conservation options and status	10:05-10:20 **Bal K. Joshi**, Anil K. Acharya, Devendra Gauchan and Madhusudan P. Upadhyay
2. Utilization of APGRs in breeding, nutrition, production, research and distribution	10:20-10:35 **Suroj Pokhrel**, Bhuwon R. Sthapit, Anil K. Acharya, Devendra Gauchan, Bal K. Joshi
3. Landraces as geographical indicators	10:35-10:50 Bal K. Joshi, **Anil K. Acharya**, Devendra Gauchan, Pashupati Chaudhary, Deepa Singh, Krishna H. Ghimire
4. Nepalese APGRs outside the country	10:50-11:05 **Umesh Acharya**, Bal K. Joshi, Bhuwon R. Sthapit, Pashupati Chaudhary
5. Introduced agricultural plant genetic resources (APGRs)	11:05-11:20 **Tek P. Gotame**, Ishowri Gautam, Krishna P. Paudel, Anil K. Acharya, Hari B. KC, Ramita Manandhar, Kailash Burer
6. Agrobiodiversity rich farmers and hot spot areas for agrobiodiversity	11:20-11:35 **Bharat Bhandari**, Bala R. Thapa, Pashupati Chaudhary, Bal K. Joshi, Anil K. Acharya
7. Community and public orchards in Nepal	11:35-11:50 Deepak Upadhaya, Bal K. Joshi, **Ramita Manandhar**, Rajeev Dhakal Anil K. Acharya, Asha Sharma
8. Government farms and Agricultural Plant Genetic Resources	11:50-12:05 **Dila Ram Bhandari**, Ramita Manandhar, Hari B. KC, Mahadev Paudel
9. NARC research stations in relation to APGRs, importance of APGRs and relevant organizations	12:05-12:20 **Mina N. Paudel**, Ishowri P. Gautam, Ananda Gautam, Yagya P. Giri, Thaneshowr Pokharel
10. Minor fruits, their utilization and conservation practices	12:20-12:35 **Shanta Karki**, Padmanath Atreya, Ramita Manandhar
Lunch	12:35-13:40
Technical Session 2: Accelerators for APGRs management	
Chair: ED, NARC	13:40-13:45
11. Use of Biotech, GIS and CAT for management of APGRs	13:45-14:00 **Bal K. Joshi**, Pashupati Chaudhary, Mahendra Khanal, Deepa Singh, Krishna H. Ghimire
12. Agrobiodiversity index and genetic erosion: We need to measure to manage agrobiodiversity	14:00-14:15 Bhuwon R. Sthapit, Pashupati Chaudhary, **Devendra Gauchan**, Bal K. Joshi
13. National and international policy and incentive mechanism on agrobiodiversity	14:15-14:30 **Devendra Gauchan**, Suresh Babu Tiwari, Kanchan Pandey, Anil K. Acharya, Bal K. Joshi
14. Education system on agrobiodiversity	14:30-14:45 Dharma R. Dangol, Madhav Pandey, **Bal Krishna Joshi**, Binayak R. Bhandari
15. Good practices of conservation and utilization in India, R&D partnership and future agenda	14:45-15:00 Krishna Kumar Nallur, Bioversity International, New Delhi, India
Coffee Break	**15:00-16:00**
Technical Session 3: Status of Agronomic Crops	
16. Cereals and Pseudocereals	16:00-16:15 **Madan R. Bhatta**, Hari Krishna Upreti, Mahendra Khanal, Prakash Acharya, Thaneshwor Pokharel
17. Status of millets genetic resources in Nepal	16:15-16:30 **Krishna H. Ghimire**, Bharat Bhandari, Narayan Dhami, Bimal K. Baniya
18. Grain legumes	16:30-16:45 **Ram Krishna Neupane**, Renuka Shrestha, Rajendra Darai
19. Oilseed crops	16:45-17:00 **Tara Ghimire**, Moji Lal Jayaswal, Devendra Chaudhary, Govinda P Koirala

Technical Session 4: Status of Horticultural Crops, Forages and CWR	
Chair: DG, DoA	
20. Vegetables (Leafy and stem, fruit, legume)	17:05-17:20 **Indra R. Pandey**, Prahlad Thapa, Hari B KC, Dhurba Bhattarai, Deepa Singh, Anil K Acharya
21. Root and tuber vegetables	17:20-17:35 **Bhim Khatri**, Binod Luitel, Shyam Dhakal, Binod Shah, Surendra Shrestha, Umesh Acharya
22. Tropical and sub tropical fruits	17:35-17:50 **Mohan B. Thapa**, Krishna P. Paudel, Purusotam Khatiwada, Lok Nath Deouju, Bidya Pandey, Bhairab R Kaini
Refreshment and Welcome Dinner	**18:00 on wards**
2nd day: 2074/2/9	
Breakfast	**7:00-8:00**
Technical Session 4 continue…	
23. Temperate fruits	8:00-8:15 **Gopal P. Shrestha**, Chut Raj Gurung, Giridhari Subedi, Kaushal Paudel, Anil K. Acharya, Durga M. Gautam
24. Spices	8:15-8:30 **Budhi Prakash Sharma**, Rajendra Adhikari, Padam Adhikari, Surendra Rijal, Govinda KC
25. Sugar, beverages and fibers	8:30-8:45 **Tufail Akhtar**, Maheshwor Lamichhane, Bahuri L. Chaudhary, Krishna B. Thapa
26. Forages (grass, tree and legume)	8:45-9:00 **Lok Nath Paudel**, Dinesh Pariyar, Kishor Shrestha, Shankar Sah
27. Crop wild relatives	9:00-9:15 **Deepa Singh**, Bal K Joshi, Kamal Aryal, Ramita Manandhar, Mahadev Paudel, Tek B Gotame, Hari B KC
28. Wild edible plants	9:15-9:30 Dharma Raj Dangol, Sanjeev K. Rai, **Anil K. Acharya**, Bhairab R. Kaini
Poster Session	***9.35-10.00***
P-01. Semi domesticated Plant genetic resources of Nepal	Hari Bahadur KC, Bal K. Joshi and Anil Acharya
P-02. Green manuring plant species: Diversity and distribution	Anupama Shrestha, Renuka Shrestha, Byung Taek Oh, S. Kamala Kannan
P-03. Pesticidal plant species: Diversity and distribution	Basanta Ranabhat, Govinda Sharma and Bal Krishna Joshi
P-04. Bee flora: Diversity and abundance	Sanjya Bista
P-05. Invasive plant species: Diversity and distribution	Bharat Babu Shrestha, Mohan Siwakoti, Jagad Devi Ranjit
P-06. Host plant species: Diversity and distribution	Ajaya Karkee, Suraj Baidya and Sushil Gaire
Group discussion: 1. Future strategies for conservation of APGRs, 2. Utilization strategies, 3. Access and benefit sharing mechanism	**10:00-11:15**
Information collection on geographical indication and IMISAP	
Closing Session	
Chair: Joint Secretary, MoAD	
Concluding remarks: Chief, NAGRC	11:15-11:25
Concluding remarks: IUCN	
Concluding remarks: Dr Ramita Manandhar, FDD	11:25-11:35
Concluding remarks: Dila Ram Bhandari, Director General, DoA	11:35-11:45
Book launching and Closing Remarks	11:45-12:15
Lunch	**12:15-13:15**
Departure from Dhulikhel to Singhadurbar Gate	14:00

Opening Session

Documented by Hari Bahadur KC, Shanta Karki and Mahadev Paudel

Chair of the Program: Dr Suroj Pokhrel, Secretary, MoAD
Chief Guest: Hon. Minister Mr Gauri Shankar Chaudhary, MoAD
Altogether 7 speakers including chairperson expressed their views about the World Biodiversity Day (May 22) and its importance in the present situation of the country. All of them thanked the organizers on organizing such an important program to discuss on the conservation and utilization of the APGRs in the country. On behalf of organizers Mr Suresh Babu Tiwari, Joint Secretary of MoAD welcomed the chief guests, all the guests and participants and shed light on the International Biodiversity Day and its importance on agriculture sector of Nepal. He explained the objective of the workshop is to discuss and document the conservation and utilization status of APGRs in Nepal. As this type of workshop is being held after 23 years, he requested all participants, authors and co-authors to take it as an important and valuable responsibility.

Dr Binod Saha, Assistant FAO-R in Nepal spoke about the importance of International treaties on APGRs and in-vitro and in-situ conservation of fruits and vegetables. As this is one of the important areas in agriculture sector of Nepal, he mentioned that FAO is ready to collaborate with Government sector. He recommended celebrating one day as the National Biodiversity Day annually.

Dr Bal Ram Thapa, ED of LIBIRD Nepal mentioned that the LIBIRD is running the home gardening project in line with the biodiversity conservation and utilization. He suggested exploring the opportunity of public-private partnership (PPP) in utilization and conservation of the APGRs. He recommended ensuring a multi-sectoral and holistic approach for this important task. He further suggested the present database should be updated and documented continuously through this type of program and the outcome should be shared to all.

Mr Dilaram Bhandari, the Director General of DoA viewed that the rain-fed ecosystem is important for biodiversity and food security. He pointed the importance and inclusion of indigenous genetic resources on the daily food menu. He suggested documenting the past efforts and presenting work and planning for the future for conservation and utilization of natural resources. He strongly pointed that none of the APGRs should get lost from the country, we must handover them to the new generation.

Dr YR Pandey, the Executive Director of NARC informed that 577 species of crops are being cultivated in Nepal, of which 30,000 are the local landraces. Altogether there are 658 varieties released and registered of which only 7% are the locals. He explained the breeding activities of NARC and mentioned the poor adoption of developed varieties at farmers' level. He discussed the importance of the conservation of the APGRs and suggested to focus on the utilization of the APGRs. The farmers' indigenous knowledge and technologies should be explored, conserved and promoted. As Nepal is already a signatory of CBD 1992 and ITPGRA 2001, we have obligation to go for conservation and utilization of APGRs with high importance. As 95% of the APGRs are still exotic in Nepal, he focused on the utilization of national APGRs in breeding programs. The indigenous resources have good market nationally and internationally, thus we can be benefitted from our biodiversity. He explained the 20 points conservation plan set by Genebank and admired the commendable work of Genebank in present days for conservation and maintenance activities in the country. He thanked Genebank on the successful Germplasm Rescue Mission from earthquake affected areas. He informed that NARC is going to open the Genebank of livestock and fishes too. He had the idea of linkage conservation and utilization activities with the climate change and its adaptation and also the designing of awareness activities in this aspect with the involvement of the community. He finally suggested to frame out the gaps identified and information collected to proceedings which should be published in time and shared to all. He further requested to organize such type of event in every 5 years interval.

Minister of Agriculture Development Mr. Gauri Shankar Chaudhary, the Chief Guest of the program mentioned that the local landraces are being lost because of the negligence in their conservation. He pointed the importance of documentation and conservation of our indigenous germplasm for the future generation. He also briefly stated the constitutional provisions and CBD and ITPGRFA which Nepal is a signatory, regarding utilization and conservation of biodiversity on a sustainable manner.

The Chair person of the program Dr. Suroj Pokharel, the Secretary of MoAD gave final remarks to close the session. He conveyed that some of the topics on animal biodiversity, flowers, microbes, mushrooms, pollinators, pests, natural enemies, etc were missing and these information should also be addressed in the future programs. He suggested the importance of these species on ecosystem services and conservation and utilization should go hand in hand. He pointed the need to tie up with threats and challenges on PGR management (national and international movement of the germplasm). He also suggested exploring the deposition of our native genetic materials worldwide and be informed. He mentioned the diversity of the indigenous resources should be explored, characterized and maintained making their availability in breeding purpose. He gave the examples of 3 sub species of *Apis cerana* with 56 ecotypes in Nepal. The wild genetic resources can be used as exportable commodities and also these resources should be linked with health and nutrition point of view.

Closing Session

Chair of the Program: Suresh Babu Tiwari, Joint Secretary, MoAD

The closing session of the two days long workshop was chaired by Joint Secretary Mr Suresh Babu Tiwari and MC was done by Mr Krishna H. Ghimire of the Genebank. In the closing session, most of the speakers highlighted the success of the event and thanked all organizers and participants.

Dr Pralhad Thapa from IUCN suggested to publish a quality proceeding with action points which should be implemented, therefore provide appropriate doable recommendation. He committed that IUCN is ready to help in implementing this action plan and would like to contribute on capacity building activities on agrobiodiversity benefit sharing.

Dr Meena Nath Poudel expressed happiness on get together of all related institutions for this successful event. He suggested prioritizing specific commodities to start working. He also pointed out that the research and development organizations should be integrated on functional basis to have better results.

Dr Ramita Manandhar stated that 2nd CUAPGR was held after 23 years, its better late than never. She acknowledged that a lot of data and information has been collected. We need to list, document and start patenting our resources. Implementation part has to get focused.

Mr Dila Ram Bhandari suggested studying available policies, acts and regulations on the conservation and utilizations of APGRs. He focused on developing package of practices for minor crop programs, and concentrate on food security and food safety.

Mr Dharma Datta Baral was happy that scattered resources came to one place and the program was refined. He emphasized registration of landraces and SQCC is willing to facilitate it.

Mr Suresh Babu Tiwari in his workshop closing remarks emphasized on formation of a think tank having 5 to 10 members (could be a roster of experts). He focused on implementation part which goes beyond commitment, so he suggested that implementation should follow the commitment. He said the program was highly successful. The full papers will be published in the proceedings. He expected high quality full papers with accurate information. He expressed the special thanks to Dr Bal K. Joshi and Mr Anil K. Acharya for their hard work on organizing this workshop.

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Keyword Index

Workshop Banner

Workshop Glimpses

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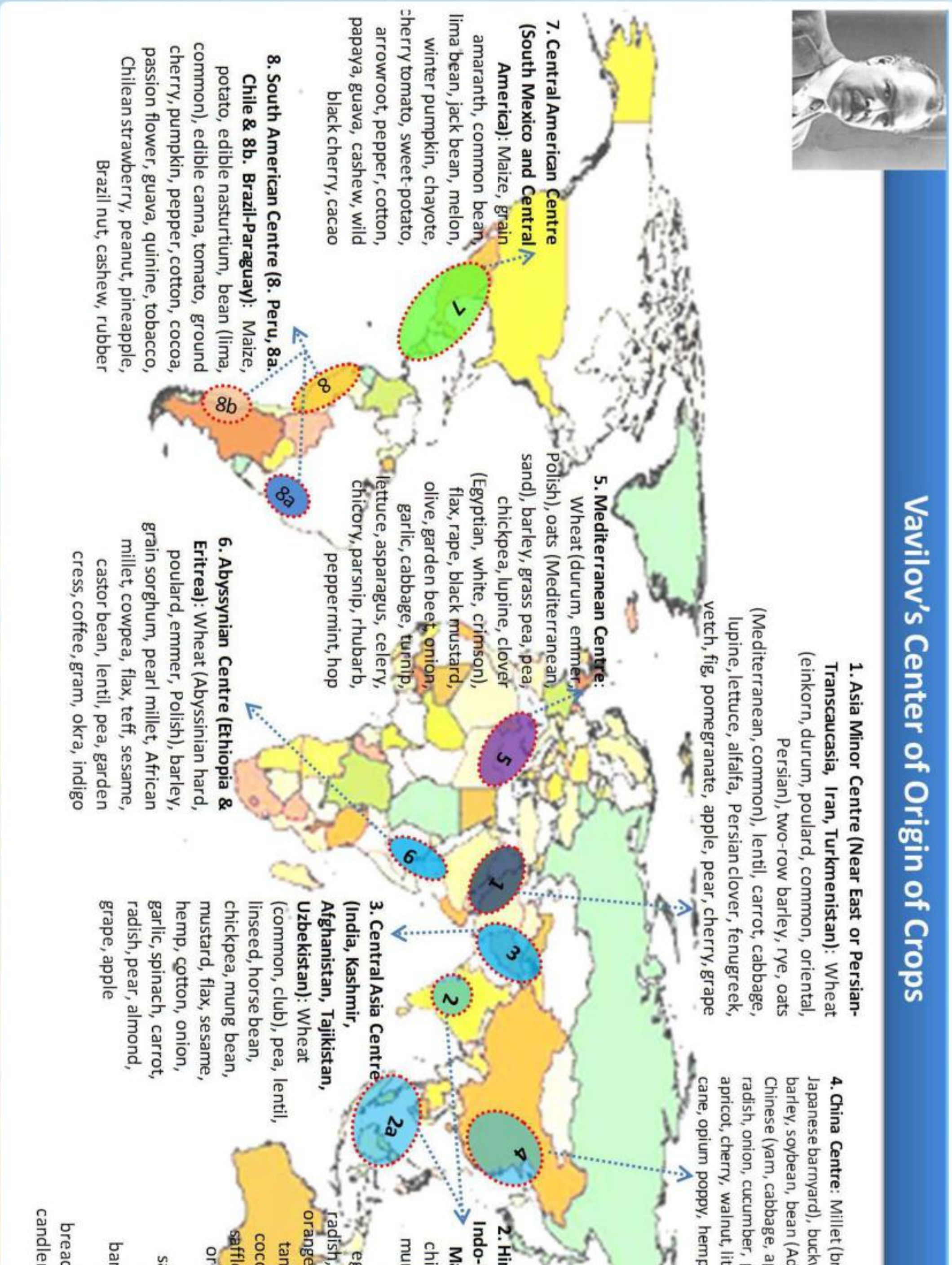

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Agro-biodiversity is the basis of life.