CONTRIBUTION OF CROP DIVERSITY TO THE LIVELIHOODS OF THE LOCAL PEOPLE IN API NAMPA CONSERVATION AREA OF KAILASH SACRED LANDSCAPE, NEPAL

A THESIS SUBMITTED TO THE

RESEARCH CENTRE FOR APPLIED SCIENCE AND TECHNOLOGY

INSTITUTE OF SCIENCE AND TECHNOLOGY

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NEPAL

FOR THE AWARD OF

DOCTOR OF PHILOSOPHY

IN BOTANY

BY

KAMAL PRASAD ARYAL

MAY 2022

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DECLARATION

Thesis entitled "**Contribution of Crop Diversity to the Livelihoods of the Local People in Api Nampa Conservation Area of Kailash Sacred Landscape, Nepal**", which is being submitted to the Institute of Science and Technology (IOST) through the Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Nepal, for the award of the degree of Doctor of Philosophy (PhD), is a research work carried out by me under the supervision of Prof. Dr Ram Prasad Chaudhary (Professor Emeritus), Research Centre for Applied Science and Technology, Tribhuvan University.

This research is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

Kamal Prasad Aryal

RECOMMENDATION

This is to recommend that **Kamal Prasad Aryal** has carried out research entitled "**Contribution of crop diversity to the livelihoods of the local people in Api Nampa Conservation area of Kailash sacred landscape, Nepal**" for the award of Doctor of Philosophy (Ph.D.) in **Botany** under my supervision. To my knowledge, this work has not been submitted for any other degree.

He has fulfilled all the requirements laid down by the Institute of Science and Technology (IoST), Tribhuvan University, Kirtipur for the submission of the thesis for the award of Ph.D. degree.

……..

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Supervisor
Professor Emeritus
Research Centre for Applied Science and Technology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

May 2022

त्रिभुवन विश्वविद्यालय
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पत्र संख्या :-
Ref. No. :-

LETTER OF APPROVAL

Date:31 May 2022

On the recommendation of Prof. Dr Ram Prasad Chaudhary, this Ph. D. thesis submitted by Kamal Prasad Aryal, entitled "**Contribution of Crop Diversity to the Livelihoods of the Local people in Api Nampa Conservation Area of Kailash Sacred Landscape, Nepal**", is forwarded by the Research Centre for Applied Science and Technology (RECAST) Research Committee to the Dean, Institute of Science and Technology (IOST), Tribhuvan University.

……

Dr Ram Nath Prasad Yadav
Professor
Executive Director
RECAST, Tribhuvan University
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ABSTRACT

This study was undertaken in Khar Village Development Committee (now part of Naugad Rural Municipality, under the new federal structure) of Darchula District in the Kailash Sacred landscape, Nepal. The study analysed the cultivated crops and the wild, edible plant diversity, their status and use, and farmers' knowledge and management practices. Data was collected using multiple methodologies and participatory tools – 45 key informant interviews, 10 focus group discussions, one crop/plant diversity fair, ethnobotanical survey and field excursion through forest and farmland visits, two rapid market assessments, four square analysis, geospatial analysis, and a household survey (195 respondents) – all complemented by a review of literature. A total of 177 cultivars from 36 families under 66 genera and 99 wild edible plant species from 58 families under 75 genera were documented. Among the 36 families in cultivated crops, family Gramineae recorded the highest cultivars (55) followed by Leguminosae (36), Cucurbitaceae (20), Cruciferaceae (12) and Solanaceae (9). Whereas out of 99 wild and non-cultivated crop/plant species Moraceae comprising 7 species under 2 genera; Rosaceae comprising 6 species under 4 genera; Urticaceae comprising 5 species under 5 genera; Amaranthaceae comprising 4 species under 2 genera; Polygonaceae comprising of 4 species under 2 genera were documented through ethnobotanical survey. Few species are listed in the IUCN Red List which includes one endangered (EN) species (*Aconitum heterophyllum*), one vulnerable (VU) species (*Paris polyphylla*), and one near threatened (NT) species (*Dioscorea hamiltonii*). *Dioscorea deltoidea* is included in the CITES Appendix II. Among the cultivated crop diversity, rich cultivar diversity was recorded in maize (*Zea mays*) with 15 cultivars, followed by 12 cultivars in paddy (*Oryza sativa*), 11 in wheat (*Triticum aestivum*), and 9 in beans (*Phaseolus vulgaris*). Together, this agroecological farming practice provides food and nutritional security to remote mountain communities, helps maintain the diverse food cultures, provides a source of livelihood, and ensures resilience against climate shocks. Our study also showed that women are the main custodians and managers of conserving, using, and managing local seeds as well as of traditional ecological knowledge related to the use of wild edible species. However, there has been a gradual decline of the crop diversity due to the availability of modern cultivars, seasonal migration of skilled manpower, the easy availability of readymade and other instant foods due to access of

transportation, changes in land use, as well as collection of yar-tsha-gunboo (*Ophiocordyceps sinensis*) the caterpillar fungus. Besides, changing food habits – especially among the youth, and the easy access to fast foods in nearby local villages are the reasons behind the growing neglect of local cuisines. Also, governmental policy, research and extension are not focused on incentivizing the management of crop diversity. However, to withstand this loss of genetic resources and for the long-term sustainability of crop diversity, farmers are adopting domestication methods and *in situ*, *ex situ* and on-farm conservation techniques. Among these practices, self-saved seeds, and local-level seeds-exchange system through informal networks play a meaningful contribution in the conservation of indigenous crop diversity. However, these practices fall short of addressing the entire issue hence applied research on promotion and marketing of these crops, should be a pressing priority. Revitalization of the traditional crops and the domestication of wild edibles can help people achieve long-term food and nutritional security, as well as conserve genetic resources and crop diversity. Most importantly, specific programmes and interventions must be designed by local and central governments to conserve and manage crop diversity in the Kailash Sacred Landscape, Nepal.

LIST OF ACRONYMS AND ABBREVIATIONS

ANCA	: Api Nampa Conservation Area
CDRC	: Central Department Research Committee
EN	: Endangered
HKH	: Hindu Kush Himalaya
HWC	: Human Wildlife Conflict
IBPGR	: International Board for Plant Genetic Resources
ICIMOD	: International Centre for Integrated Mountain Development
IOST	: Institute of Science and Technology
FAO	: Food and Agriculture Organization
FGD	: Focus Group Discussion
KII	: Key Informants Interview
KSL	: Kailash Sacred Landscape
KSLCDI	: Kailash Sacred Landscape Conservation and Development Initiative
LDCs	: Least Developed Countries
LULC	: Land Use and Land Cover
NAPA	: National Adaptation Programme of Action
NARC	: Nepal Agricultural Research Council
NT	: Near Threatened
NTFPs	: Non-Timber Forest Products
RECAST	: Research Centre for Applied Science and Technology
SDG	: Sustainable Development Goals
TAR	: Tibet Autonomous Region
TU	: Tribhuvan University
VDC	: Village Development Committee
WNEPs	: Wild and Non-cultivated Edible Plants
VU	: Vulnerable

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CHAPTER 1

1. INTRODUCTION

1.1 Introduction

Mountain ecosystems are characterized by extraordinary biological richness, and they support about half of the world's biological diversity (Aryal *et al*., 2020; Hassan *et al*., 2005). Agrobiodiversity, an important subset of biodiversity, is the major life-support system of the indigenous and traditional agricultural communities living in the mountain areas. Agrobiodiversity has been recognized as an important factor in maintaining or enhancing agricultural sustainability; it plays a major role in household level daily food requirement and in providing livelihood to a huge number of people globally (Aryal *et al*., 2021a; Baldinelli, 2014). Agriculture is the major source of human wellbeing of over 80 per cent of the people in the countries of the Hindu Kush Himalaya (HKH), which is known as a hotspot for crop diversity (Agnihotri & Palni, 2007). It is also home to many endemic and endangered species; however, they are facing huge pressure from climatic and anthropogenic drivers of changes.

The agroecosystem provides the basket of food and feed for mass population who depend for their livelihood (Hassan *et al*., 2005; Rudebjer *et al*., 2009). About 60% of the global agriculture area (approx. three million ha) consists of subsistence farming having rich diversity of cultivated and wild plants (Jackson *et al*., 2005). Furthermore, the diversity in wild and non-cultivated edible plants/crops contributes significantly to food security and the livelihoods of the local communities (Aryal *et al*., 2018; Aryal *et al*., 2009). In this regard, the agroecosystem has played a critical role in supporting mountain livelihoods; however, collaborative research on subsistence farming is needed, without eradicating the diversity that the farmers have in their field (Aryal *et al*., 2017; Rana *et al*., 2007).

The traditional agroecosystem provides a wide range of products and services which are important for the mountain people's livelihood and for the management of the mountain environment (Macchi, 2010). These include provisioning services such as food, timber, firewood, and water, regulating services such as flood and soil erosion control, cultural services such as spirituality and recreation, and supporting services such as nutrient cycling (Rasul *et al*., 2011). However, over the time, these products and

services are changing due to changing patterns of land use and human interventions (Baral *et al*., 2013). The ecosystem goods and services that differ at spatial scales in mountain areas have provided opportunities to people living in down-stream area. The large amount of agrobiodiversity that are of vital importance has not been systematically inventoried in terms of their services and functions. Data that can be used to analyse the ecosystem condition and their service status are often inadequate (Sharma *et al*., 2010). In addition, there is limited information about vulnerability of mountain ecosystems to climate change (Sharma *et al*., 2010). Mountain people have been using diversity for a range of reasons: to supplement their daily food requirement; to cope with adverse climate impacts, change in crops based on market demand; and to diversify their options and opportunities. Since our culture and traditions are heavily rooted with the diverse use of crops/plants that help to maintain the sustainable management of crop diversity (Aryal *et al*., 2017; Chaudhary *et al*., 2007).

In recent years, the mountain communities are experiencing natural and anthropogenic drivers of changes (Chaudhary *et al*., 2011; Thapa & Hussain, 2021). Climate change is now emerging as a huge challenge and its impacts on agriculture, biodiversity, ecosystem services and natural resource-use (Chaudhary *et al*., 2011; Chaudhary & Aryal, 2009; Dendup, 2018; Oli & Zomer, 2011; Singh *et al*., 2010). The initiatives and the current management practices to tackle the impacts of such changes are not enough. In addition, global policies related to climate change have also largely overlooked these facets despite their importance to rural livelihoods; these policies have not properly addressed the issue of developing adequate adaptation and mitigation strategies for agricultural development. Climate change is making new demands on adaptation and mitigation strategies and is also presenting new challenges for environmental governance as well as sustainable development in the mountains (Altieri &Nicholls, 2017; Chaudhary *et al*., 2011; Regmi *et al*., 2009).

The study assesses the status of cultivated and uncultivated diversity, land use and land cover change and its implication for crop diversity management, their contribution to food and livelihood security, the anthropogenic and climate factors impacting this diversity, and local knowledge and practices related to the management of this diversity.

1.2 Rationale

The conservation and utilisation of agrobiodiversity is key to maintain the life and livelihoods of the overwhelming mountain communities (Regmi *et al*., 2009). Maintaining the diversity along with proper conservation measures is key strategies for adaptation to climate change and resilience building (Ravera *et al*., 2019). The social and economic processes prevalent among culturally linked groups affect resource-use patterns and pressures on agroecosystems. So, it is necessary to understand how social and economic relations aid or ruin natural resources. Now, let us take the case of the traditional knowledge and practices on agrobiodiversity that mountain farmers possess; they are indeed an asset, especially in the case of *in situ* conservation (Upadhyay & Subedi, 2003). The mountain people, with their in-depth knowledge and well-honed practices related to crop characteristics and requirements, maintain high levels of agrobiodiversity in their fields. This local knowledge also plays a vital role when it comes to managing and monitoring agroecosystems (Moller et al., 2004). Several local cultivars reside in their farming systems, which are productive under local circumstances, but are also threatened with extinction. The pace towards extinction is bound to quicken as traditional knowledge and practices are not really being passed on to the next generation.

The Kailash Sacred Landscape (KSL) is diverse in terms of culturally and ecologically. This region encompassing over 31,000 km^2 of the Tibetan Autonomous Region (TAR) of China and adjacent areas in India and Nepal (Oli & Zomer, 2011). Home to multi-ethnic communities, KSL is rich in agricultural crops and genetic resources and its farmers rely heavily on local cultivars of various crop species for supporting their livelihood. However, in recent years, many cultivars are depleting from the area (Aryal *et al*., 2017; Verma et al., 2010), which is putting pressure on the food security of the people. Furthermore, the genetic erosion of crops and cultivars has direct implications on agrobiodiversity management on farm (Brookfield *et al*., 2003). It is, therefore, important to assess the diversity and the status, including those of wild and non-cultivated plants, and the knowledge associated with them so that we can provide relevant information for proper management and future utilisation of this diversity. Then there is the issue of changing land use patterns and its implications on the management of crop diversity. However, the current land use change and their underlying causes, both in terms of climatic and non-climatic changes in the Api Nampa

Conservation Area, has been rather limited. Hence, it is important to fill this gap to know more about the magnitude and potential drivers of change along the altitudinal gradient.

The Kailash Landscape provides a wide range of ecosystem services and support to the livelihoods of both the mountain people and the downstream populace. However, data that can be used to analyse the contribution from the ecosystem goods and services towards people's livelihood and management of the system is inadequate (Oli & Zomer, 2011). It is important to evaluate the contributions of ecosystem services and mainstream them into government plans and programmes. It is equally important to document knowledge and evidence about climate and anthropogenic drivers of changes and its impacts on crop diversity management (Chaudhary *et al*., 2011; Oli & Zomer, 2011; Singh *et al*., 2010). There is an urgent need to study the causes of climate change and its impacts on agrobiodiversity management; this will also help us understand the effect of climate change on the food security of the people. In this regard, it is imperative that the local people's perceptions about climate change and its ecological consequences be understood and then be incorporated with empirical data to inform policymakers about the ill-effects of climate change. Climate change-related information on local biodiversity and agricultural systems can serve as the baseline information for monitoring the effect of climate change on high-altitude environments.

Though the people of the landscape hold diverse knowledge and practices on conservation and management of crop diversity, however due to the outmigration of the youth to city area these practices becoming limited. It is important to initiate practical action for better management of such traditional knowledge and practices (Chaudhary & Aryal, 2009; Chaudhary *et al*., 2007; Oli & Zomer, 2011; Rana *et al*., 2007). Therefore, it is vital to document and analyse farmers' local knowledge not only in terms of "what" and "how," but also "why," so that the blending of scientific knowledge and local knowledge is achieved for strengthening the farmers' capacity to continue growing traditional cultivars and to contribute to on-farm conservation. This thesis explores the status, use patterns and dependency of the people on crop genetic resources (both agricultural and wild and non-cultivated) in the Api Nampa Conservation Area (ANCA) of the KSL, Nepal. Crop diversity in this study are crops and cultivars that farmers cultivate and use as part of their subsistence. They consist of local farmers' cultivars, modern cultivars of traditional crops, introduced crops (like maize and

cassava), as well as crop wild relatives, weedy forms of crops and wild species used by communities for food and agriculture (Engels *et al*., 2014). Furthermore, the study has explored the potential drivers of change and provides recommendations for the management of these genetic resources in the landscape.

This study was conceived to fill a critical gap in a newly established conservation area – the Api Nampa Conservation Area – which was established in 2010, and to provide recommendations for crop diversity management within the landscape and beyond.

1.3 Objectives

The main objective of this research was to assess the richness of agricultural crop diversity, their status and use, and contribution to food security and livelihoods. Research questions and hypothesis are presented in Appendix 1. The specific objectives of the study were:

- To assess the agricultural crop diversity that the households have maintained in their agroecosystems and their contribution to local food security and livelihoods
- To assess the status, use and management practices of wild and non-cultivated edible plants/crops and their contribution to local livelihoods
- To assess and quantify the past and current land use patterns and examine the underlying causes of changes in the Api Nampa Conservation Area
- To understand and document the climatic and anthropogenic drivers of change affecting the choice and management of crop genetic resources, and to study the local adaptive measures
- To document the local knowledge and practices on crop diversity management on farm

CHAPTER 2

2. LITERATURE REVIEW

2.1 An overview of agrobiodiversity

Agricultural biodiversity, also known as agrobiodiversity for food and agriculture, is an important subset of biodiversity. Agrobiodiversity is crucial for food, nutrition, livelihood security and for overall human health (Aryal *et al*., 2020; Campbell *et al*., 2021). It also provides humans with fibre, wood for energy and shelter, as well as medicinal plants and roots; besides, it is a means of subsistence farming and income generation from the sale of various products. Moreover, it supports a range of ecosystem goods and services such as management of soil health (soil fertility and biota), water conservation, and the pollination necessary for food production and human survival (Aryal *et al*., 2020).

Agrobiodiversity embraces all the components of biological diversity which make up the agroecosystem and are related to food and agriculture. The Food and Agriculture Organization (FAO) of the United Nations defines agrobiodiversity as "the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries." By this definition, agrobiodiversity comprises the diversity of genetic resources (cultivars, breeds) and the species used for food, fodder, fibre, fuel, and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators) and those in the wider environment that support agroecosystems (agricultural, pastoral, forest, and aquatic) as well as the diversity of the agroecosystems (Belanger & Pilling, 2019).

Agrobiodiversity is seen at ecosystem, species, and genetic level diversity. It is important to understand the function, structure, and processes of the agrobiodiversity management (Belanger & Pilling, 2019). Agrobiodiversity includes diverse range of crop cultivars, fodder and tree species, animal breeds, aquatic and marine species, soil biota, pollinators and the great diversity of wild and non-domesticated plant species used by the people.

Agriculture is the primary source of the livelihood of over 80 per cent of the rural population in the countries of the region, which is considered as an important hotspot for crop diversity (Agnihotri & Palni, 2007) with its large numbers of endemic and endangered species. Mountain communities and the livelihood sources are limited and are highly fragile and susceptible to climate change, as is the case with other mountainous regions of the world (Aryal *et al*., 2020; Xu *et al*., 2019). Traditional mountain farming systems with key cultivated crops like maize, rice, naked barley, wheat, buckwheat, amaranth, and integrated with subsistence livestock production systems (Oli & Zomer, 2011).

2.2 Importance of agrobiodiversity for food and livelihoods

The significance of agrobiodiversity encompasses sociocultural, economic, and environmental elements. It provides food and raw materials, wood for fuel and shelter, plants and their parts are for medicines, as well as contribute to income generation (Aryal *et al*., 2021b; Campbell *et al*., 2021).

2.2.1 Source of food and nutrition security

The Sustainable Development Goals (SDG) 2 and 3 of the United Nations are related to food and nutrition security. SDG 2 (End hunger and achieve food security) aims at promoting sustainable solutions to eradicate hunger in all its forms and achieve food security and improved nutrition by 2030 through safe, nutritious and enough food throughout the year, while SDG 3 (Ensure healthy lives) aims at ensuring healthy lives and promoting well-being among people of all age categories). This aspect of food and nutrition security addresses the required levels of calorie intake and the proper balance of household's food items that are important for human health (Adhikari *et al*., 2017; Konsam *et al*., 2016).

Globally, there are over 7,000 edible plant species, but over 50 per cent of our plant-derived calories come from only three crop species – rice, wheat, and maize (Ramadan, 2017; Schmidt *et al*., 2010). This heavy dependence on few staple food crops makes people more vulnerable to future food and nutritional security.

Therefore, maintaining crop diversity at the farmland level is crucial for the mountain people operating on small landholdings in remote areas; this brings balance in the local

food systems through improvement in dietary diversity by making available diverse food sources Similarly, some wild edible plants have high nutritional value and are in great demand in the market. These include diverse kinds of mushrooms and various roots and leafy vegetables, including *Morchella* and *Agaricus* mushrooms, yams, ferns, and nettles, as well as a diversity of other herbs (Belanger & Pilling, 2019).

2.2.2 Economic significance

Traditional crops and cultivars are gaining high popularity among urban consumers as health foods or superfoods (Adhikari *et al*., 2017). Barley, naked barley, buckwheat, millets such as finger millet and fox tail millet amaranth and some high-mountain cultivars of rice, beans and pulses are among the preferred crops, particularly in the urban areas. These crops having good taste and health benefits, they are called "superfoods" or "future smart crops" and are in high demand in recent times (Adhikari *et al*., 2017; Aryal *et al*., 2021a).

The market for traditional mountain agricultural niche products as well as wild, edible food products is growing as people in urban areas are becoming more health conscious (Adhikari *et al*., 2017). This provides an opportunity for the development and promotion of mountain agricultural biodiversity. So, there is a need is to exploit these opportunities and enhance benefits for the mountain communities. This would require maintaining quality standards and improving packaging and presentation, as well as branding (for instance, environmental and social branding or as a pro-poor and environment-friendly income generation activity) as per market requirement.

These traditional crops/wild edibles have the potential to contribute to socio-economic equity and poverty alleviation. Presently, smallholder mountain farmers are engaged in production of these crops on limited land. They also contribute to environmental protection through conservation of unique agrobiodiversity using non-hazardous cultivation practices (Aryal *et al*., 2021a).

2.2.3 Sociocultural and ecological significance

Agrobiodiversity also has great sociocultural significance among the communities in the landscape. However, there is a dearth of detailed social-ecological research about the cultural landscapes (Frison *et al*., 2011). Agrobiodiversity contributes significantly

to the maintenance of ecosystem health and enables to provide better services delivery (Frison *et al*., 2011; Giri *et al*., 2020).

Agrobiodiversity is considered an important part of cultural identities and traditions. For instance, people in the Kanchenjunga landscape use 739 species of various non-timber forest products for 24 different purposes. Among these, 598 medicinal plants are used to cure 27 different ailments (Uprety *et al*., 2016). Agrobiodiversity is the powerhouse of the genetic material and important foundation for the agriculture farming system. But gradual erosion put questions to us for the management of such diversity for long run. It is estimated that about 940 cultivated plant species are in an endangered state (Khoshbakht & Hammer, 2007). In this regards, management of such diversity is required through proper research and development interventions.

Agrobiodiversity can also reduce the risk of pests and diseases in crops It is estimated that annually around 15 per cent of crop harvest is lost through pest and diseases (Chakraborty & Newton, 2011). Hence, it is important to keep/maintain the crop/plant diversity on farm for cope with such challenges.

2.3 Role of agrobiodiversity in adaptation and resilience building

Majority of the farmers are experiencing various extreme weather events like too much and too little water, rising temperature and so on (Aryal *et al*., 2021b; Chaudhary *et al*., 2011; Malhi *et al*., 2021; Ngoma *et al*., 2021;). Agrobiodiversity provides farmers better options to cope with climate risks. For example, planting cultivars of crops which mature faster can help in dealing with changes in precipitation (Altieri & Nicholls, 2017; Aryal *et al*., 2021b). In recent years, many farmers particularly in the hill slopes prefer cultivating cultivars that are drought resistant to less water to cope with changing environmental conditions (Aryal *et al*., 2017; Di Falco *et al*., 2010; Ngoma *et al*., 2021).

Agrobiodiversity can lower the risk of crop failure and enhance the productivity through climate resilient agricultural practices. Study by Kayode (2020) highlighted that agrobiodiversity reduces the pressure on marginal and fragile agriculture environments. This can make the farming system more robust and sustainable. Diversity enables effective use of natural resources which limit the dependency on outside sources and make our system more resilient. (Kayode, 2020; Paudel *et al*., 2016; Rahman & Karuppaiyan, 2011).

An analysis of the National Adaptation Programmes of Action (NAPA) of 50 Least Developed Countries (LDCs) by Villanueva et al. (2017) focuses on the climate adaptation activities. Mostly, the NAPAs are promoting agroforestry practices in the farmers' field and engaged in promoting stress-tolerant cultivars in farmers' field (Regmi *et al*., 2009; Villanueva *et al*., 2017). However, the degree of integration varies across the NAPAs when it deals with agrobiodiversity-related activities. So, huge efforts are needed to make agrobiodiversity work effectively in climate change adaptation in vulnerable countries (Sardaro *et al*., 2021; Villanueva *et al*., 2017). Moreover, activities creating demand for agrobiodiversity products and their marketing in national and international level is necessary (Aryal *et al*., 2020; Ngoma *et al*., 2021; Regmi *et al*., 2009; Sharma *et al*., 2016; Singh *et al*., 2010).

It is understood that conserving and maintaining agrobiodiversity will improve local food systems and lower the risks associated with climatic and non-climatic changes. Promotion and development of local cuisines and linking with tourism and other business diversify the income opportunities. Improved consumption involving diverse foods lower the chances of nutrient deficiencies (Zimmerer & de Haan, 2020). There is also the need for policy support/ government support for promotion and better management of rich diversity that we have for long-term resource use (Aryal *et al*., 2021b).

2.4 Agriculture crop diversity, wild and non-cultivated plants, and their status

2.4.1 Cultivated crop diversity in the KSL

The mountains are the pool of many crop cultivars that are locally developed and adapted in wide range of environment (Bisht *et al*., 2007). Agriculture, though occupying less than 10 per cent of the land area in the KSL is among the primary source of livelihood and contributes significantly to biodiversity and ecosystem processes (Oli & Zomer, 2011; Saxena *et al*., 2005). The Uttarakhand Himalaya have 14 per cent of land under cultivation and about 65 per cent of the population depends on agriculture for their livelihood (Thapliyal & Singh, 2014).

The Indian and Nepali parts of the KSL is rich in agrobiodiversity and the local farmers rely heavily on local cultivars of various crop species for their livelihood. Commonly

cultivated crop cultivars are wheat, millet, barley, and beans. The land use pattern in KSL Nepal indicates very less arable land having less than one per cent irrigated land (Oli & Zomer, 2011). Food self-sufficiency is the issue despite of practicing diverse strategies like seasonal out-migration, collection and use of wild plants, collection of high value products (Aryal *et al*., 2017; Oli & Zomer, 2011).

The percentage of land covered by Nepal in the KSL is 42.5, i.e., 13,289 sq. km out of a total 31,000 sq. km. The KSL Nepal extends across four districts of Nepal: Baitadi, Darchula, Bajhang and Humla. The main crops that are grown here include paddy, barley millet, maize, and wheat. Among the legumes, *Phaseolus vulgaris* locally known as *sotta* is an important cash crop grown widely. It is grown from the Tarai (300 masl) to the high hills (2,500 masl). They are considered as an important cash-generating legume in Nepal, especially in Jumla and its adjoining hill districts, as well as also in Mustang where mixtures of cultivars of varying morphologies with varied sizes and seed-coat patterns are harvested and sold in the market (Neupane & Vaidya, 2002; Pandey *et al*., 2011).

Beans seeds are of high quality in terms of taste and nutrition and can easily be sold in faraway markets and cities (Neupane & Vaidya, 2002). A better evaluation of its agronomy and genotypes can be done if experiments are conducted in wide range of environments; this will help in identifying and selecting widely adaptive and location-specific genotypes, thereby setting the stage for farmers to earn more profit (Pandey *et al*., 2011). The use and cultivation of beans in Nepal involves various reasons, such as in the form of green vegetables (fresh green pods), dried seeds as pulses, and for seed purposes. The pattern of cultivating beans differs from the low-land plains to the high hills. The people in the lower plains (below 500 masl) cultivate kidney beans as a sole crop which is one of the key sources of traditional cuisine. In the hills (500–1,600 masl), the French beans, both pole and bush type, usually cultivated for the consumption of green pods as vegetable; here, snap bean is the most popular. In the higher altitude (1600–2,500 masl), dry shelling beans are intercropped with maize, (Pandey *et al*., 2011).

In Nepal part of the landscape, the research and documentation in the field of agriculture crop diversity and its contribution to the livelihoods of the local communities is exceptionally low compared to KSL India (Aryal *et al*., 2017). Indeed, the rich

agricultural crop diversity and agricultural trends of KSL Nepal have been ignored for lack of proper documentation (Aryal *et al*., 2017; Oli & Zomer, 2011; Verma *et al*., 2010).

2.4.2 Wild and non-cultivated crops/plants diversity

The wild and non-cultivated edible plant species (WNEPs) are a rich source of food supplement to many of the households residing in the mountain areas. The WNEPs are a common source of food, nutrition, and medicine; they are also income cultivators and preservers of tradition – all contributing to human well-being. In this research, WNEPs are harvested/collected from fallow agriculture field, forests, plants growing naturally alongside crops in cultivated field for the various use. This covers a wide range, including wild vegetables, wild fruits, medicines, and other use value (Aryal *et al*., 2021a; Campbell *et al*., 2021; Konsam *et al*., 2016).

These plants are widely used across the Himalayan region and provide green social security for millions of people, not only in the KSL but also in other parts of the HKH. Throughout the KSL, WNEPs contribute to the daily diet of many rural households and are an integral part of their livelihood. These collected WNEPs are used for fulfilling food requirement, maintaining health, earning income, and securing family nutrition. These resources are used in different forms raw, mixed salads, fried, curry, soups, and various other ways – depending upon people's preferences and taste (Akhtar, 2001; Aryal *et al*., 2018; Aryal *et al*., 2013; Aryal *et al*., 2009). Many of these plants are also used for cultural and religious purposes in number of occasions (Campbell *et al*., 2021; Konsam *et al*., 2016).

The WNEPs such as yams, wild mushrooms, leafy vegetables, and fruits not only provide nutrition and food benefits to the mountain communities, but they are also a source of cash income. Nowadays, WNEPS are also gaining popularity among health-conscious urban populace who are looking for more organic and natural food products. Wild edibles, particularly vegetables like *Dioscorea bulbifera*, *Dioscorea deltoidea*, *Urtica dioica*, *Fagopyrum esculentum*, *Dryopteris cochleata* and *Paeonia emodi* are in increasing demand in the market (Aryal *et al*., 2020; Aryal *et al*., 2018). Besides, wild edibles such as wild mushrooms (of the *Morchella* species and *Ophiocordyceps sinensis (*yar-tsha-gunboo) are highly valuable with huge market potential and demand. However, the availability of such species has been decreasing in recent years compared

to 10– 15 years ago; this is due to overharvesting and habitat degradation (Aryal *et al*., 2020; Konsam *et al*., 2016).

In the changing climatic context, word is facing severe food crises due to low production potential of the key staple foods and the case of mountain countries is severe (Chaudhary *et al*., 2011; Thapa & Hussain, 2021). In such a situation, WNEPs can contribute fighting against food crisis and malnutrition. Thus, there lies a wonderful opportunity in promoting these wild, non-cultivated plant species, especially as export-value products, through product diversification and market linkages.

There is also a growing realization among the scientific and development communities that these plants can widen the food base to provide nutrient rich foods to the thousands of people, not only in the KSL but elsewhere too. However, these remain neglected and do not really find a place in national research and development programmes. Furthermore, there are limited studies that document the usefulness of such diversity (Abdullah *et al*., 2021; Akhtar, 2001; Baldinelli, 2014; Campbell *et al*., 2021).

Efforts are needed to increase awareness among many stakeholders, including farmers and policymakers, about the many benefits of conserving and promoting this important but non-recognized plant diversity. Thought should also be put into maintaining standards and quality through proper cleaning and packaging so that these wild species are able to capture the growing consumer demand. In this regard, proper ecosystem management must play a crucial role.

2.5 Land use and land cover change

Land is the important resources that comprises of soil, water, and plants; it meets the demand for food, energy, and livelihood. Factors such as deforestation, rapid urbanization, expansion of roads and conversion of agricultural fields have been the main reasons behind land use and land cover (LULC) changes (Lambin *et al*., 2010). LULC changes have been accompanied by an increase in water and energy consumption, along with biodiversity loss (Foley *et al*., 2005). Land-use intensification has effects on biodiversity and the services that it provides (Chaudhary *et al*., 2017; Chaudhary *et al*., 2016; Chillo *et al*., 2018). Clearing of tropical forests on a large scale has been responsible for extremely hot weather, while the clearing of temperate and boreal forests has been responsible for triggering extremely cold weather. Changes in

the land use are the outcome of the activities that the human have been doing over the time (Rimal *et al*., 2011).

Increasing population has not only put pressure on natural growth but has also forced the migration of people from the uplands to the lowlands. Moreover, urbanization in the lowlands has made farmers respond to market demands in a hasty manner – by growing crops that have led to land degradation and a decrease in productivity eventually (Valentin *et al*., 2008).

Conventional farming on cropland aggravates impacts on biodiversity and makes it vulnerable to climate risks and environmental pollution (Reidsma *et al*., 2006). This then becomes a fertile ground for invasive plant species (Chapin et al., 2000). After habitat destruction, plant invasion is considered as the greatest threat to native biodiversity (Bellard *et al*., 2016). When invasive plant species expand in cropland areas, it reduces both productivity and crop diversity (Shrestha *et al*., 2015). Famers have been adapting the effects of climate change by changing the planting dates, cultivating drought-resistant cultivars and by using different cultivars; but this reduces crop diversity (Lobell *et al*., 2007; Piao *et al*., 2010). In the mountain watersheds of Nepal, the cultivable agriculture land is decreasing, and grass land and forest land is increasing. It is due soil erosion and nutrient depletion from the steep slope land hence farmers abandon the field for few years. (Gautam *et al*., 2002). Besides, many households kept their agricultural lands fallow due to shortage of labour caused by seasonal migration of male labourers to foreign countries (Naudiyal *et al*., 2019).

Land-use intensification has also affected the plant community in terms of biodiversity loss and ecosystem multifunctionality (Allan *et al*., 2015; Chillo *et al*., 2018; Foley *et al*., 2005). There is mounted pressure on natural resources to meet the growing demands of human populations; rapid economic development and the emerging global markets have also worsened the situation. Agricultural intensification using genetically uniform crops and considerable amounts of chemical fertilizers has placed stress on the existing natural diversity of landscapes, thereby causing a decline in both floral and faunal diversity and a reduction in species diversity; this is currently considered as one of the greatest ecological problems. Given this context, there is need of proper land use management plan and policies for sustainable management of natural resources (Ali, 2007).

2.6 Climatic and non-climatic factors affecting crop diversity management

Despite a rich diversity of agricultural crops/plants, many species and cultivars are getting eroded from their habitats (Aryal *et al*., 2017; Chaudhary *et al*., 2015; Katwal *et al*., 2015; Rahman & Karuppaiyan, 2011; Sharma *et al*., 2016). Several studies have documented the key drivers behind this loss (Table 1). Both the natural drivers of change and anthropogenic change are affecting crop diversity. Natural drivers like climate variability frequency of extreme weather conditions, variations in the length of the growing season are leading reasons reported by people. Climate change and variability are considered as the major threat of low agricultural yields and leading to food insecurity (Chaudhary *et al*., 2020; Lobell *et al*., 2007).

The anthropogenic drivers of change include displacement of indigenous cultivars by new, improved, and high-yielding cultivars; commercialization of agriculture, i.e., shifting from diverse traditional systems to a few market-oriented cash crops; infrastructure development and improvement in road access to villages; changes in food preferences (moving away from traditional food); market linkages; and outmigration and the subsequent labour shortage (Aryal *et al*., 2017; Naudiyal *et al*., 2019). Modern techniques in agriculture have also exacerbated the climate change situation due to use of chemical fertiliser and pesticides; then there is the matter of land-clearing practices (Smith, 2008). A study by Aryal *et al*. (2017) recorded five human induced drivers of change leading to loss of cultivars. Among them, the leading driver (77 per cent) was of the introduction of improved and hybrid seeds, followed by labour shortage due to seasonal out migration (56 per cent). Sociocultural, and economic factors also play a role in human decisions on crop selection which resulted in management of few preferred cultivars (Gauchan *et al*., 2003; Rana *et al*., 2007).

Table 1: Drivers of crop/plant diversity loss

Key Factors Contributing to Crop Diversity Loss	**Nature of Loss**
Availability of improved crop cultivars	• Local cultivars of traditional crops have been replaced due to introduction of improved and hybrids, and the mixed cropping system has been replaced by monocropping • Displacement of indigenous cultivars

Seasonal migration of skilled and energetic human resources	• Less interest in agriculture farming • Shortage of human resources for farm activities • Fallow of agriculture fields
Access to road, infrastructure, and market	• Changes in cropping pattern due to comparative economic advantage • Access to road and market leading to easy availability of fast foods, resulting in the loss of traditional crops and food recipes
Lack of incentive mechanisms for promotion of traditional crops/cultivars	• High exploitation of resources • Unsustainable and illegal harvesting/collection of wild edibles
Human-wildlife conflicts	• Crop and livestock depredation • Death of animals and humans
Sociocultural transition from subsistence to commercial farming because of the market economy; changes in food choices and preferences	• Local cultivars replaced by modern cultivars for commercial reasons • Declining interest in traditional cuisines; and the tendency to maximize profits through cash-crop monocultures such as maize
Land-use change	• Species habitats have been disturbed and rendered unsuitable • Traditional agricultural land is now being used to cultivate cash crops • Population growth and land fragmentation
Climate change and disasters	• Increasing temperatures and unprecedented instances of long drought, less winter rains, diseases and pests have resulted in the loss of traditional cultivars
Degradation of natural forests	• Loss of gene pool (especially of wild cultivars)
Poaching and illegal trade in flora and fauna	• Loss of threatened species

(Source: Aryal et al., 2020; Aryal et al., 2018; Aryal et al., 2017; Chaudhary et al., 2015; Katwal et al., 2015; Rahman & Karuppaiyan, 2011; Sharma et al., 2016)

Many traditional crops, particularly millets, are stress-tolerant short-duration crops. These crops can tolerate hot temperatures and grow well on marginal lands, less fertile

soils, and under water-stress conditions. They are resistant to pests and diseases and perform well without much external inputs. Some of these crops complete their life cycle in three months to avoid periods of high stress and diseases and pest attacks. A study in Bhutan mentioned a substantial loss – 28.6 per cent – in traditional cultivars of six major cereal crops; barley at an alarming 43 per cent fared the worst, while the least loss – 14 per cent – was suffered by millets (Katwal *et al*., 2015). Even among major crop cultivars promoted by agricultural extension offices reported declining over the time (Aryal *et al*., 2017; Chaudhary *et al*., 2015; Sharma *et al*., 2016). Surprisingly, with better accessibility, people focus on cultivating market driven crops and cultivars (Chaudhary *et al*., 2020; Naudiyal *et al*., 2019).

The impacts of natural drivers of change such as fluctuations in weather events, unreliable monsoon – leading to droughts and floods – prolonged occurrence of frost or hailstorms and rising local temperature (which has spawned new pests and diseases of not only crops but also livestock) have affected agrobiodiversity (Chen *et al*., 2016). Among the drivers, erratic rainfall and intensity of weather events and hazards are reported as the leading cause of decline in yield particularly to the rain-fed agriculture practices. (Chen *et al*., 2016; Thapa & Hussain, 2021).

Another difficult barrier to agricultural activity in the KSL has been the issue of human–wildlife conflict (HWC). Crop depredation by wild animals particularly wild boars and monkeys perceived as a serious threat by the farming communities for the decline in cultivated crops on farmland (Chaudhary *et al*., 2015; ICIMOD, 2019; Katwal *et al*., 2015).

As for the labour shortage on farms due to seasonal outmigration, resulting in abandonment of farmlands which is leading cause to loss of genetic diversity (Aryal *et al*., 2017; Naudiyal *et al*., 2019; Oli & Zomer, 2011).

CHAPTER 3

3. MATERIALS AND METHODS

This chapter is divided into four broad subsections. The first section summarizes the general features of the study site and its people. In the second, the general methodology used for this research is described. The third section captures the experimental research design of the study, and the last section is about data entry and analysis.

3.1 Study site and people

This study was conducted in Khar Village Development Committee (now part of Naugad Rural Municipality, under the new federal structure) of ANCA of KSL Nepal (Figure 1). The conservation area covers 1,903 sq. km in Darchula District and falls under the Sudurpaschim Province in western Nepal. Its altitude varies from 539 masl to 7,132 masl (DNPWC, 2019). It is surrounded by Bajhang District to the east, India to the west and south, and the Tibet Autonomous Region of China to the north. The Mahakali, Laku and Naugad are the major river systems of the area. The study site ranges from 1,324 to 3,242 masl with subtropical temperate climate. The area is about 14-kilometre drive in rural road from Khalanga Bazar, the headquarters of Darchula District and accessible except rainy season. The total household of the VDC is 698 households and a population of 4,272 (CBS, 2012). The cultivated land is mostly along the hill slopes with less area having cultivated low land. The forest types are mixed, coniferous, and deciduous. Chettri is the pre-dominant ethnic group followed by Brahmins and the major castes are Bohara, Manyal, Dabal, Sitoli, Tamata, Thagunna and Bisht. The average landholding of the surveyed households is 0.5 hectare which is close to the national average of 0.68 hectare.

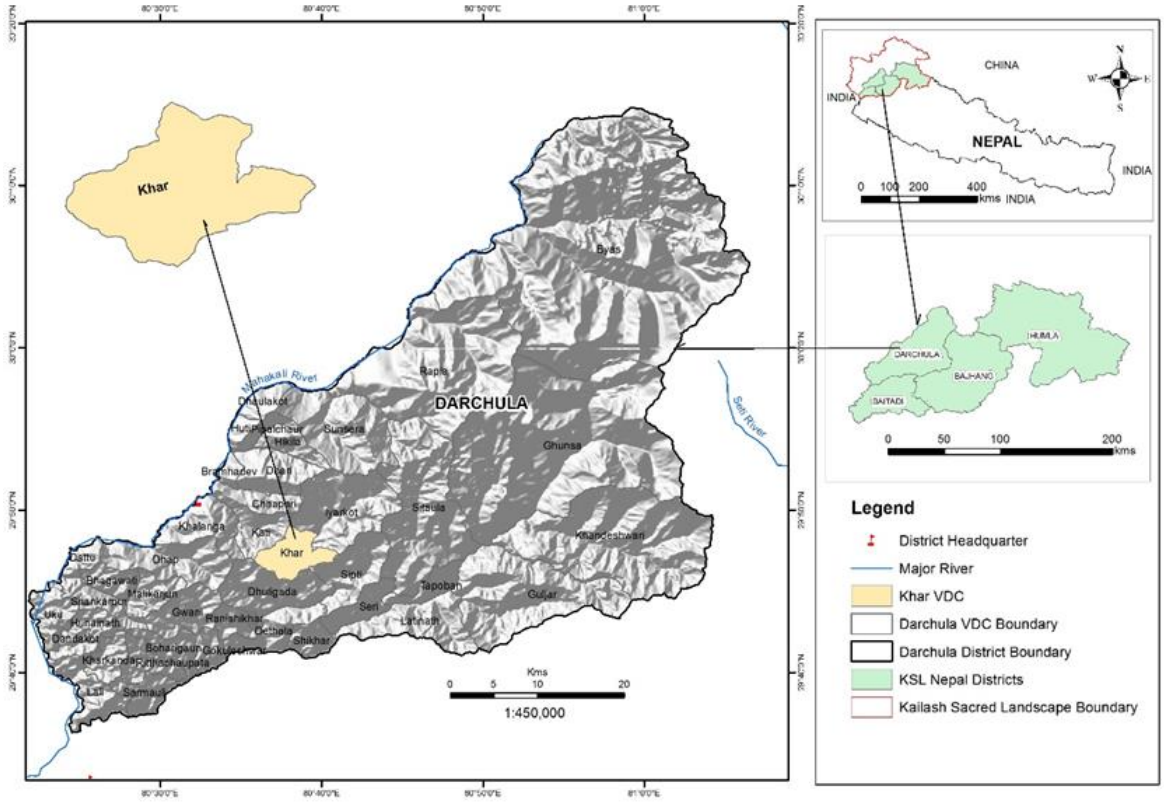

Figure 1: Study site map (Currently falls under Naugad Rural Municipality)

3.2 Methods

For this research study, I used four broad approaches and tools, and the systematic study framework is presented in Figure 2. Household survey, experimental design research along with participatory tools were used for the primary data collection which were supplemented by geospatial analysis and the collection of secondary information through literature review. Key participatory tools used in this study is presented briefly in section 3.2.1. For the wild and non-cultivated component of this study, there was a greater emphasis on ethnobotany, looking at use, knowledge associated with use, cultural and religious significance, and conservation and management practices.

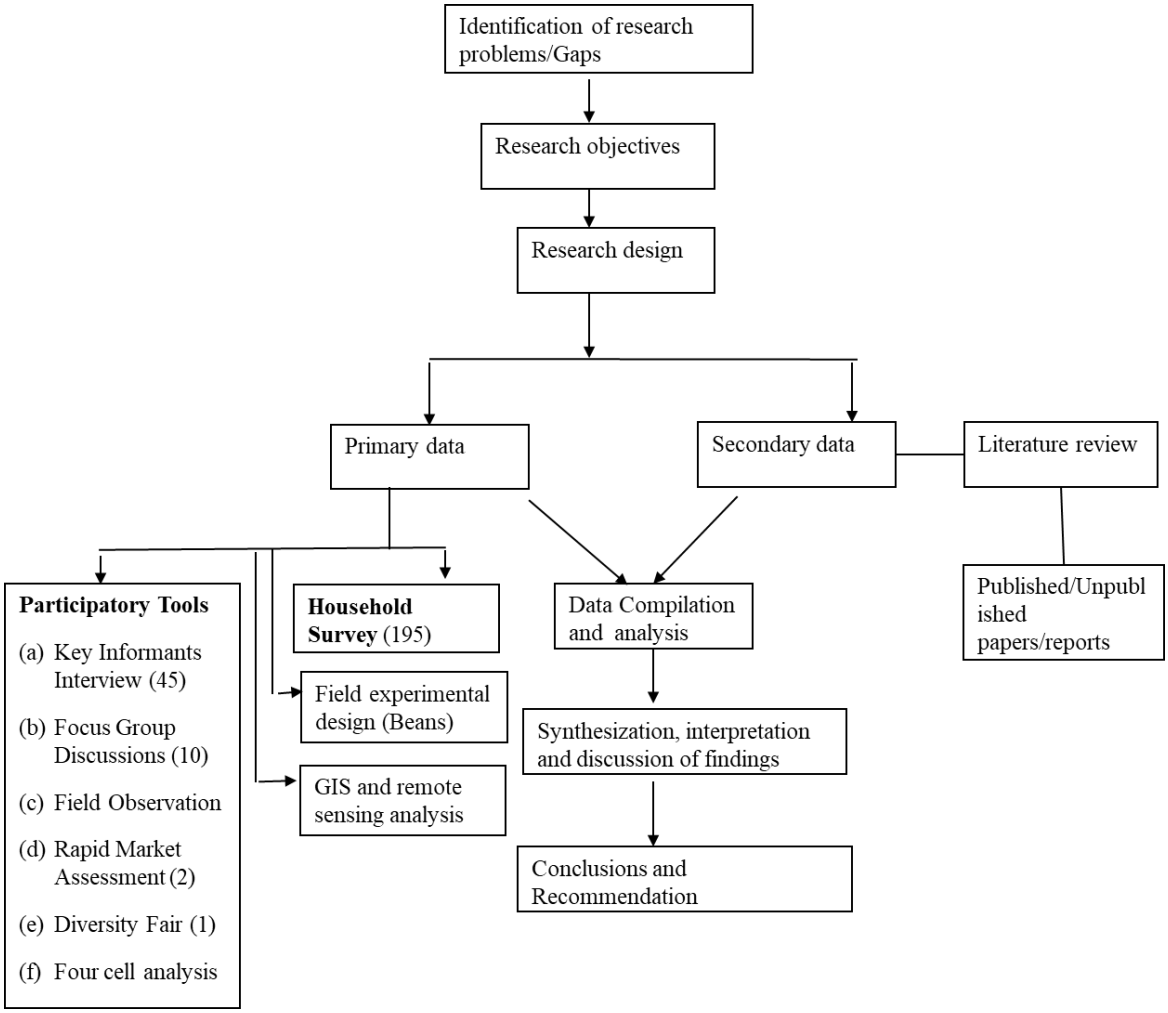

Figure 2: Study framework

3.2.1 Participatory tools

Five broad participatory tools were used for the study (Focus group discussions, key informants' interview, rapid market assessment, crop diversity fair, four cell analysis). Among them, I organised 10 focus group discussions (FGDs: one in each ward (Nine wards) and one with representatives from the nine wards and other key institutions) with 7–12 people in each group (82 participants: 40 women, 42 men). The discussions focussed on the status and use of both cultivated and wild crop/plant diversity available in the study area, as well as on challenges on their conservation and management.

Altogether, total of 45 key informants (18 women, 27 men) from all nine wards including farmers and other key stakeholders, within the broad age group of 28–78 years, were interviewed. ANCA village level conservation committee members identified the informants considering their extensive knowledge of crop/plant diversity in the study area. Nine faith healers (one from each ward) who are known for their

services for treating health related issues were purposively selected. The key informants were interviewed about their knowledge and experiences on the availability, various uses, and the status of the diversity and their role in human well-being.

A diversity fair of local agrobiodiversity was organized at the study site in February 2015; it particularly focused on crop/plant diversity (cultivated, wild and non-cultivated). The objective of the fair was to quickly assess the extent of diversity and general status of the crop/plant diversity in the area. This fair provided opportunities for individuals and community members to display their local plant material, as well as to share and document associated knowledge (Sthapit *et al*., 2003). Farmers brought various crops/plants samples that they are using in the venue of fair and voucher specimens of unidentified plants were prepared.

A Four Cell analysis was conducted to understand the status and local knowledge about the local bean (*Phaseolus vulgaris*) diversity at the community level. This provided information on those bean cultivars that are grown by a few households in small parcels of land, and which needs immediate attention from the authorities concerned. This tool was helpful to understand the status of those cultivars on farm and identify the crops that needs special attention for conservation and management. This tool can also be useful in monitoring and decision-making because of its ability to capture the dynamics of on-farm management (Rana *et al*., 2005).

For the identification of the market potential crops/ plants and their current demands, we conducted two rapid market assessments, one at local market (Dallekh Bazar), and the other at district headquarter (Khalanga Bazar).

Four field visits (in winter (February 2015), spring (May 2015), summer (July 2016) and autumn (October 2016) were organised for the collection and identification of wild and non-cultivated edible plants. During this visit, I invited a taxonomist and a social mobilizer to be with me in the field for gathering and collecting the samples and identification of them. For both cultivated and non-cultivated diversity, use, and trends, we interviewed knowledgeable elderly members of the community, and took them to accompany to the field. We collected samples from all nine wards where species were found extensively in the field. Specimens along with photos were taken for reference. The unidentified specimens were later identified with the help of reference collections

(Akiyama *et al*., 2011; Bailey, 1969; Press *et al*., 2000) and an expert taxonomist from the National Herbarium and Plant Laboratories, Godavari, Lalitpur, Nepal (KATH).

We got prior informed consent from household respondents and the participants who were engaged in participatory identification of the wild plants for the documentation and publication for study purposes.

Household survey questionnaire (Appendix 2) was used to get wide range of data and information. The questionnaire consisted of six sections. The first section consisted of general/household information, including sex, age, household size, education, key occupation, and wealth categories. The second section was focused on household income and the major sources of family income. The third section covered agriculture and farming, spanning major land types, major crops grown and changes over time, access and control over the resources and market-related information. The fourth section covered food security issues, including the coping strategies of families during the shortage months. The fifth section covered perceptions on climate change, anthropogenic change, and adaptation strategies. And the sixth and last section was about information- and communication-related questions. Sample size of the respondents to be interviewed was determined using formula:

$$\text{Number of households to be interviewed} = \frac{Z_{1-\propto}^2 * N * P(1-P)}{(e^2 * N) + (Z_{1-\propto}^2 * P(1-P)}$$

Where *N* is the total number of households (N=698); *Z* is the level of confidence (the assumed value for 90 per cent level of confidence is 1.65); *P* is the estimate of the indicator to be measured (assumed value of 50 per cent in the absence of any prior information); and *e* the margin of error to be accounted for (assumed level of precision was set at 5 per cent).

With this formula, we calculated 195 households distributed proportionally from the number of households in all nine wards ensuring well representation. Computer generated random sampling techniques was used for identification of household in each ward.

3.3 Experimental design

Three experimental plots and one diversity block were established in Dallekh, Sundamunda and Dhamidera. These locations represented three elevation gradients

with the difference of about 300 metres from one to another. They were also selected keeping in mind that they were visible and noticed by many people for displaying diversity in beans. The investigation was conducted on nine bean cultivars which has been cultivated on-farm by many households. Establishment of the diversity block was to display various beans cultivars in a common place so that farmers can see and do their own comparison. Twenty seeds of each cultivar were planted in the diversity blocks. The bean cultivars were planted on 27 June 2016 (on the same day at all three locations). The average maximum and minimum temperature were 22°C and 13°C in June to 16°C and 5°C in October.). The randomised complete block design was done for the experimental research plots having three replications. The beans were planted with 60 cm × 20 cm plant-to-plant distance for determinate bush type and 75 cm × 30 cm for indeterminate climber type. Besides one treatment consisting of mixed cultivars of beans was used as control (mixing of beans together is the general practice). The experimental plots were managed as per local practices (no additional inputs, extra weeding and so on) were done at the same time intervals in all three sites. There was no other special treatment such as more input supply or better management given to any of the experimental plots. A display board with the objectives of its establishment along with name of the individual variety where it was grown was placed at all the three sites. For the agro-morphological characterisation of *Phaseolus vulgaris* we adapted and contextualise the standard beans descriptors (See Appendix 3) developed by International Board for Plant Genetic Resources (IBPGR) in 1982. Valuable information such as on pests and diseases was also noted to compare which variety was pest and disease resistant. For each cultivar, five plants per replication were taken and data were recorded. The yield of different bean cultivars was also calculated at the three sites. With the help of local motivators various growth data were recorded in different time intervals. The date of germination and flowering was noted when 50 per cent of the plants had germinated or had flowers. The same method was applied for pod maturity as well. The measurements of pod length and width were noted in centimetres of largest, fully expanded, immature, and green pods from five randomly selected plants. Similarly, seeds per pod was taken and counted the average numbers from five plants. The average seed weight from five randomly selected plants was calculated by taking 100 healthy seeds and used the weighing machine at the National Gene Bank of Nepal Agricultural Research Council (NARC) office, Kathmandu. Other morphological

characters such as leaf colour, germination type, pod surface, pod margin and seed colour were also noted.

3.4 Geospatial analysis

A geospatial analysis was undertaken to evaluate the major land use and land cover types in the study area and to record the changes over time. Decadal land cover data 1990, 2000 and 2010 of Nepal co-developed by ICIMOD (Uddin *et al*., 2018; Uddin *et al*., 2015) was downloaded from ICIMOD regional database system (RDS). For the estimation of land cover, Uddin *et al*. (2014), perform the object-based image analysis (OBIA) in Landsat image. With the Khar area boundary, three landcover data (1990 AD, 2000 AD & 2010 AD) was clipped using ArcGIS software. For the development of 2016 land cover of Khar VDC/area, maximum likelihood classifier algorithm was performed in Landsat 8 imagery in Google Earth Engine (GEE) platform. To identify land cover change detection; remote sensing data, satellite imagery and image processing techniques had done within four dates of 1990, 2000, 2010 and 2016 using Landsat imagery having 30 m spatial resolution. Local people consultation/discussion, Google Earth and GPS data collected from the field were used for the classification accuracy and validation of the developed map.

3.5 Data entry and analysis

The data from the household survey was entered into a CS Pro 6.2 and the analysis was done by using the SPSS 16.0 software. The findings of the research were presented in figures and table through descriptive analysis and frequency calculation techniques.

For the beans experimental design: For the data collection a standard beans descriptor developed by IBPGR, 1982 was used. This descriptor was modified and contextualise in consultation with scientist from National Gene Bank, NARC, Nepal. For the yield calculation, the area of per square metre was taken for the measurement and later converted into tons per hectare. The formula used for calculating yield was:

Yield (ton/hectare) = Pod number per m2 * Seed per pod * 100 seed weight (gm) /10000

The analysis was done using Excel and the statistical software, R *64 3.1.3. The comparison between cultivars and differences in quantitative characteristics at the three sites were done using the Kruskal-Wallis test

Besides, we calculated use value (UV) of frequently used wild vegetables and the informant consensus factor (ICF) of the most common taxa used for medicinal purpose.

Use Value (UV) was calculated for individual plant species to give quantitative measures of its relative importance to the informants objectively. Use value was calculated by using the following equation: $UVs = \sum U/n$,

Where, UV refers to the use value of a species, U is the number of use reports mentioned by the respondents and n is the total number of respondents interviewed.

Informant Consensus Factor (ICF) was calculated to determine the homogeneity of the information and degree of overall agreement in using plant species with medicinal values – the species that are used for treating health related problems at household level. The following formula was used

ICF=Nur-Nt/Nur-1

Here, Nur is the number of use reports mentioned by the informant for the given species and Nt is the number of taxa (species) used by majority of the households.

CHAPTER 4

4. RESULTS AND DISCUSSION

This chapter consists of two main parts: Results and Discussion. The results are organized under 4.1.1 to 4.1.7 subsections. Similarly, the discussion is organised into four subsections.

4.1 RESULTS

4.1.1 Richness and status of cultivated and uncultivated diversity

This study documents the presence and use of a range of cultivated and uncultivated diversity, including 177 crop cultivars from 36 families under 66 genera and 99 wild and non-cultivated edibles from 58 families under 75 genera. The diversity of crops includes both improved as well as traditional cultivars of rice (*Oryza sativa*), maize (*Zea mays*), highland barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), amaranth (*Amaranthus caudatus*), proso millet (*Panicum miliaceum)*, foxtail millet (*Setaria italica*), and finger millet (*Eleusine coracana*). Among the WNEPs, at least three – *Aconitum heterophyllum*, *Paris polyphylla*, and *Dioscorea hamiltonii* – are threatened by habitat loss and unsustainable harvesting and figure on the IUCN list of threatened species. These changes have implications for household level food, health, and nutrition security; for resilience in the face of climate change; and the loss of suitable cultivars that are well adapted to marginal lands, harsh conditions, and climate shocks.

The study also documents community perceptions of change, traditional knowledge, and local crop diversity management, including seed saving and sharing, and local adaptation and coping responses, such as changes to the cropping calendar and planting locations, mixed cropping, and the introduction of multipurpose trees.

4.1.2 Diversity of cultivated crops

Altogether, 177 types of cultivars belonging to 36 families from 78 cultivated crop species are cultivated by the farmers in the study villages (Appendix 4). Among the cultivated crops, Family Gramineae recorded the highest number of cultivars (55) followed by Leguminosae (36), Cucurbitaceae (20), Cruciferae (12) and Solanaceae (9). The major crops grown, and their cultivar diversity is presented in Table 2. Among

these, the greatest diversity was in maize, which includes 15 cultivars, come after paddy (12) and wheat (11) see table 2 for detail. The cultivars which were showcased during the diversity fair were described by the respondents. Most households (95) grow maize, followed by barley (94) and wheat (91). Besides staple crops, beans are also grown by 86 households on a relatively large scale (0.2 hectare). However, despite varietal diversity being high, most households only grow a few cultivars.

Table 2: Varietal diversity in major crops

Crops	**Local name**	**Botanical name**	**Cultivars' local name**	**Remarks**
Maize	*Ghoga* (15)	*Zea mays* L.	*Bhabari, Pahelo, Rato, Murali, Ragese, Temase, Bhate, Seto, Airkoti, Baktado, Male, Ghar, Baure, Bikasi, Marudi,*	Only one farmer continues to grow the *Baktado* cultivar, while other cultivars (such as *Rato* and *Ragase*) are also disappearing since farmers are not growing them due to their low production.
Paddy	*Dhan* (12)	*Oryza sativa* L.	*Khasare, Sali, Chamade, Takmaro, Roti dhaan, Jumli dhaan, Choti dhaan, Kirmuli dhaan, Jaili dhaan, Jau dhaan, Rato dhaan, Mangali dhaan*	*Sali dhan and Jau dhaan* are in a stage of extinction in Khar VDC; these are only being grown by few farmers, in a less than 0.1 hectare
Wheat	*Gau* (11)	*Triticum aestivum* L.	*Jumli bhoto, Dautkhane, Jhuse, Bhote, Thulo, Rato, Geru, Moto, Nangri, Haasa, bhoto, Lide, ,*	*Jhuse*, *Dautkhane, Haasa*, *Geru* and cultivars are already disappearing

Beans	*Sotta* (10)	*Phaseolus vulgaris* L.	*Kalo local, Seto local, Rato kirmire, Asali rajma, Kaleji kirmire, Marma, Bote Kalo, Temase, Ankhe Simi, Batule*	*Kalo and Seto* are grown from generation as the oldest cultivars however in recent time it is cultivated by less than 10 households in the area)
Finger millet	*Kodo* (7)	*Eleusine coracana* Gaertn.	*Kalo, Nang kate, Temase, Rato, Tiuli, Kodekauli, Mutke,*	These cultivars are disappearing because of their less yield
Barley	*Jau* (5)	*Hordeum vulgare* L.	*Jhuse, Mankare, Kalo, Seto, Thang Jau*	*Thang, Kalo and Jhuse,* cultivars are eroded from the area

Source: Aryal et al. (2017)

The largest number of cultivated crops are cereals and pseudo-cereals, followed by vegetables, fruits and spices. The list of the ten most important crops (cereals, vegetables, fruits, and spices) cultivated by many of the households is presented in Table 3. Most of these crops are grown for household purposes, except for maize and beans which are also sold in the local market. However, only 5 per cent of the households were found to depend entirely on self-grown food.

Table 3: Important crops for HH food and nutritional security

Cereals and Pseudo cereals	**Vegetables**	**Fruits**	**Spices**
Maize (*Zea mays* L.)	Potato (*Solanum tuberosum* L.)	Walnut (*Juglans regia* L.)	Prickly ash (*Zanthoxylum armatum* DC.)
Paddy (*Oryza sativa* L.)	Broadleaf mustard (*Brassica juncea* (L.) Czem.)	Banana (*Musa paradisiaca* L.)	Marijuana (*Cannabis sativa* L.)
Wheat (*Triticum aestivum* L.)	Taro (*Colocasia esculenta* (L.) Schott.)	Pear (*Pyrus communis* L.)	Ginger (*Zingiber officinale* Roscoe)
Finger millet (*Eleusine coracana* Garetn.)	Cauliflower (*Brassica oleraceae* var. *botrytis* L.)	Plum (*Prunus domestica* L.)	Perilla (*Perilla frutescens* (L.) Britton)
Barley (*Hordeum vulgare* L.)	Cabbage (*Brassica oleraceae* var. *capitata* L.)	Peach (*Prunus persica* (L.) Batsch)	Turmeric (*Curcuma longa* L.)

Buckwheat (*Fagopyrum esculentum* Moench.)	Brinjal/eggplant (*Solanum melongena* L.)	Lime *Citrus aurantifolia* (Christm.) Swingle	Chillies (*Capsicum annum* L.)
Proso millet (*Panicum miliaceum* L.)	Radish (*Raphanus sativus* L.)	Box myrtle (*Myrica esculenta*. Buch)	Cinnamon (*Cinnamomum zeylanicum* Breyn.)
Foxtail millet (*Setaria italica* (L.) Beauvois)	Tomato (*Lycopersicum esculentum* L.)	Indian gooseberry (*Phyllanthus emblica* L.)	Coriander (*Coriandrum sativum* L.)
Amaranth (*Amaranthus caudatus* L.)	Pumpkin *(Cucurbita maxima* L.*)*	Apple (*Pyrus malus* L.)	Garlic (*Allium sativum* L.)
Bitter Buckwheat (*Fagopyrum tataricum* Gaertn.)	Spinach (*Spinacia oleraceae* L.)	Guava (*Psidium guajava* L.)	Onion (*Allium cepa* L.)

Source: Field data collected during the diversity fair at Dallekh of Darchula district in 2016

But people also sell and exchange their crops. For example, beans are exchanged for rice with the local buyers – one kilogram of beans is exchanged for two kilograms of coarse rice – who visit the farmers during the bean harvest season. The cropping pattern is mostly mixed wherein different cultivars are planted together. The common practices are planting maize, beans, soybeans, and amaranths together; planting wheat and mustard together; and mixing millets and barley. Such techniques adopted by the farmers are aimed at getting maximum benefit from the land and getting more cultivars of crops in one season. However, despite such practices, number of cultivars is on the decline in the area.

Beans, locally known as *sotta*, are a socially, culturally, and economically important crop grown by most of the households in the study area. However, the farmers were not able to identify all the cultivars. Upon the request of farmers, made through the Khar Conservation Management Committee, for providing suitable, high-performing varieties, the ANCA and the former District Agriculture Development Office, Darchula, together with ICIMOD/RECAST under the KSLCDI programme, assessed the information regarding different cultivars of beans and established experimental plots and diversity blocks in the farmlands.

4.1.2.1 Diversity of local beans

Nine local bean cultivars (*Phaseolus vulgaris* L.) collected from the farmers were planted following the standard IBPGR descriptors (IBPGR, 1982) (Appendix 3). Seeds were planted in Randomized Complete Block Design (RCBD) to make sure the three replications and treatments are compared under similar circumstances. This research was technically supported by the National Gene Bank for characterization and to assign national accession numbers. Brief descriptions of the nine cultivars are presented in Table 4, and the seeds shape and colour of the nine cultivars planted in the experimental plots are presented in Figure 3.

Table 4: Brief information about nine bean cultivars and their National Gene bank collection numbers

Collection number	**Name of Local Cultivars**	**Collection from**			**Seed colour**
		District	**VDC**	**Altitude (masl)**	
KA-17-08-FB	*Seto sotta*	Darchula	Khar	1,500–2,150	Creamy white
KA-17-07-FB	*Temase rato*	Darchula	Khar	1,500–2,150	Maroon
KA-17-02-FB	*Kaleji kirmire*	Darchula	Khar	1,500–2,150	Dark red with white spots
KA-17-05-FB	*Marma sotta*	Darchula	Khar	1,500–2,150	Yellow peach
KA-17-09-FB	*Asali rajma* (*Seto kirmire*)	Darchula	Khar	1,500–2,150	black and red stripes in white base
KA-17-03-FB	*Rato kirmire*	Darchula	Khar	1,500–2,150	Red bran with white dots
KA-17-04-FB	*Ankhe thulo*	Darchula	Khar	1,500–2,150	Black shade in light maroon base
KA-17-01-FB	*Golo batule sotta*	Darchula	Khar	1,500–2,150	Creamy yellow
KA-17-06-FB	*Kalo local*	Darchula	Khar	1,500–2,150	Black

Source: Aryal et al. (2020)

Figure 3: Beans cultivars planted in the experimental plots

The phenotypic characterization of the beans showed diverse characteristics. The morphological characters of the nine cultivars are analysed and presented in Table 5. The qualitative variables were evaluated following the standard IBPGR descriptors 1982.

Table 5: Qualitative traits of the bean cultivars

NS	GT	PT	PS	IP	PCM	PCEIP	PBO	PBP	Seed Shape	Seed Colour	Leaf Shape
KA-17-08-FB	E	IC	G	NG	Y	SC	St	M	C	PW	T
KA-17-07-FB	E	IC	G	CR	R	SC	D	M	C	M	T
KA-17-02-FB	E	IC	G	CSG	PYCS	SC	St	NM	C	DRCS	Q
KA-17-05-FB	E	IC	P	DG	PY	S	St	M	KS	LB	T
KA-17-09-FB	E	IC	G	PSG	Y	S	D	M	C	LBPS	T
KA-17-03-FB	E	DBG	G	NG	Y	S	U	NM	KS	RLBS	Q
KA-17-04-FB	E	IC	P	NG	Y	C	D	M	C	PBS	R
KA-17-01-FB	E	IC	G	NG	Y	S	D	M	Ro	LB	Q
KA-17-06-FB	E	IC	G	PSG	PY	S	St	M	C	PB	T

Source: Aryal et al. (2020)

Note: Name of Species (NS); Germination Type (GT): Epigeal (E); Plant Type (PT): Indeterminate Climber (IC), Determinate Bushy Growth (DBG); Pod Surface (PS): Glabrous (G), Pubescent (P); Immature Pod (IP): Normal Green (NG), Carmine Red (CR), Carmine Stripe on Green (CSG), Dull Green (DG), Purple Stripe on Green (PSG); Pod Colour at Maturity (PCM): Yellow (Y), Red (R), Pale Yellow Coloured Stripes (PYCS), Pale Yellow (PY); Pod Curvature of Expanded Immature Pod (PCEIP): Slightly Curved (SC), Straight (S), Curved (C); Pod Beak Orientation (PBO): Straight (St), Downward (D), Upward (U); Pod Beak Position (PBP): Marginal (M), Non-marginal (NM); Seed Shape (SS): Cuboid (Cu), Kidney Shaped (KS), Round (R); Seed Colour (SCo): Pure white (PW), Maroon (M), Dark Red with Cream Streaks (DRCS), Light Brown (LB), Pure Black (PB), Purple with Black Streaks (PBS), Red with Light Brown Streaks (RLBS); Leaf Shape: Triangular (T), Quadrangular (Q), Round (R), Light Brown with Purple Streaks (LBPS)

Table 6 summarises the quantitative characteristics, including plant growth behaviour, which includes germination days, 50 per cent flowering days, and pod maturity days. All nine cultivars took three to six days to germinate in all sites. The 50 per cent pod maturity and 50 per cent flowering occurred earliest in Dhamidera (1, 536 masl) for all cultivars and took the longest time in Dallekh (2146 masl).

Table 6: Quantitative characteristics of the bean cultivars

Characteristics	**KA-17-08 FB**	**KA-17-07 FB**	**KA-17-02 FB**	**KA-17-05-FB**	**KA-17-09 FB**	**KA-17-03 FB**	**KA-17-04 FB**	**KA-17-01 FB**	**KA-17-06 FB**
Dhamidera (1,536 masl)									
days to germination	4.3	4.67	5	5	5	5	5.67	6	3
days to 50% flowering	61	41	49	41	49	46	63	41	40.33
days to 50% pod maturity	96	61	69	68.67	70	74	96	92.67	74
days to 90% pod maturity	109	104	104	104	104	104	104	104	104
number of pods	9.16	23.3	31.3	32.33	18.33	16.67	9.5	29.67	13.67
length of pod	12.56	14.4	17.03	16.86	11.83	13.16	15.37	14.23	12.67
breadth of pod	1	1.5	1.5	1.5	1	1	2.5	1.5	2
seed per pod	7	7	7	5	6.33	4	4	7	7
100 seeds' weight (gm)	32	37.87	51.22	64.33	37.18	44.96	98.03	48.93	30.32
Sundamunda (1,862 masl)									
days to germination	4.33	4.33	5	5	5	5	5.67	6	5
days to 50% flowering	65	41	49	41	49	46	66	41	41
days to 50% pod maturity	98	67.33	70	69.67	70.67	76.33	98	91	75
days to 90% pod maturity	109	104	104	104	106	104	104	104	104
number of pods	12.33	17	29.33	19.33	15.67	12.67	7.83	23	12
length of pod	13.4	14.06	17.1	16.67	11.46	12.3	14.16	14.13	11.67
breadth of pod	1	1	1.5	1.5	1	1	2.5	1.5	2
seed per pod	6.67	7	7	5	6	4	4	7	7
100 seeds' weight (gm)	33	37.2	50.67	63.76	36.43	44.53	97.36	49	29.73
Dallekh (2,146 masl)									
days to germination	4	5	4.3	4.67	4.3	4.3	4.67	5	5
days to 50% flowering	64	42	41	41	41	43	67	42.3	41
days to 50% pod maturity	102	67.3	90	69.67	71.67	75	98	96	75
days to 90% pod maturity	109	104	104	94	104	97	104	104.67	104
number of pods	9.67	14	20.33	18	12	15.33	10.33	20.67	12.67

length of pod	13.93	15	16.93	15.67	11.67	12.83	12.9	14.56	12
breadth of pod	1	1.5	1.78	1.5	1	1.93	2.16	2.1	1.93
seed per pod	7	8.3	6	5	5.67	4	4	7	7
100 seeds' weight (gm)	35.33	36.76	51.4	63.36	37	43.43	96.95	48.51	30.3

Source: Aryal et al. (2020)

Each cultivar was assessed for 100-seed weight. The oldest cultivar *kalo* local is the lowest 100 seed weight having 30.32 g only, while KA-17-04-FB recorded highest with 98.03 g (Table 6). In terms of overall yield, *Kaleji Kirmire* (KA-17-02-FB) recorded the best yield among all, with 4.48 (t/ha) in the lower altitude (Dhamidera), followed by 4.16 (t/ha) in Sundamunda and 2.80 (t/ha) in Dallekh. This shows that higher temperatures are favourable for beans production. The average maximum temperature of Dhamidera is 27.78°C compared to 20°C in Dallekh and Sundamunda (DNPWC, 2017a). Kruskal- Wallis test was performed to find out whether there is significant differences between the nine cultivars and the characteristics measured. Substantial differences were noted between the cultivars and the characteristics except the days to germination.

The local cultivars KA-17-08-FB and KA-17-06-FB are perhaps no longer in cultivation due to less yield, despite of their better taste. These cultivars need to be taken up for promotion as local product through product diversification and market linkages. KA-17-02-FB is the high yielding variety among all in Dhamidera and Sundamunda. This is recommended for the lower altitudes. However, the cultivar KA-17-01-FB showed better yield in Dallekh, at a higher altitude. Thus, these cultivars can be promoted in similar agroecological zones in the country

4.1.3 Diversity of WNEPs

During the study period, a total of 99 WNEPs used for food, medicine and various other purposes were identified and documented (Appendix 5.). These plants belong to 58 families and include 96 angiosperms, 1 gymnosperm and 2 pteridophytes, including one endangered (EN) species (*Aconitum heterophyllum*), one vulnerable (VU) species (*Paris polyphylla*), and one near threatened (NT) species (*Dioscorea hamiltonii*). *Dioscorea deltoidea* is included in the CITES Appendix II (Joshi *et al*., 2017).

Among the families, Moraceae comprises 7 species under 2 genera; Rosaceae comprises 6 species under 4 genera; Urticaceae comprises 5 species under 5 genera; Urticaseae comprises 5 species under 5 genera; Amaranthaceae comprises 4 species under 2 genera; Polygonaceae comprises of 4 species under 2 genera; Dioscoreaceae comprises of 3 species under one genus; Myricaceae comprises of 3 species under 2 genera; Lamiaceae comprises of 3 species under 2 genera. The detail of species is presented in Appendix 4. A breakup of the most common life forms is presented in Figure 4. The life form includes 36 species herbs, 35 species trees, 15 species shrubs, 11 species creepers and 2 species pteridophytes.

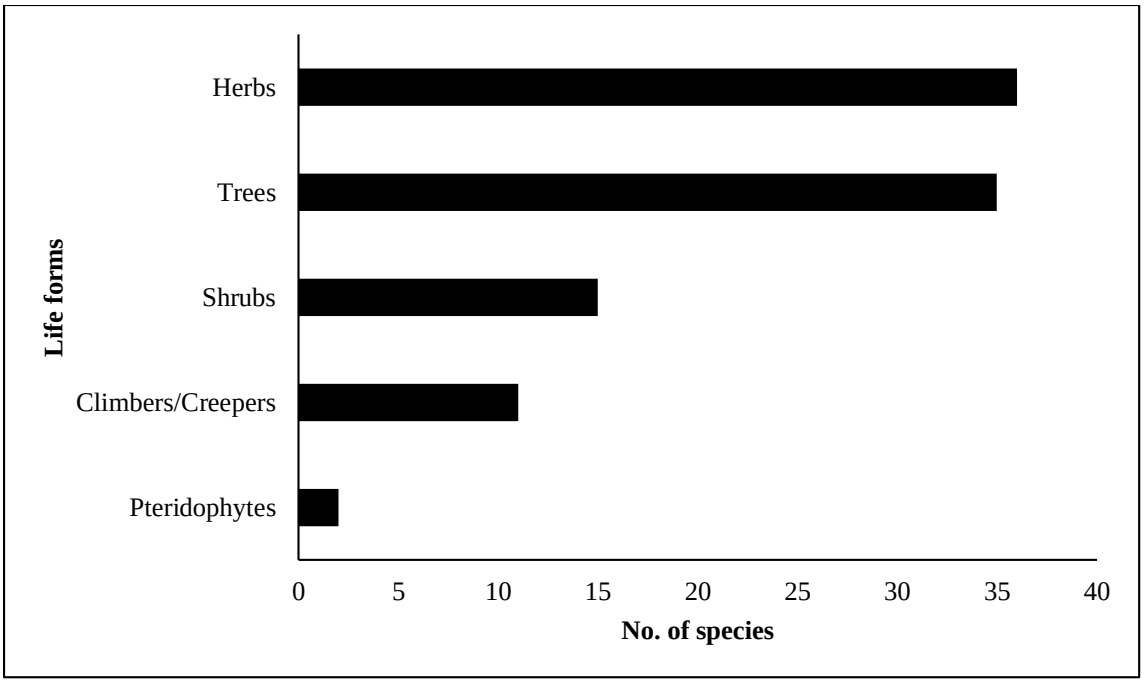

Figure 4: Life forms of WNEPs diversity

4.1.3.1 Role of WNEPs to food and nutritional security

Households used diversity of WNEPS for food, medicine, spice, and for religious and cultural purposes. The most uses (Figure 5) were for food (40 species as fruit, 31 as vegetable), medicine (30 species) and as spice (10 species); 16 species were used for other purposes. This study documented 35 species as having multiple use value which means that the same species is used for food and medicine and for cultural and religious purposes.

As mentioned in the earlier section, among the WNEPs, 40 species of fruits and 31 species

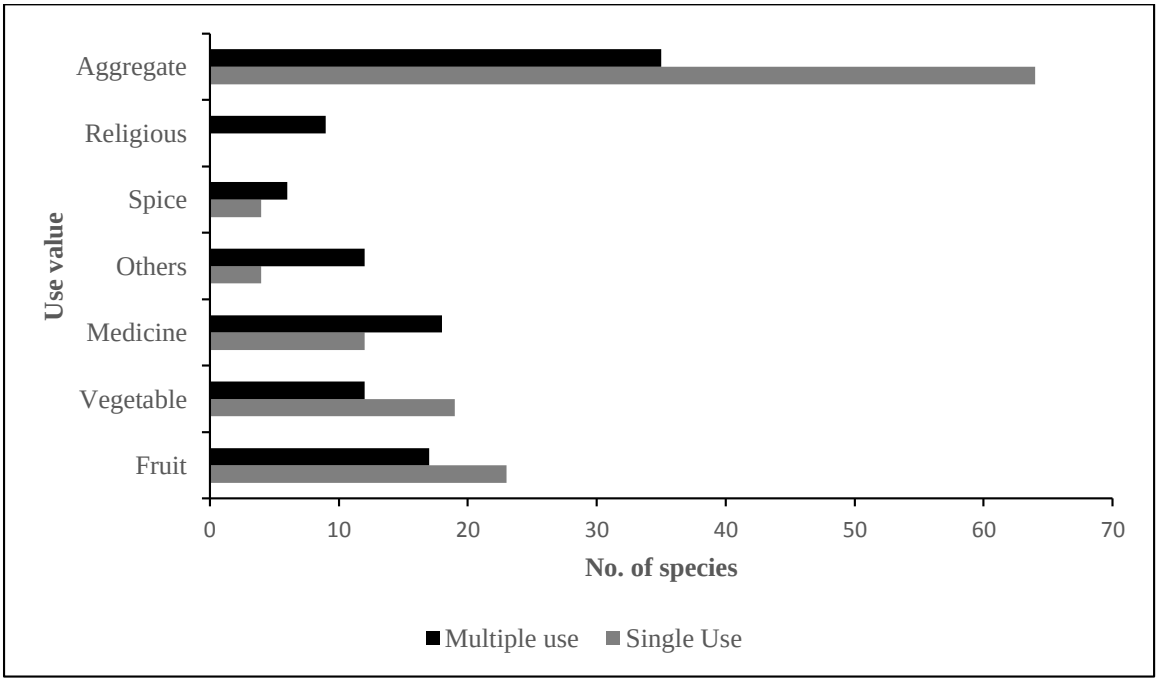

Figure 5: Uses of WNEPs

of vegetables are used during the season of their availability (Appendix 4). These species are considered as important source of family nutrition and contribute highly to meeting their daily vegetable requirements. During the household survey, respondents reported using WNEPs regularly as vegetables. Among these, *Paeonia emodi*, *Fagopyrum esculentum*, *Dryopteris cochleata* are collected the most along with *Dioscorea bulbifera*, *Dioscorea deltoidea*, *Urtica dioica*. About 92 per cent of respondents reported using WNEPs for day-to-day vegetable item during the season of their availability, with 75 per cent depending on them for one to three months and 10 per cent for more than three months of the year (Figure 6).

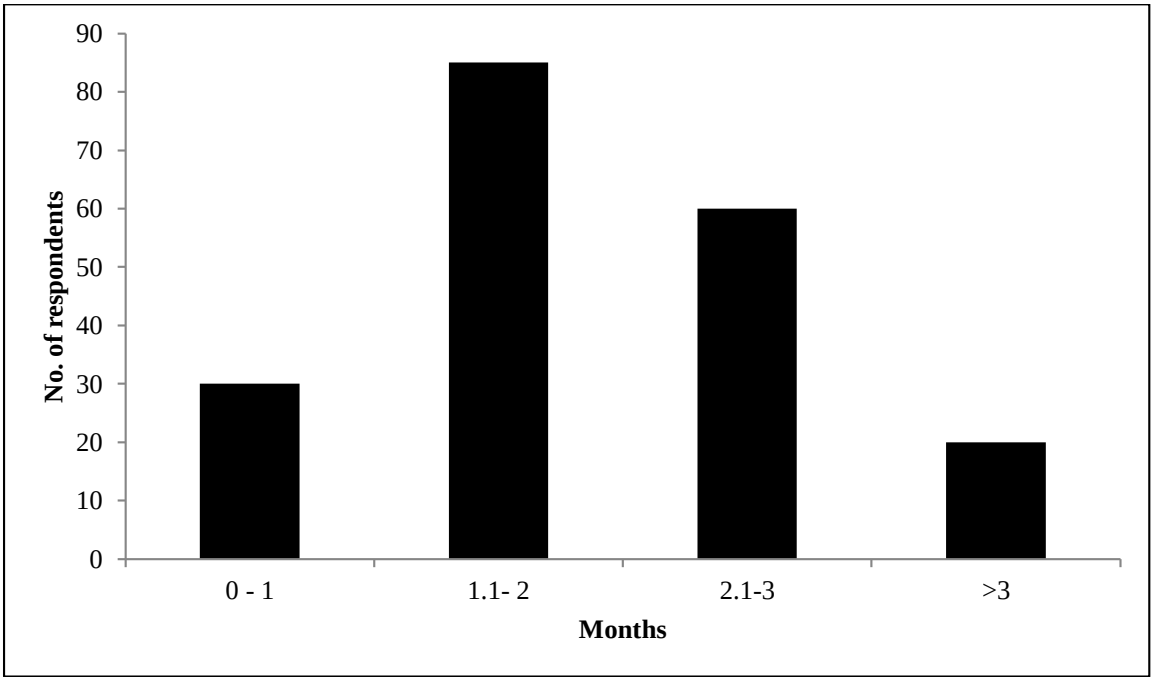

Figure 6: Household dependence on WNEP vegetables for their daily requirements

Species that are frequently used are harvested the most. The five most used WNEPs, as reported during the FGDs, is presented in Table 7. One of the most widely used species is *Paeonia emodi*; annually, on an average, each household uses 150 kg of it; this is followed by *Fagopyrum esculentum* at 110 kg (Figure 7). The study further analysed the use value or the relative importance of the most harvested vegetables. While the seasonal harvest of *Paeonia emodi* and *Fagopyrum esculentum* is far more than *Dryopteris cochleata* (Figure 6), the latter's use value (0.98) is greater than that of *Paeonia emodi* (0.96) and *Fagopyrum esculentum* (0.74) (Figure 8). The reasons behind the higher use value of *Dryopteris cochleate* mentioned were that they are nutritious and taste better as well as use to make multiple recipes like fried and curry vegetable, use for making pickles. The photographs of wild vegetables which is highest harvested (*Paeonia emodi*) and most used (*Fagopyrum esculentum*) is presented in Appendix 6

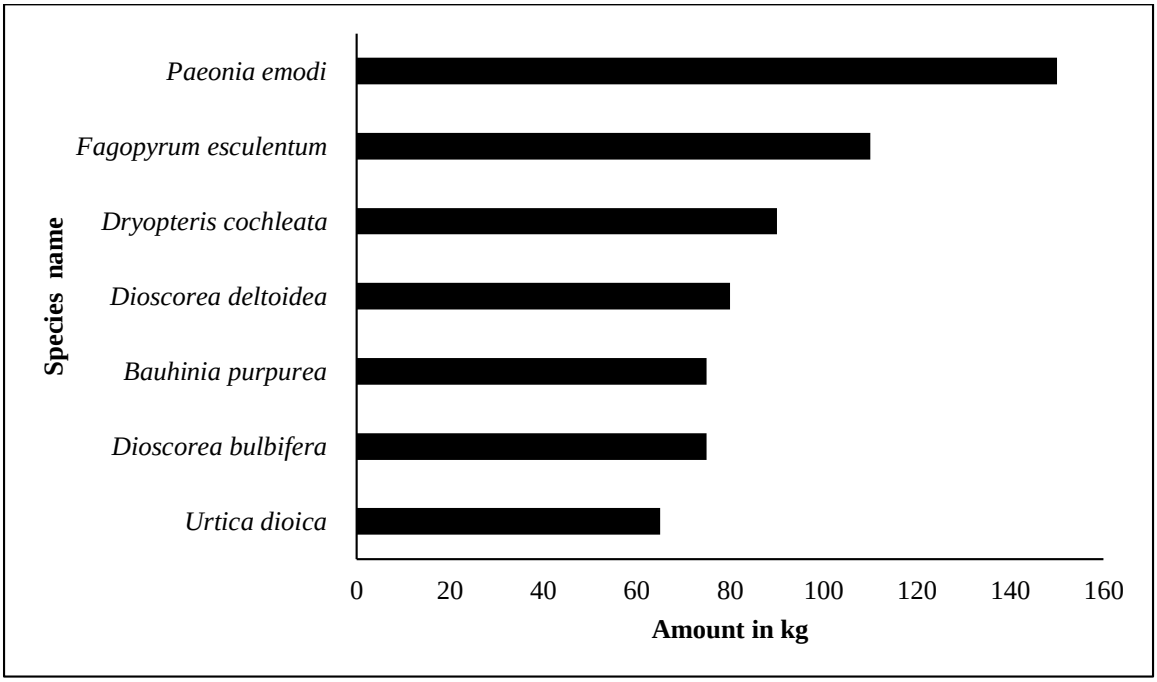

Figure 7: Average harvesting/collection per annum of wild vegetables per household

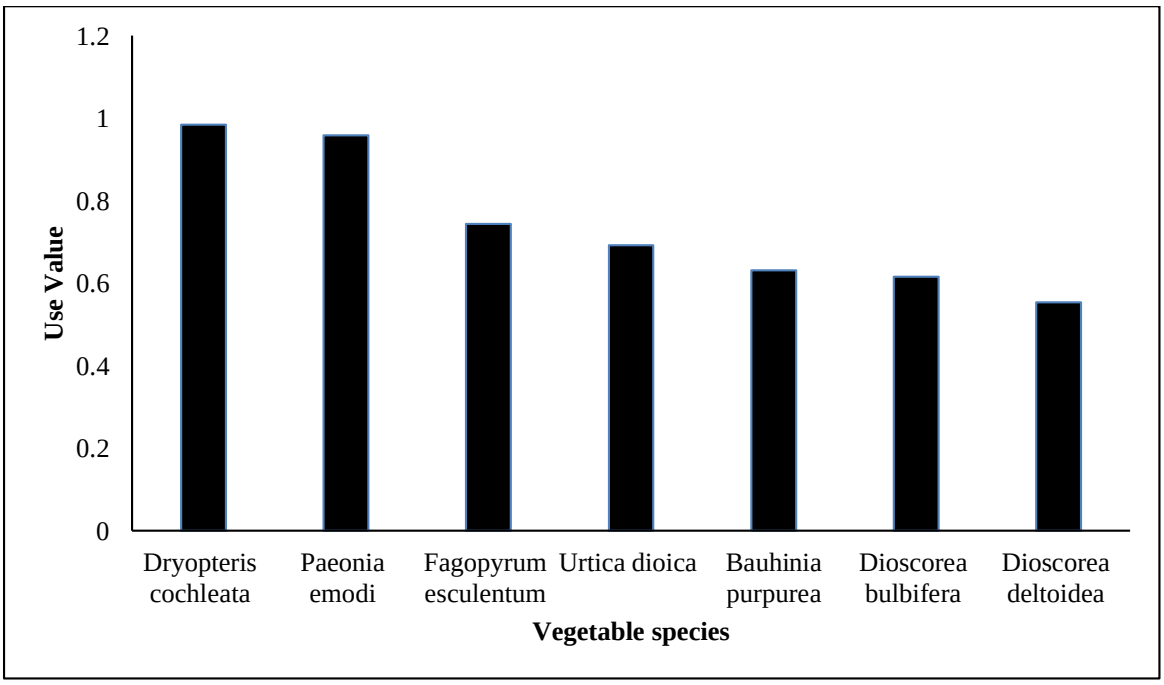

Figure 8: The use value of frequently used wild vegetables

Table 7: Five most used WNEPs in the study area

Scientific Name	Local Name	Use Value	Parts Used	Remarks
As vegetable				
Paeonia emodi Wall. ex. Royle.	*Hetto*	Vegetable, medicine	Leaves, young shoots	Young shoots and leaves are eaten when it is in season; they are also cut and dried for use in the winter season when vegetables are scarce. The dried leaves and shoots are soaked in hot water and then cooked. This green vegetable is also given to diarrhoea patients. Indigenous peoples and local communities (see photograph in Appendix) commonly use this.
Dryopteris cochleata (D. Don.) C. Chr.	*Liundo*	Green vegetable	Young shoots and coil fronds	Young shoots and coiled fronds are used as green vegetable. Very tasty and nutritious and use for making pickles except the use as vegetable
Fagopyrum esculentum Moench	*Phanpar*	Green vegetable	Fresh leaves and young shoots	Tender leaves and shoots are consumed as greens. It is believed that excessive consumption can cause dizziness.
Urtica dioica L.	*Sisnu*	Vegetable used in curry	Young shoots and leaves	The young shoots and leaves are plucked carefully, boiled, and cooked to be part of a curry that's mixed with flour.
Dioscorea hamiltonii Hook. f.	*Ban taud*	Vegetable and as snacks	Tubers and bulbils	Tubers and bulbils are usually boiled and cooked. Sometimes, they are just boiled.
For cultural/social purposes				
Fragaria nubicola Lindl. ex. Lacoita	*Gande kafal*	Needed during funerals	Whole plant, flower, fruit	Whole plant or just flower or fruit is used during funerals as part of *pinda*, the offering made to the departed soul. This plant is considered pious and is an essential part of funerals.
Rubus foliolosus L.	*Kalo anselu*		Leaves or whole plant	Whole plants are needed for performing funeral rituals.

Cannabis sativa L.	*Bhango*	For making clothes	Fibre	The fibre from the plant is traditionally used for making clothes.
Boehmeria rugulosa Weed.	*Githi*	Used as soda	Bark	The paste or powder of its bark is used in the preparation of *sel roti*, a traditional ring-shaped sweet rice bread; the paste or powder acts as soda and makes the roti soft and tasty.
Gonostegia hirta **(**Blume) Miq	*Attinno*	Consumed as chapatti	Roots	Chapattis are prepared by grinding its roots.
Amaranthus viridis L.	*Ghiya marshi*	Consumed as vegetable and as chapatti, *geda* (sweet dish)	Fresh leaves, young shoots, seeds	The chapatti flour is made by grinding the amaranth seeds and the dough is prepared from the flour by mixing with water. In the case of amaranth seeds, they are used to make laddoos (locally known as *geda*) wherein the seeds are fried in ghee and honey is added to it.
As medicine				
Aesculus indica (Colebr.ex Cambess) Hook	*Pangar*		Fruit or seed	Roasted fruits are taken to cure worms in the stomach.
Phytolacca acinosa Roxb.	*Jarka*		Leaves	The leaves are consumed to treat dizziness.
Bauhinia variegata L.	*Koiralo ko phool*		Buds, flowers	Buds and flowers, taken as vegetables or boiled in water and cooled, are used to treat bacillary dysentery.
Angelica archangelica L.	*Ganano*		Rhizome	The rhizome is dried, and the powder is used for curing stomach pain, excessive urination at night and ulcer.
Viola vetonicifolia Smith.	*Juke jhar*		Leaves and dry roots	The leaves and roots are soaked in hot water and given to children to cure them of worms in the stomach. Even a garland of dry roots, with seven knots, is hung around the neck of children in the belief that it will

				prevent them from being vulnerable to worms.
As raw fruit				
Phyllanthus emblica L.	*Aaula*		Fruits	Dry pickle is also prepared from the fruits.
Juglans regia L.	*Okhad*		Fruits	It has a high market value.
Rubus ellipticus Sm.	*Ainselu*		Fruits	It is widely consumed as a wild fruit and is popular among children.
Berberis asiatica Roxb. ex. DC.	*Kirmada*		Fruits	It is widely consumed when in season.
Myrica esculenta Buch.Ham. ex D. Don	*Kaphal*		Fruits	It is considered a tasty fruit.

Source: Field survey data (2016)

4.1.4 Land use and land cover change and its implications on crop diversity

A four decadal land use and land cover change analysis was done by preparing maps which were also compared with people's own indication of the changes over the time. See Figure 9-12 for the LULC of the study area.

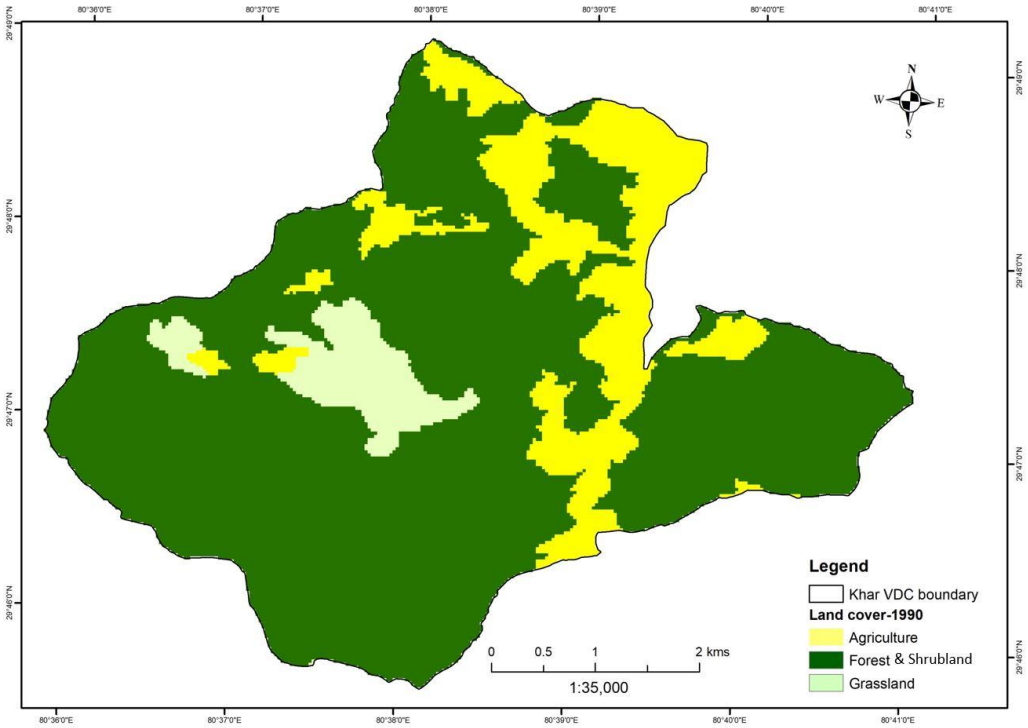

Figure 9: Land cover map of the study site (1990) (Source: ICIMOD)

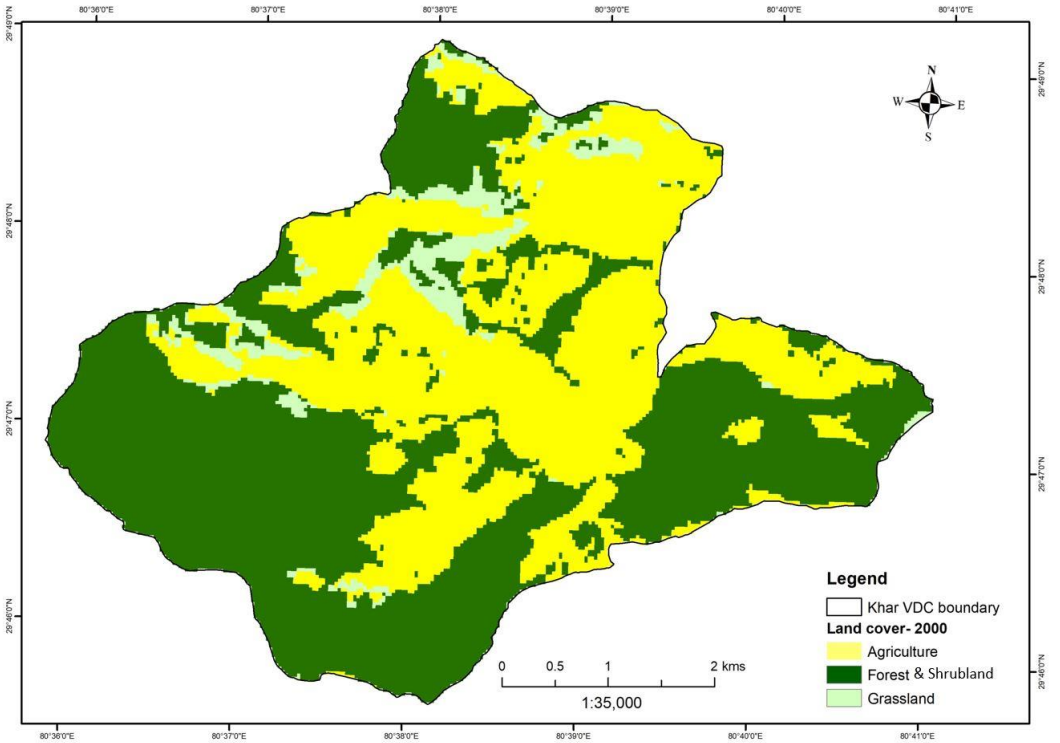

Figure 10: Land cover map of the study site (2000) (Source: ICIMOD)

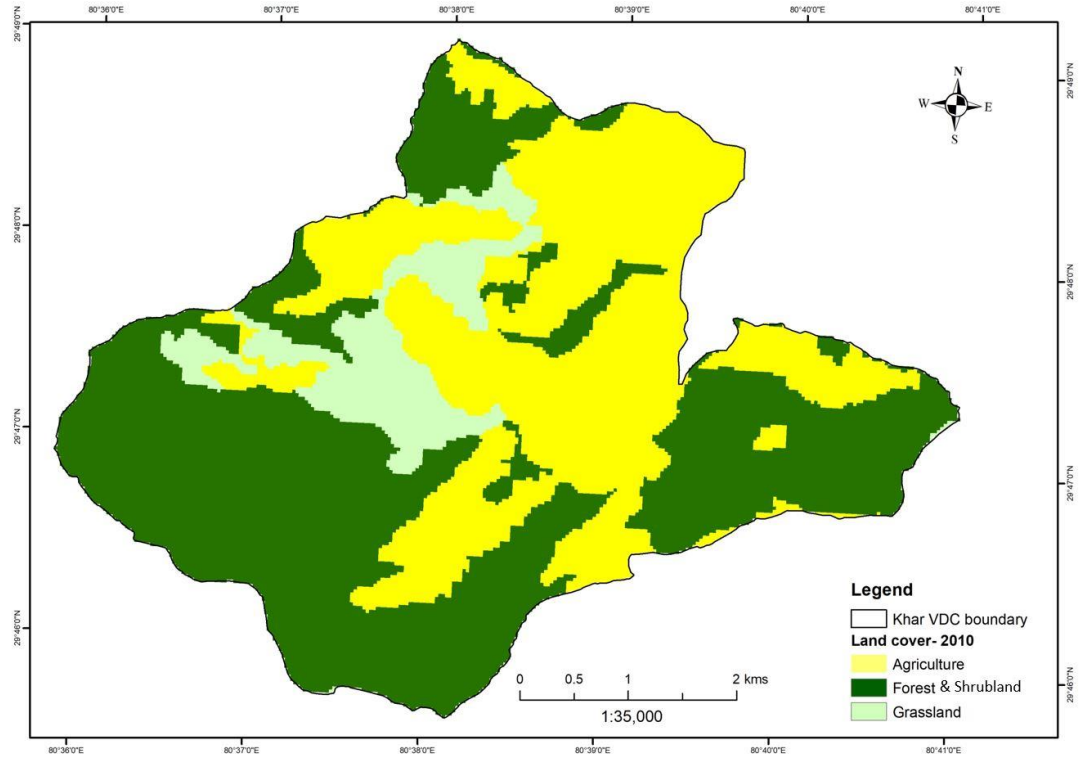

Figure 11: Land cover map of the study area (2010) (Source: ICIMOD)

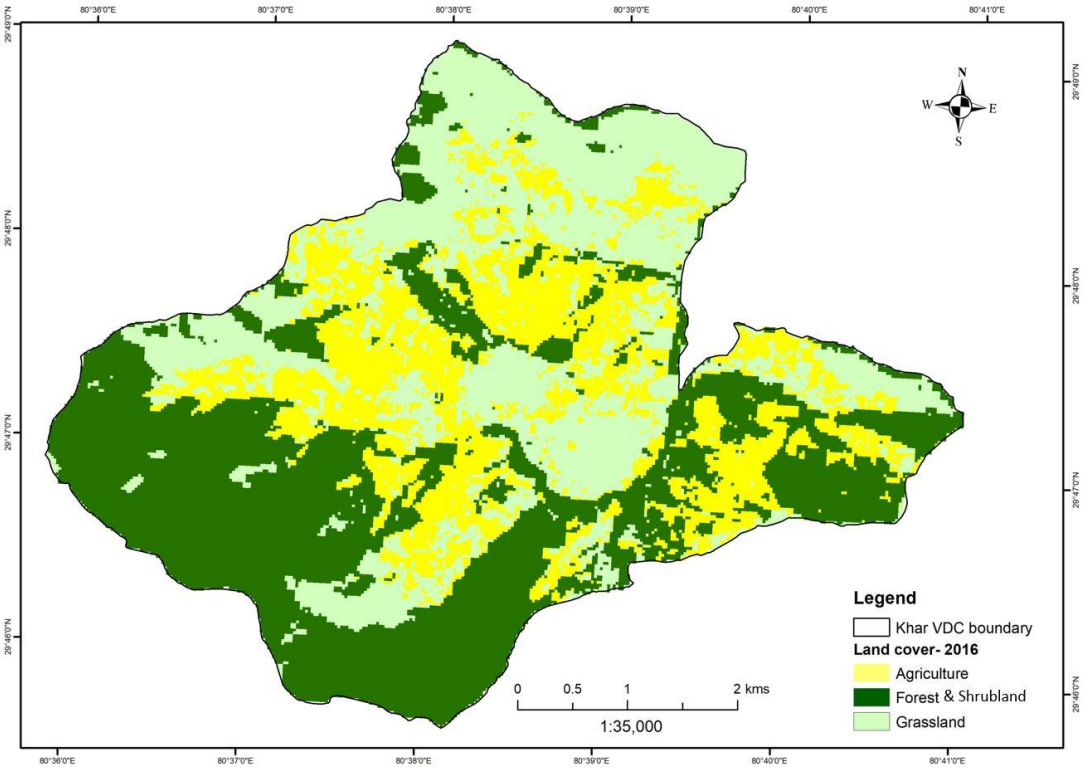

Figure 12: Land cover map of the study area (2016) (Source: ICIMOD)

The analysis showed that the study area has been experiencing a lot of dynamics during the last few decades (Figure 13). Most of this could be linked to anthropogenic factors and, to some extent, to changes in climatic patterns. More than 70 per cent of Nepal's

rural population depend on forest resources for their daily livelihood, which makes forest ecosystems vulnerable to degradation. In the year 1990, forests covered the largest land area (62 per cent or 15.32 km^2) of Khar VDC, followed by grasslands (20 per cent or 4.91 km^2); the least land area (18 per cent or 4.41 km^2) was covered by agricultural lands. By the year 2000, there was a substantial increase (by around 24 per cent or of 6.38 $km^{2)}$ in the area covered by agricultural lands, which resulted in a decrease in the grassland area by 3.14 km^2 and a minor decrease in the forest area by 2.24 km2. By 2010, land cover remained like that of 2000; however, in 2016, the grassland area has increased significantly which could be attributed to a decrease in forest cover by around 13 per cent (3 km^2) and a reduction in agricultural area by 13.5 per cent (3.36 km^2).

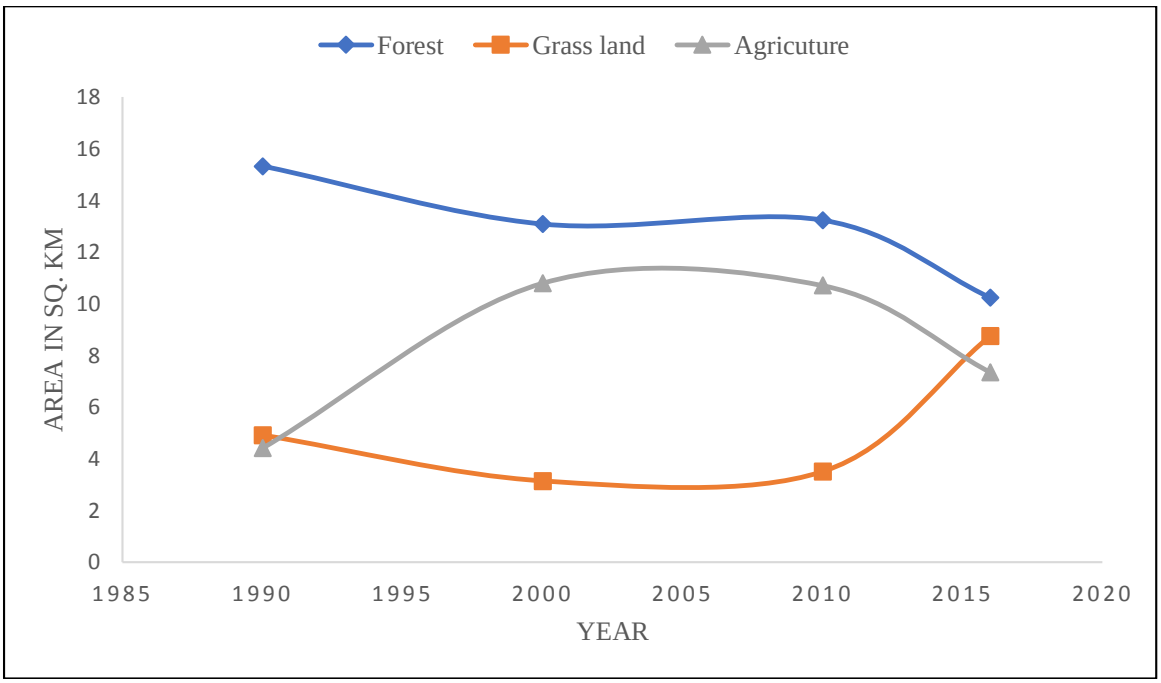

Figure 13: Trend of land use and land cover change over time (1990 to 2016)

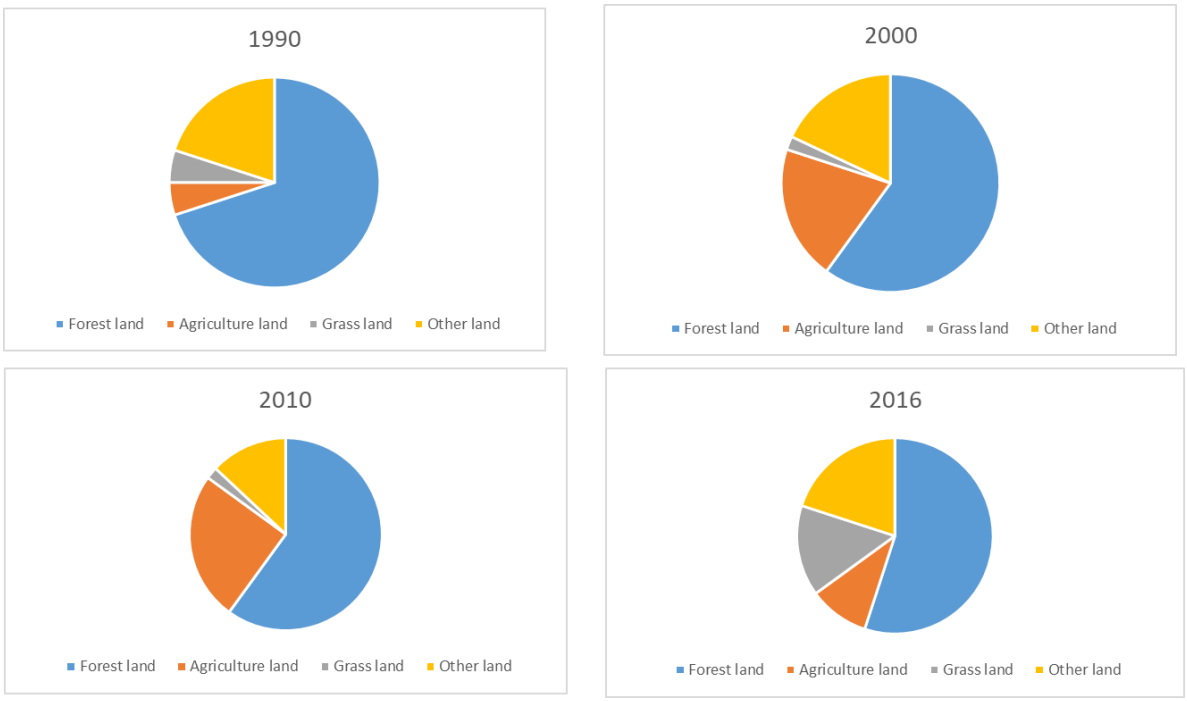

Figure 14: Local perceptions on land use and land cover change

Farmers' perceptions and their indicative percentage on these land use over four decades is like that of a geospatial analysis carried out by ICIMOD (Figure 14). The most notable change can be seen in agriculture land which used to be 5 per cent in 1990 and then increased in 2000 by 15 per cent and 5% more in 2010. Much of this was due to government incentivizing agricultural expansion and production through promotion of high-yielding varieties, particularly maize. This includes those private shrublands that was put to production. However, this trend reduced by almost 15% in just six years' time (in 2016). Seasonal outmigration mostly to India, declining interest in agriculture work particularly among the youth, and high income from yar-tsha-gunboo and non-timber forest products are reported as the major drivers of change in the decrease of agricultural land. Similarly, prolonged dry periods and less rainfall and snow are mentioned as the climatic factors leading to a decline in agricultural land. On the other hand, grasslands increased by threefold in area from 1990 (5 per cent) to 2016 (15 per cent). So, abandoned agricultural lands became grasslands (Figure 12).

These factors have had both positive and negative effects on crop diversity management. The perception about area of cultivation of major crops like rice, barley, millets, wheat, and potato has decreased significantly, however the area under maize cultivation has increased in a decade's time. The area under grain amaranth, finger millet which used to be grown on marginal land has decreased due to abandonment of

the land (see cultivated amaranth photographs in Appendix 6). The reasons behind the decline in the cultivation of barley and millets are that they have extremely low market demand although they require less input than other crops. As for wheat, long dry spells and less or no rainfall during the winter season has reduced its cultivation area. In case of paddy which is grown only in the lower belt of Khar VDC, its cultivation area has reduced due to longer dry periods and the decline in regular water sources. Besides, most of the farmers (65 per cent) say that growing paddy requires more inputs and labour, while the crop is also prone to diseases, pests, and failure.

4. 1.5 Local knowledge on crop/plant diversity management

The people of Khar Village have been practising their age-long traditional techniques of diversity management and passing them on to generations, thereby contributing to maintaining a rich culture and heritage. They have auspicious days to start the planting or harvesting of crops. The customary practice is "*Som Kheti Budh Ghar*", meaning "Planting crops on Mondays and Harvest crops on Wednesdays". They consider Monday as an auspicious and lucky day for planting and even if they cannot plant the whole crop, they will begin the planting on a Monday. Harvesting is mostly done on Sundays and Wednesdays. As for protecting seeds from pests and insects, they are mixed with ash and mustard oil and even milk, especially in the case of maize and wheat seeds, and stored in large wooden utensils and a layer of mud and cow dung is applied to protect the grains from decay. When the harvest is stored and then taken out for the first time, there is a tradition of conducting a small ritual by burning incense sticks and mixing oil and leaves and sprinkling it on coal. It is believed that the smell from this will help in the purification of the harvest.

Traditional knowledge regarding crops and cropping practices is maintained by both men and women equally. The famers consider local crop cultivars to be more nutritious and with many medicinal values. For example, the soup prepared from the local white and black beans is considered ideal for curing fever. They also have festival called *Maijaaro* after wheat plantation when they organize a big feast for the farm animals, especially for bullocks that had worked hard during the monsoon and brought in a rich harvest for the family. During this feast, the cattle are decorated with flowers and fed with grain delicacies. In the autumn and winter months, the cattle are given a good diet and not used for ploughing.

The role of traditional knowledge and practices in crop diversity management, especially in adaptation to climate change, is important. The farmers in the study area have been experiencing various climatic and non-climatic changes in their area. In Table 8, farmers' key knowledge in various aspects and common examples of their traditional practices in crop diversity management are presented.

Table 8: Farmers' traditional knowledge on crop diversity management

Local knowledge and practices	**Adaptation strategies**
Knowledge about climate forecasting	The farmers use local cultivars and associated knowledge to adapt to climate change. For example, the farmers at the study site have grown a local wheat variety called *dautkhane* which is grown at lower altitudes; this was in response to rising temperatures.
Knowledge about local resource utilization	They use plant debris as mulch, especially for ginger and turmeric crops, to protect them from insects/pests and weeds. This also helps to reduce water use. They also use ash to protect the vegetable crops from being damaged by aphids (*lahi kira*).
Knowledge about selecting the right crop	The people in the study area cultivate *dautkhane*, a local wheat variety, when they think that a year's dry period will be longer. They also think that this cultivar is drought resistant.
Knowledge about seed management	Farmers select seeds based on preferred and adaptive characteristics. Due to many male outmigration, the local cultivars are in the hands of women and the elderly, most of whom are experienced in seed selection. The farmers share seeds of various traditional cultivars and hence enhance crop diversity on most farms; (this also helps in avoiding the clustering of specific cultivars in only certain areas. What this does is it ensures the survival of the cultivars even when there is total crop failure in some parts of the community area.
Knowledge about the use of crop wild relatives	The local communities use several wild edibles to supplement their diets. During the season of its availability, they carefully harvest the plant parts and then store them so that they can be used for food in the future. These crop wild relatives are also domesticated in their home gardens

	for sustainable utilization and to be conserved as genetic resources.
Knowledge about resilient properties	The farmers grow fast- and slow-maturing variants together to reduce risk of crop loss. Like in the case of *khasare*, a local paddy cultivar that matures early, which paves the way for the cultivation of potato and other vegetables; this improves the household income.
Knowledge about soil fertility management	Some of the traditional practices used by the famers for soil fertility management are use of farmyard manure, green manuring, in situ manuring such as keeping animals in open fields; crop rotation; fallowing; and mulching.

The farmers in the study area still grow several traditional crops for cultural, ritual, and medicinal purposes. Besides, most households use many wild and uncultivated edible plants, and they have a deep knowledge related to their specific uses. When the farmers perceive that a particular species has use value, they will conserve it with priority. This kind of conservation through the utilization approach enhances genetic diversity management. In this study, the older people revealed that they depend heavily on plant sources for treating several human and livestock aliments. About 98 per cent of the respondents said that they use different plants and their parts for medicinal purposes. Few medicinal plants and their use are presented in Table 9.

Table 9: Local knowledge and use of WNEPs for health care

Common name	Scientific Name	Medicinal Use
Jarak	*Phytolacca acinosa* Roxb.	The leaves are supposed to cure dizziness, especially when one has had excess buckwheat.
Pangar	*Aesculus indica* (Colebr.ex Cambess.)	Roasted fruits are consumed to kill worms in the stomach.
Pani amala	*Nephrolepis cordifolia* (L.) C. Presl	The tubers get rid of worms in the stomach.
Ganano	*Angelica archangelica* L.	The rhizome is used for curing stomach pain and ulcers.
Atish	*Aconitum heterophyllum* Wall. Ex Royle.	The entire plant and its roots are used in the treatment for reducing the swollen muscles, high fevers, and abdominal pains.
Koiralo	*Bauhinia variegata* L.	Buds and flowers are used to treat bacillary dysentery.
Airal	*Cucumis sativus* L.	The fruit is used to cure fever and stomach pain.
Salla	*Pinus roxburghii* Sargent	The resin is used for clearing blood clot.
Barro and *Bojho*	*Terminellia bellirica* (Gaerth.) Roxb. And *Acorus calamus* L.	The fruit of *barro* and the rhizome of *bojho* are used for curing cough and common cold.
Banmara, *Majitho* and *Gandhe*	*Ageratina adenophora* (L. King & Robinson), *Rubia manjith* Roxb. Ex Fleming and *Ageratum conyzoides* L.	The leaves are used for treatment of cuts and wounds.
Juke jhar	*Viola vetonicifolia* Smith.	The leaves and roots are given to children to get rid of worms in the stomach.
Akash beli	*Cuscuta reflexa* Roxb.	The whole plant is used for cattle when it suffers from cough and cold.
Guras	*Vigna angularis* (Wild.) Ohwi & Ohashi	The soup of the grains of this species is believed to be a cure for chickenpox (*theula*).

Source: Field survey 2016

Traditionally, the local healers have been using raw herbs and shrubs to prepare drugs; for this, they rely both on personal experience and handed-down knowledge. Such

natural remedies are prescribed and used regularly and are considered inexpensive and effective, with fewer adverse effects than allopathic medicines. Besides, such use of these species not only saves the money of treatment, but also save and conserve these species for future availability and use. Hence, such traditional knowledge and practices are quite helpful in conserving genetic diversity.

4.1.6 Threats to crop/plant diversity management and factors affecting it

Despite having excellent diversity in terms of both cultivated and wild/non-cultivated crops, the study area reported a recent decline in the number of local cultivar crops. During the participatory exercises (FGDs, KIIs and Four Cell analysis), the respondents mentioned that they cultivated a diversity of local crop cultivars in the past, but that is not the case now. The cultivation of local crops like foxtail millet, finger millet, proso millet, amaranth, rice bean and buckwheat has declined over the last decade. Today, even finding the seeds of these crops is extremely difficult. An older cultivar of wheat (*Malaya*) has been reported lost. Many old cultivars of barley, maize and beans are difficult to find today (Table 10). The current trend showed that crop cultivars if not managed can erode unnoticed. This will lead to reduced local crop diversity, increase farmer vulnerability to climate change, and undermine the resilience of traditional farming systems. Table 10 lists some of the threatened and lost cultivars. More cultivars could be permanently lost if proper conservation and management plans are not put in place.

Table 10: Threatened and lost crop cultivars

Crop	Local name	Botanical name	Threatened cultivars	Lost cultivars from the study area	Remarks
Paddy	*Dhan*	*Oryza sativa* L.	*Chamade, Oskalo, Gataalo*	*Jau dhan, Sali dhan, Kirmuli dhan*	Most of these cultivars in the threatened list are on the verge of genetic erosion. Currently, very few farmers are growing these cultivars, and that too in small areas.

Wheat	*Gau*	*Triticum aestivum* L.	*Dautkhane, Bhote, Lide, Jumli bhoto, Nangri bhoto*	*Malaya, Jhuse, Haasa, Geru*	*Dautkhane, Bhote* and *Nangri bhote* cultivars are grown by only a few households.
Maize	*Ghoga*	*Zea mays* L.	*Bhabari, Rato bilas*	*Baktado, Ragase, Rato bilaas*	Local cultivars of maize are being lost due to their low yield and the introduction of improved cultivars.
Finger millet	*Kodo*	*Eleusine coracana* (L.) Garetn.	*Mudke, Rato, Temase, Tiuli, Kodekauli*	*Nang kate, Kalo*	All the cultivars are on the verge of genetic erosion due to shift towards new high-yielding cultivars.
Barley	*Jau*	*Hordeum vulgare L.*	*Mankare, Seto*	*Jhuse, Kalo, Thaang*	Even the *Mankare* variety is grown by only a few households.
Beans	*Sotta*	*Phaseolus vulgaris* L.	*Rato kirmire, Kalo local Seto local, Bote Kalo, Kaleji kirmire, Ankhe simi, Batule,*		*Kalo and Seto* – two of the oldest cultivars – are grown by fewer than 10 households today.

Source: Aryal et al. 2017; field survey, 2016

4.1.6.1 Farmers' perceptions on crop/plant diversity loss

The respondents highlighted both natural and anthropogenic factors for loss of crop diversity (Table 11). A brief information about the drivers and the reasons of loss based on local knowledge and experiences is presented in table below.

Table 11: Key threats to crop diversity

Key Threats to Crop Diversity Management	**Loss Reported by Farmers**
Environmental: Land use and land cover change, climate change	- Increased temperature, drought, and incidence of diseases and pests result in crop loss - Phenology, productivity, and incidence of disease altered by climate change

	- Abandonment of agricultural field due to changes in land use, leading to loss of local cultivars - Weed infestation (invasives) results in the loss of local cultivars
Social: Increasing population, rural development, and the local people's aspirational attitude towards urbanization	- Fragmentation of land due to property partition. - Infrastructure development has enabled the penetration of market forces in rural areas; this has resulted in market-oriented cash cropping at the cost of subsistence crops - Interest in agriculture work is declining, particularly among the youth; furthermore, the education system does not encourage/motivate youth to join agriculture-related courses
Economic: Local and district market forces, promotion of cash and improved crop cultivars gradually replacing subsistence farming	- The diversity of local cultivars is being replaced by a few high-yielding hybrids, for example maize and potato. - Declining interest in agriculture, particularly among the youth due to short-term cash opportunities; for example, most of the youth go for the collection of yar-tsha-gunboo during its season since it is profitable - Unavailability of farm labour - Agricultural land abandonment - Expansion of the road network and increased market access has resulted in fast food being readily available, resulting in the neglect and loss of local cuisines and crops
Cultural: Changes in food habits and food choices	- The modern food system is replacing ethnic cuisines - Less product diversification options, particularly in the traditional food system - Intergenerational knowledge transfer related to crops and WNEPs has been disrupted
Governance and institutions	- Traditional norms and practices in managing crop diversity are no longer followed or practised - Government agriculture offices do not prioritise preservation of crop cultivars; they promote new cultivars/hybrids - Seed exchange practices are not followed properly

The availability of improved varieties (150 respondents), seasonal outmigration (110) and the low yield and longer crop duration of the local cultivars (107) were reported to be the major reasons behind local crop diversity loss (Figure 15). Seasonal out-migration to cities of Nepal, India, and few to abroad for wage labourers and other services for income and the households' other members prefer to buy rice from the market. As a result, there is a scarcity of farm labour, which has an implication on abandonment of agricultural land and the loss of local cultivars. Furthermore, improved access to roads and markets were the associated reasons of farmers' dependency on few cash-oriented crops. Earlier, people's lives depended on the food they grew and the traditional cultivars that they conserved and cultivated each year.

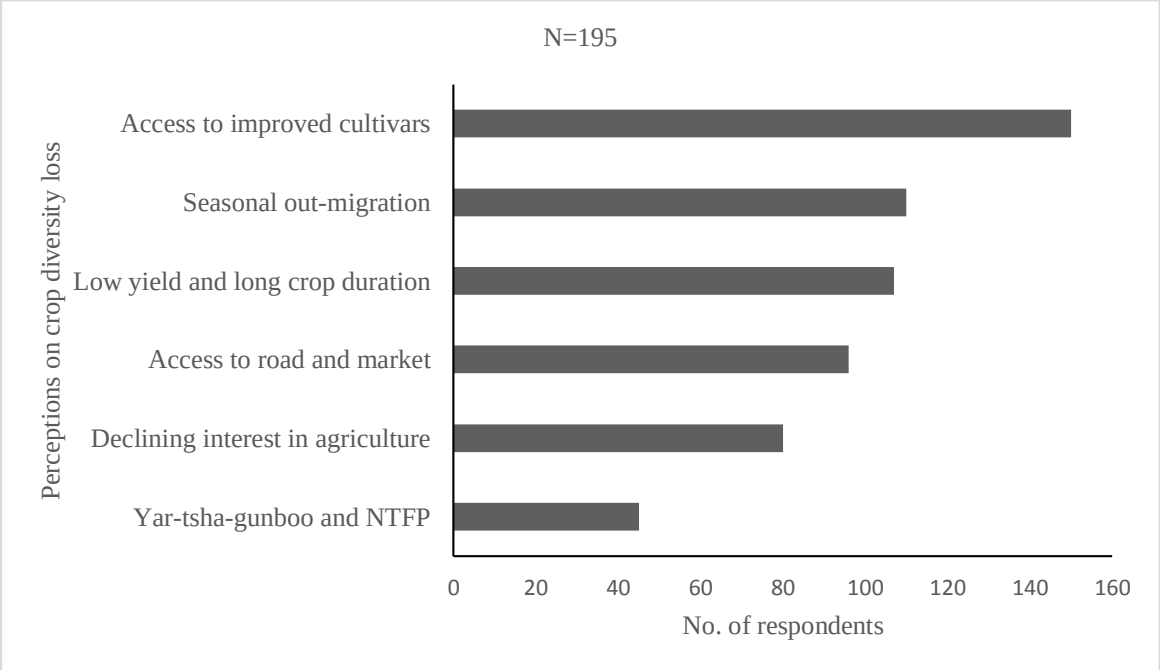

Figure 15: Local perceptions on crop diversity loss

During the KIIs and FGDs, respondents described indicators of climate change based on their experiences. It ranged broadly from erratic weather events, drying up of water sources, phenological change, and their adverse impacts on crop management. However, they were unsure if these changes were solely due to climate change or due to other reasons. The respondents' observations on climate change indicators are presented in Figure 16. Around 85 per cent of them said that in recent years, longer dry days have been more prevalent. Here, it must be noted that the personal attributes of the respondents also come into play in their perceptions about the changes in climate. The study found out that the literate respondents were more aware about the impacts of

climate change in their area as they were tuned into various communication/news sources. However, the elderly people were more knowledgeable as they had the benefit of experience, having lived in the area for long. Another reason mentioned for the decline of crop diversity and yield was the proliferation of invasives.

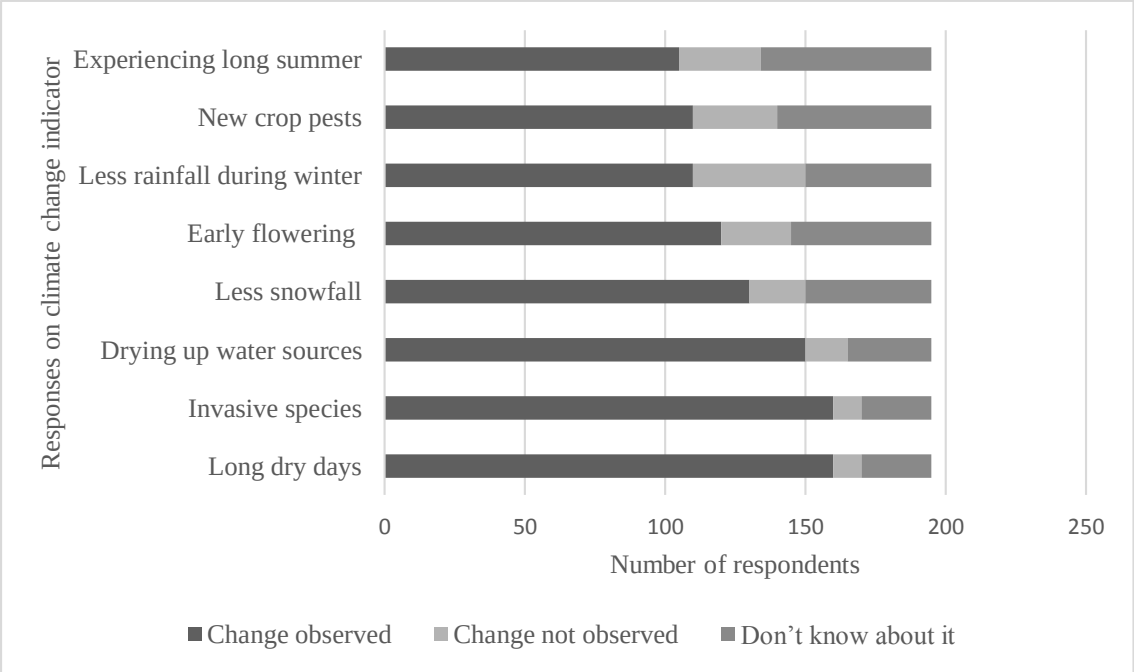

Figure 16: Farmers experiences related to climate change indicators

Among the respondents, 85 per cent of them stated that deforestation was the major reason behind climate change; 73 per cent thought it was regular forest fires; and 62 per cent said that open grazing was the cause. The loss of forest cover means less rainfall and thereby a decline in crop production.

4.1.7 Local management practices and adaptation strategies

Various responses came up about local adaptation practices related to the management of crop/plant diversity. Given the various strategies that farmers are adopting, it indicates that they are very aware of the changes taking place and are adapting to such changes. In the other hand, the access on the knowledge and practices on global best practices related to management of crop cultivars. Furthermore, they lack access to climate services. Therefore, there is a need for a blended approach that combines the best of local knowledge and practices and scientific crop management. In the following section, local seed management practices and other various practices that farmers are adopting for crop diversity management is briefly highlighted

4.1.7.1 Seed management practices

Multiple responses came up on the issue of seed management, particularly related to the local cultivars (Figure 17). The main practice in the study area involves saving seeds for planting the next season of crops.

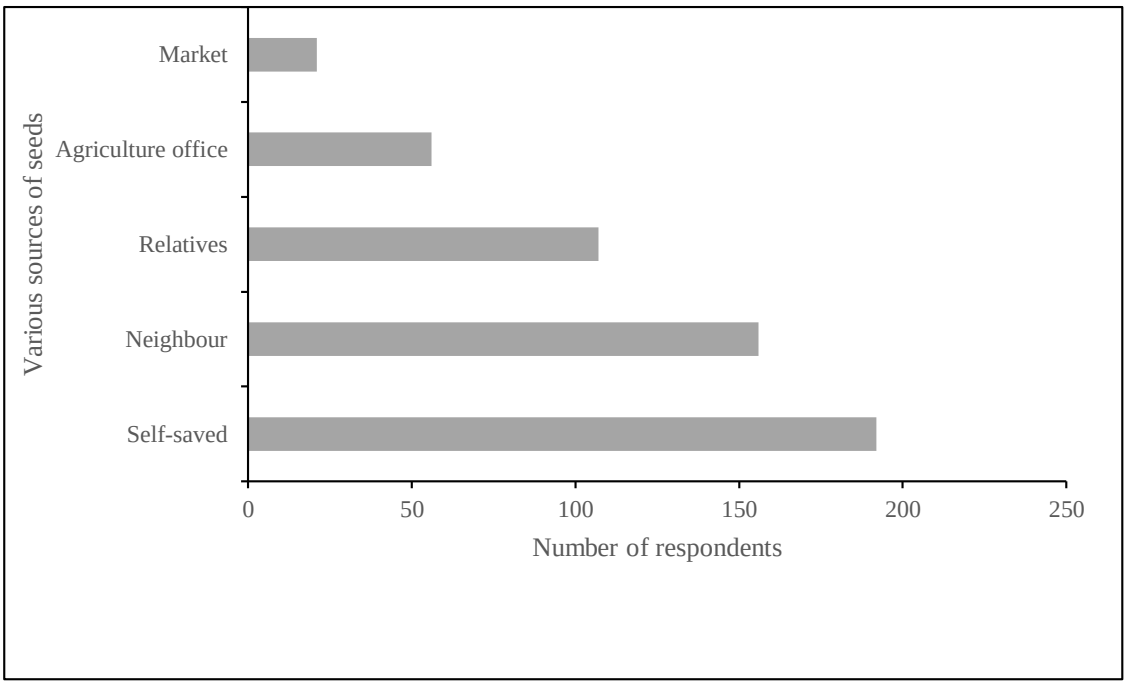

Figure 17: Seed management practices

An overwhelming 98.5 per cent of the respondents reported that they depended on their own seeds for cultivation in the next season. This is especially true in the case of cereals and pulses. Apart from such saved seeds, people also exchange seeds with neighbours in 80 per cent of the cases and with relatives (55 per cent); this maintains the gene flow of crops in the area. The findings showed that maintenance and management of on-farm diversity is important and can be accessible by other farmers whenever they needed it. So, the informal seed saving and sharing system needs to be supported.

The responsibility of seed management, such as selection of healthy seeds, drying them and storing them properly, is mostly borne by women. They are also in charge of seed supply and exchange, especially within their own village; in many ways, they run the informal seed network. About 82 per cent of respondents felt that women are responsible for management of local crop diversity, since they do the actual seed selection as per their preferences. The women also have expertise and experience in

growing cultivars, and they are repositories of information regarding crop performances and management of crop pest.

4.1.7.2 Local crop diversity management and adaptation strategies

Planting two or more crops together (87 per cent) is one such strategy, for example,

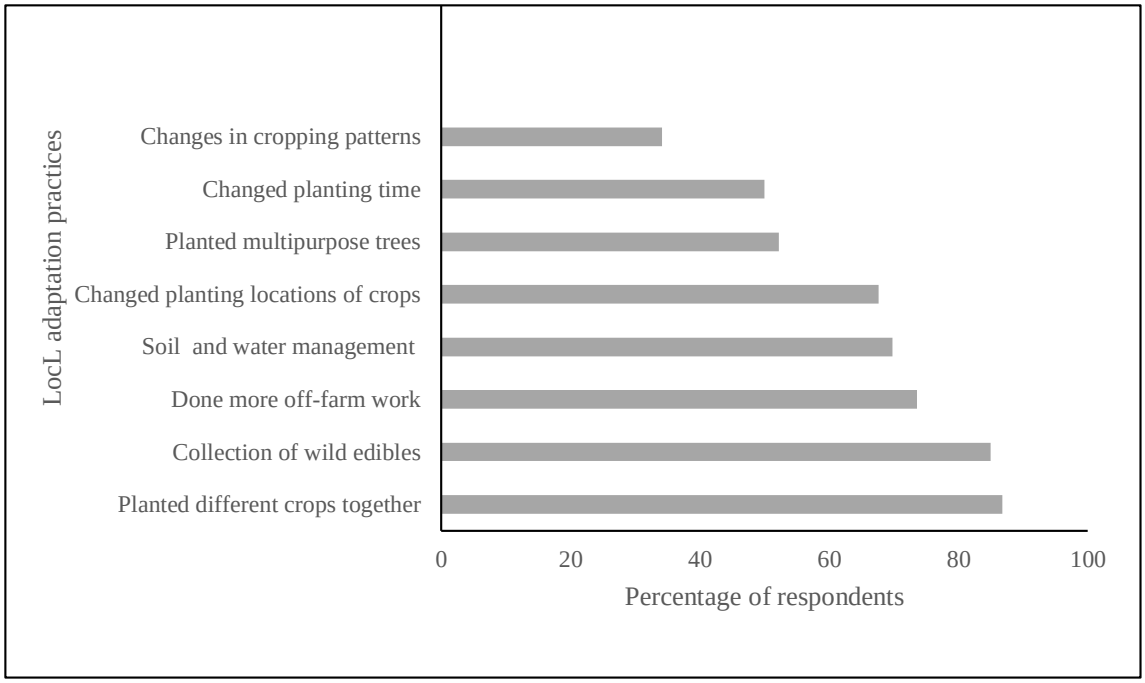

Figure 18: Local practices adopted for coping with climatic change

growing maize and beans together are a major approach that farmers are adopting for increasing yield and diversifying income. About 85 per cent of the households also collect and use wild and non-cultivated edibles. Importantly, about 75 per cent of the respondents mentioned that they were particularly careful in selecting the right seed and crop during adverse conditions. For instance, the people in the study area cultivate *dautkhane* (a drought-resistant local wheat variety) when they think that the year will have long dry season. Number of local on farm management practices (Figure 18) involve changing the planting time and location and soil nutrient and water management. And when the situation gets particularly adverse, farmers depend on other livelihood options like mat making and wage labour.

4.2 DISCUSSION

4.2.1 Diversity of cultivated crops: their use and status

Globally, crop diversity is a major contributor to food, nutrition, health, and income security for millions of people (Aryal *et al.*, 2021a; Aryal *et al.*, 2017; Baldinelli, 2014;

Belanger & Pilling, 2019; Ong & Kim, 2017). The current study has documented 177 cultivars/local cultivars from 78 cultivated crop species; these include cereals, pseudo-cereals, vegetables, fruits, spices, and oilseeds. A recent study by Aryal et al. (2021) documented about 330 crop species grown in the Kangchenjunga Landscape. Similarly, Rahman & Karuppaiyan (2011) inventoried 178 cultivars/local cultivars from 69 crops in Sikkim, India. Among the crops, maize, rice, wheat, barley, and millets contribute immensely to food security. Besides, food, vegetable, fruit and spice crops, beans (*Phaseolus vulgaris*) play a key role in people's livelihood, not only in terms of family nutrition but also as a cash-generating source for most of the households in the study area. Beans are cultivated across a broad range of agroclimatic situations and the area under its cultivation is increasing day by day as it fetches a fair price (Mishra *et al*., 2011; Neupane *et al*., 2008; Neupane & Vaidya, 2002; Razvi *et al*., 2018).

A participatory experiment (using experimental plots and diversity blocks) on nine local bean cultivars showed significant differences between them. Pandey *et al*., (2011) also observed similar variations when they studied 18 bean cultivars from the western midhills of Nepal. In the present study, among the bean cultivars, the *local seto* and *ankhe thulo* were found to mature late as compared to other cultivars, particularly at the Dallekh site which is in a higher elevation than the other two sites. At high elevations, with early winter onset, the cultivars that needs more days to maturity cannot complete its life cycle and produce a good yield (Neupane *et al*., 2008). This clearly indicates that temperature plays a vital role in the maturity of these cultivars. Three cultivars, namely *temase rato, ankhe tulo* and *local kalo,* were more resistant to disease and pest. Among the nine cultivars, *kaleji kirmire* had the highest yield, at an average of 3.8 t/ha across the three sites. The findings suggests that this research will be useful for participatory identification of suitable cultivars for future promotion of these crops, based on their characteristics such as time to maturity, grain yield, and disease resistance.

4.2.2 Diversity of wild and non-cultivated crops/plants and their contribution

WNEPs are estimated to be used by at least one billion people and they have been using these species in numerous ways – as staple food, vegetables, and fruits, and for medicinal and cultural purposes (Aryal *et al*., 2018; Aryal *et al*., 2013; Ong & Kim, 2017). This study documented a total of 99 WNEPs used by the people in the study area. Several studies on WNEPs have documented a diversity of species, their use and some

local-level conservation and management practices (Abdullah *et al*., 2021; Aryal *et al*., 2021b; Badola & Pradhan, 2013; Campbell *et al*., 2021; Chaudhary *et al*., 2015; Dorji, 2012). But the actual contribution of these species to food and nutrition security, and household healthcare, is yet to be documented systematically. A study conducted in Bandipora District of Kashmir Himalaya documented the use of 111 local wild, edible plants for various purposes (Singh *et al*., 2016). A similar study in Nepal by Aryal et al. (2009) documented 112 uncultivated edible plant species used by the people of Dhading and Kaski Districts; other studies have documented 64 species in Bhutan (Thapa, 2009) and 54 in the Tibetan Plateau of China (Kang *et al*., 2016).

This study shows that people prefer species with multiple use value, meaning the same species can be used for food, medicine, cultural and other purposes. Species like *Paeonia emodi*, *Fagopyrum esculentum* and *Dryopteris cochleata* are collected in greater frequency and quantity and constitute important sources of vegetables in the household food recipe. However, the use value of *Dryopteris cochleata* is higher than other frequently harvested species. It is one of the most demanded species and rich in nutrient element like calcium, magnesium, silicon, iron, barium, aluminium, sodium, and potassium (Kathirvel *et al*., 2014). Studies have pointed out to the quantum of harvest and thus the WNEPs importance as food items. For instance, a study conducted in Dhusa VDC of Dhading District in Nepal reported an average annual collection of 200 kg for *Dioscorea bulbifera* by an individual household (Aryal *et al*., 2009). Similarly, a study by Aryal et al. (2013) recorded 364 kg of *Dioscorea bulbifera* and 96 kg of *Urtica dioica* harvested and stored by Chepang people in Gorkha District, Nepal for future use. The communities in the study site depend on WNEPs for one to three months a year to fulfil their vegetable requirement during their season of availability. A similar study by Aryal et al. (2009) documented that 58 per cent of the households of Dhading District, Nepal, depend on wild foods for around five months a year. Another study in a small village in India showed that the villagers consume wild vegetables for 50–80 days a year (Reddy *et al*., 2007). Our study showed that the leaves of *Paeonia emodi* are dried and stored for future use or sometimes gifted to relatives and friends. So, wild edibles have also a part to play in maintaining social cohesion. However, the collection and harvesting trends for some of these species do not seem to be sustainable. This contention is supported by many studies around the globe (Aryal *et al*., 2021b; Aryal *et al*., 2018; Campbell *et al*., 2021).

However, despite the meaningful contribution of the WNEPs to the livelihoods of the people in the study area, these species are often underutilized and ignored in the daily diets and other uses. This has to do with current food preferences, tastes, and lifestyles of the youth who opt for the readily available processed foods (Aryal *et al*., 2018; Chauhan, 2017; Matsushima *et al*., 2012; Tamang *et al*., 2013).

The people in the study area have been using several wild plants for household-level health care. During the survey, several households reported that, based on their native knowledge, they use wild plants to cure various diseases or ailments. However, many of the respondents stated that it was the local healer who knew about the preparation of medicines from herbs; for this, they depended on ancestral prescription as well as on personal experience. A few other studies have also highlighted the use of wild plants for local-level health care (Aryal *et al*., 2018; Aryal *et al*., 2009; Badola & Pradhan, 2013; Chauhan, 2017; Chaudhary *et al*., 2015; Dorji, 2012; Maurya *et al*., 2017; Wani *et al*., 2022). However, this practice of using wild plants as medicines is on the decline. This is partly due to lack of knowledge transfer, with healers reluctant to share their knowledge of preparation of medicines, and partly due to the younger generation not being interested in studying and learning about traditional ways of medication.

Despite such a scenario, WNEPs are key in the fight against food and nutritional insecurity. They are organic, adapted to adverse climatic condition, and are rich source of vitamins, proteins, and minerals. Thus, there is an opportunity for promoting them by linking the farmers to the markets and through product diversification.

4.2.3. Land use land cover change and its implications on diversity loss

Changes in land use has negative effects on food security – while food production may increase for a short time, there are adverse consequences in the form of long-term losses in ecosystem services. The four decadal (1990, 2000, 2010 and 2016 AD) analysis on land cover of the study site showed that there are remarkable changes can see between 2016 compared to 2010 only. Land cover between 2010 and 2016 showed that the grassland area has increased significantly where the agriculture land and forest cover is decreased. Most of this could be linked to anthropogenic factors and, to some extent, to changes in climatic patterns. Degraded forest ecosystems (road expansion, fuelwood collection, forest grazing), out-migration of the seasonal work and high income from yar-tsha-gunboo and Non-Timber Forest Products (NTFPs) are some of the factors

reported (Aryal *et al*., 2020; Foley *et al*., 2005). The study showed the visible land use change over the past four decades. In many instances, land use change leads to the abandonment of agricultural fields and to the loss of local cultivars (Aryal *et al*., 2017; Campbell *et al*., 2021 Katwal *et al*., 2015). Similarly, decline in the vegetation cover resulted in loss of many wild plants that communities are using. Furthermore, land use changes lead to introduction of invasive species, fragmentation of native vegetation (Gardner & Gerrard, 2003). Besides, a large part of agricultural lands has been converted into fallows and settlements (Elhadary *et al*., 2013; Halim *et al*., 2013).

Similarly, cash crops and monocropping replace the traditional cultivars leading to diversity loss. Many local cultivars of *amaranth, finger millet, maize* which were grown good in marginal and dry lands are now converted in grass land. Land fragmentation, outmigration and land abandonment have been reported to be the other drivers of LULC changes in the area, particularly that of agricultural lands becoming grasslands; this has resulted in a severe decline in the number of local cultivars. Similar reasons have been cited by a few studies from the region (Adhikari *et al*., 2017; Katwal *et al*., 2015; Sharma *et al*., 2016). If the current ratio of land use change cannot be stopped or managed, community will face the profound consequences for the availability of food both from cultivated as well as non-cultivated sources. It is therefore important that the local governments and agriculture and forest department to incentivize community people for on-farm conservation as well as conservation of wild edibles on forest and natural environment.

4.2.3 Drivers of changes affecting crop diversity management

The study site is rich in crop/plant diversity; but over the time this diversity has been gradually diminishing despite their tremendous social, economic, and ecological significance. Many cultivars of many crops/plants are disappearing from their natural habitats (Aryal *et al*., 2021a; Aryal *et al*., 2017 & 2018; Chaudhary *et al*., 2015; Katwal *et al*., 2015; Rahman & Karuppaiyan, 2011; Sharma *et al*., 2016) and many are on the verge of extinction (Adhikari *et al*., 2017; Aryal *et al*., 2017; Schmidt *et al*., 2010). Natural and anthropogenic pressures are reported as leading causes for loss. In this regard, the major drivers that this research identified are: availability of improved varieties (150 respondents), seasonal outmigration for employment (110 respondents); development of road and infrastructures (96 respondents); land use and land cover

change (86 respondents); changing food habits and attitudes (82 respondents); declining interest in agriculture, particularly among the youth (80 respondents); and high dependence on high-value species like yar-tsha-gunboo and NTFPs (45 respondents). Several studies also recorded similar changes affecting crop diversity maintenance (Adhikari *et al*., 2017; Aryal *et al*., 2017; Baldinelli, 2014; Bhattarai *et al*., 2015; Chaudhary *et al*., 2011; Chaudhary & Aryal, 2009; Chettri *et al*., 2012; Chettri *et al*., 2010; Verma *et al*., 2010). This study suggests that in any conservation and management activity involving important cultivars, it is essential that the farmers' knowledge and practices are given their due weightage.

4.2.4 Conservation and management of crop/plant diversity

Both cultivated and wild crop/plant diversity contributes to meeting the food, medicine, fibre, and other needs of about 700 households of the study area. However, the true status of both cultivated and wild and non-cultivated crops/plants and their exact contributions to food and nutritional security as well as to livelihood in the study area are yet to be studied systematically. The current study has documented 178 local cultivars from 69 cultivated crop species, and 99 wild and non-cultivated plant species, but many of them are already in disappearing trend, and some are on the verge of extinction from the study sites. This erosion of the traditional cultivars and wild and underutilized plants has also been documented by several studies around the globe (Aryal *et al*., 2018; Bisht *et al*., 2007; Chaudhary *et al*., 2015; Joshi *et al*., 2020; Joshi, 2017; Katwal *et al*., 2015; Rahman & Karuppaiyan, 2011; Sharma *et al*., 2016). The farmers in the study area have been managing the diversity through traditional knowledge, skills and practices that have been passed over to generations. Thus, it is important to document such knowledge, practices and skills that enhance the management of such diversity on farm.

4.2.4.1 Local knowledge and management practices

Local knowledge and management practices on managing the adverse effects and its implications on food availability and diversity management is key to sustainable use. (Ajani *et al*., 2013; Aryal *et al*., 2021b; Aryal *et al*., 2017; Chaudhary *et al*., 2011; Paudel *et al*., 2016). Among the traditional management practices, seed management practices are crucial in crop diversity management. The study documents that about 98 per cent of the farmers retain their own seed bank for the next year's crops; however,

about 80 per cent of the household's exchange seeds, while about 55 per cent of the households borrow the seeds of vegetables and minor crops from neighbours or relatives. This practice is quite common in Nepal and other Asian countries (Abdullah *et al*., 2021; Abioye *et al*., 2014; Aryal *et al*., 2017; Farooquee & Maikhuri, 2009; Hodzkin *et al*., 2007). The farmers' seed networks help to provide alternative options for farmers in times of adversity/shortage such as by way of outbreak of disease/pest attacks. They also create linkages among farmers and provide channels for mutual assistance; overall, they establish a seed safety net (Sperling & Mcguire, 2010). The informal seed management systems of traditional cultivars of underutilized crops also promote the role of farmers as conservers and innovators; so, this system should be strengthened for on-farm conservation and for the sustainable utilization of crop diversity (Poudel *et al*., 2015). This process of collective actions of the community in terms of access to a variety of seeds and the community's proactive role in seed selection and production ensures the flow of quality seeds and strengthens the farmers' capacity to adapt to climate change in traditional production systems (Aryal *et al*., 2021b; Aryal *et al*., 2017). Thus, for the proper maintenance of traditional cultivars, it is essential that such informal seed exchange networks continue to function (Hodgkin *et al*., 2007).

Diversification of crop cultivars is one of the approaches that the local farmers have been practising to maintain genetic diversity on their farms. Among the surveyed households, 87 per cent of the respondents reported that they practise intercropping of beans with maize. This practice of intercropping is common across Nepal and several studies have documented it as a traditional practice of crop management (Aryal *et al*., 2017; Chapagain *et al*., 2018; Farooquee & Maikhuri, 2009; Ghimire *et al*., 2018; Giri *et al*., 2020; Khatri *et al*., 2014; Neupane *et al*., 2008; Poudel *et al*., 2015). Furthermore, about 75 per cent of the respondents reported that the farmers at the study sites are careful about selecting or choosing the right crop since they do not want to be vulnerable to adverse climatic conditions. For example, *dautkhane*, a local drought-tolerant wheat cultivar is grown if they perceive that a year is likely to have a long dry spell. The other practices that are being used in the study area include changing the cropping patterns, changing the planting location, and changing the planting time. These local practices have been documented by several publications across Nepal (Aryal *et al*., 2021b; Poudel *et al*., 2015; Rana *et al*., 2007). Furthermore, the performance of local cultivars can be

improved by employing pest- and disease-resistant techniques and the use of seeds that are known to withstand drought; this obviously will strengthen the farmers' capacity to maintain crop genetic diversity in situ (Aryal *et al*., 2017; Bhandari, 2014; Poudel *et al*., 2015; Rana *et al*., 2007).

A majority (86 per cent) of the respondents reported *in situ* management, while 38 per cent of them said that they have been domesticating few important species in their home yards. Home gardens offer better availability of water, good caring and monitoring and easier protection against predators (Aryal *et al*., 2017; Aryal *et al*., 2009; Castaneda-Navarrete, 2021; Galluzzi *et al*., 2010). This study has documented 11 species of WNEPs which have been domesticated for their medicinal and cultural values, as well as for the fact that they are also used as vegetables. As an example of ritual value, the case of wild yam stands out – it is a tradition to eat it on the first day of the Nepali month of *Magh* when the festival of Makar Sankranti. Farmers in other parts of the world also practice in situ conservation and domestication for the long-term management of wild plant species (Aryal *et al*., 2020; Aryal *et al*., 2017; Aryal *et al*., 2009; Ogle *et al*., 2003; Shrestha & Dhillion, 2006).

Several households in the study area also process and store these wild species to prolong their availability; this is particularly so in the case of wild vegetables which are available in enormous quantities during their season. For example, take the case of the wild vegetable called *hetto* (*Paeonia emodi*). Its young shoots and leaves are collected and dried for future use, especially for winter when vegetables are scarce. A similar study by Aryal et al. (2009) reported that the local people collect *Dryopteris cochleata* (edible fern) and steam it to prolong its storability for future use. The processing and storage are also linked to the sufficiency of the vegetable and the availability of household members to collect it. The lower the vegetable sufficiency, the higher will be the collection and storage, however, depends on the human capital at household. This aspect of processing and storing for long-term availability has also been documented by number of studies around the globe (Abdullah *et al*., 2021; Akhtar, 2001; Aryal *et al*., 2018; Aryal *et al*., 2009; Campbell *et al*., 2021; Regmi *et al*., 2009). Meanwhile, edible ferns and nettle plants have been gaining popularity in high-end niche markets as nutritious foods and so there is a scope for them to be in wider urban markets (Aryal *et al*., 2018). The farmers are also realizing the potential of their products and how they can generate better income by selling them to niche markets; so, local agro enterprises

have come up. For example, since local beans, edible ferns, *hetto* and the powder of nettle leaves are in high demand in Khalanga and the Indian town of Dharchula, the local entrepreneurs have recently been engaged in collecting and supplying these products at a commercial scale.

Crops, either cultivated or wild and non-cultivated, represent one of the major and important aspects of ecosystem services and nature's contribution to people. They are not only essential for the very survival, but they are also important for all human beings. Moreover, the Indigenous knowledge associated with the utilization and sustainable management of these resources is extremely important for crop diversity management and sustainable development.

CHAPTER 5

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

A total of 177 cultivars from 78 cultivated crop species and 99 wild and non-cultivated plant species were documented in the study area. Among the cultivated crop diversity, the highest diversity was recorded in maize with 15 cultivars, followed by 12 cultivars in paddy, 11 in wheat and 9 in beans. Similarly, 35 species of WNEPs plants were found having more than one use, including these: 31 species belonging to 21 genera were used for vegetable and 40 species belonging to 28 genera as fruits. These diversities are the life-support system of the local people and contributes significantly to food, nutrition, health and relatively low to cash income. However, their own cultivable production is sufficient for only 5 per cent of the households; the rest were self-sufficient up to 10 months or less. When food is scarce, people focus on multiple strategies, including collection of wild foods, selling and exchange of crops and livestock produces (particularly beans, maize, and milk products), seasonal out migration for work to the district headquarters or to parts of India, and collection and sale of yar-tsha-gunboo and NTFPs.

However, the huge diversity in terms of both cultivated and wild crops/plants is under threat as a high number of crops/cultivars have already disappeared, while some are on the verge of extinction. This loss in diversity is due to the introduction of improved and hybrid cultivars, seasonal outmigration, people's declining interest in agricultural farming, and their tendency to look for high income from resources like *Ophiocordyceps sinensis* (yar- tsha-gunboo) and NTFPs. Then there is the issue of disregard to the use of local food items in the kitchen recipe due to changing food habits (especially among the youth), as well as the easy access to fast foods in the village shops.

It is also evident that change in land use is driving the erosion and loss of cultivated and wild diversity in the area, particularly conversion of agricultural land into grassland, and fallowing.

Farmers in the study area have been practising various local-level adaptation strategies like domestication and in situ, ex situ and on-farm conservation of crop diversities. Among these practices, self-saved seeds and the local-level seed exchange system involving informal networks have played a significant role in the conservation of local crop diversity. Conservative management practices in crop diversity can increase the adaptation capacity of farmers to fight with adverse effect of climate change. However, the current efforts and strategies are not adequate to curb the ongoing loss of local crop diversity. Therefore, appropriate policy mechanisms for participatory breeding combined with product development and market linkages at local, district, provincial and national levels are necessary for the long-term conservation and management of the diversity that we have now.

5.2. Recommendations

Crop diversity helps maintain diverse food cultures, supports livelihoods, and strengthens resilience against climate shocks. However, wide range of issues and challenges are pertinent hence practical actions/interventions are required to ensure the better management of such diversity; only then can there be sustained support to food security and local livelihoods. Some of the conservation and management recommendations that this study proposes are listed below:

- Given that there is widespread loss of crop/plant diversity, the primary task is to conduct in-depth assessments of this loss and the key drivers behind it, as well as of its impacts on the food and nutritional security of the communities. A proper study and documentation of local knowledge and understanding of these factors is necessary for identifying and co-developing solutions with the communities. This can feed into the participatory planning that is necessary for crop diversity management.
- In addition to the erosion and loss of traditional crop cultivars, it is evident that there is a decline in WNEPs and NTFPs in the study area – warranting their inclusion in the IUCN list of threatened species and CITES Appendix II. This will have immediate and long-term implications for household food, nutrition, health, and livelihood security. This warrants conservation attention and some locally agreed protocols for sustainable harvesting and use of these resources.

These protocols can be embedded in the local NRM plans, including CFUG plans, and monitored by the local government.

- Our study of various land use and their change shows that agricultural land abandonment and change to grassland or pasture is leading to the loss of traditional crop cultivars. This will have profound consequences for local food and nutrition security. Here, it is important for local governments and agriculture department to incentivize on-farm conservation by providing targeted support for farmers who grow and retain traditional crop cultivars. This support could be extended to strengthen seed saver networks and diversity fairs for sharing and exchange.
- The local communities need to be engaged in the *in-situ* conservation of crop diversity (both cultivated and non-cultivated). The communities in the study sites have extensive knowledge about climate impacts on crop diversity. However, their knowledge and adaptation practices are not well recognized and valued in mainstream government plans and programmes. Local climate knowledge can play a critical role in designing and implementing adaptation and mitigation measures in a situation where data are scarce, and the impacts of climate change are already being felt. In high altitude areas, with early winter onset, greenhouses could help farmers advance or extend the season and produce good yields.
- Given the overall emphasis on a handful of staple crops, many local crop cultivars and traditional cuisines have not been assessed in terms of their nutritional value which makes it difficult to promote them as safe and nutritious food. A proper nutritional assessment would help build trust and confidence among the consumers. It is also important to document the rich traditional knowledge about crop diversity (cultivated, wild, and non-cultivated) its management, its processing and use.
- It is necessary to create a wider interest and revalorize local crops and cuisine. Local-level crop/plant diversity fairs and food fairs can be one way of raising awareness and providing information about the sources of seed/planting materials within a village for better conservation of the local genetic resources. Traditional ways of sustaining crop diversity can also help diversify livelihood opportunities for the host communities through agro-tourism, farm stays and

ethnic foods. Traditional cuisines can play a key role in attracting tourists to destinations.

- Home gardens are an integral part of local food systems. If promoted and supported well by local government and development agencies, home gardens can contribute significantly towards addressing food insecurity and malnutrition, provide other benefits such as enhanced household income and livelihood opportunities for resource-poor families, and reduce pressure on wild stocks of edible plants. Home gardens can also reduce the burden on women who engage in foraging for wild edibles. Most importantly, they can become sites of *in situ* conservation and domestication of preferred food crops.
- Strengthening village level seed exchange and sharing mechanism of local cultivars is crucial for managing crop diversity. It is necessary to monitor and record the changes and factors affecting the crop diversity management and prepare the local action plan for its better management.
- Beans from the area are becoming popular in urban markets in Nepal and nearby Indian towns and command a premium price. However, there is little support for local conservation of these cultivars and the erosion and loss of diversity is a cause for concern. The government must earmark support for work on documenting bean diversity and nutritional value, identify and strengthen informal seed saving and exchange systems, support registration and *ex-situ* conservation in the national gene bank, and incentivize the cultivation of beans as a niche crop from the KSL.
- We must also recognize the potential role that traditional crop diversity can play in future food security, especially given the widespread environmental and climatic changes. This requires an understanding of cultural change that is affecting the conservation and use of such diversity and how to revitalize traditional agriculture and food practices to build community resilience.
- In-depth and detailed research is required on species like *hetto* (*Paeonia emodi*) which holds great promise as a marketable commodity.

CHAPTER 6

6. SUMMARY

This research was conducted in Khar Village Development Committee (now part of Naugad Rural Municipality, under the new federal structure), a part of KSL Nepal. Home to multi-ethnic communities, the study site is rich in agricultural crop/plant diversity and the local farmers rely heavily on local cultivars/cultivars of various crop species and wild and non-cultivated edibles for their livelihood. This study focuses on crop diversity which refers to the crops and cultivars that the farmers cultivate and use as part of their subsistence. They consist of local farmers' cultivars, modern cultivars of traditional crops introduced by commercial seed companies, as well as crop wild relatives, weedy forms of crops and the wild and non-cultivated species used by communities for food and agriculture.

Agriculture is the primary source of food and livelihoods for most of the households (92 per cent). The study has documented 177 cultivars from 78 cultivated crop species from 66 genera and 36 families and 99 wild and non-cultivated plants from 75 genera and 58 families. Among the cultivated crops, cereals, and pseudo-cereals (including paddy, wheat. maize, finger millet, buckwheat, and barley), vegetables, fruits, beans and pulses, spices and condiments, wild and non-cultivated edibles, and non-timber forest products. Within the cultivated crops, maize has the maximum cultivar diversity (15), followed by paddy (12), wheat (11) and beans (9). The WNEPs are used as food, vegetables, spice, and medicine, and for rituals, sold in the market. Species having multiple uses are 35, 40 are consumed as fruit and 33 as vegetables. Among the wild edibles, vegetables contribute significantly to food requirements and 85 per cent of the surveyed households rely on them for more than a month annually. These diversities contribute significantly to the food, nutrition, health, and income security of the households. Furthermore, these local crops and some wild vegetables and fruits are gaining attention in urban areas. These crops include high mountain beans, finger millet, buckwheat, and wild vegetables like edible fern, nettle plant, and asparagus. Owing to their peculiar taste and high nutritional values, these crops are also called "superfoods." And, given their growing demand in the market, they can be potentially the high value income generating options for the local people.

However, in a decade's time, crop diversity (both of cultivated cultivars and wild edibles) in the study area has been steadily declining. *Jhuse*, *Malaya* and *Haasa* cultivars of wheat, *Jau dhaan*, *Kirmuli dhaan* and *Sali dhan* of Paddy, *Nang kate*, *kalo kodo* of finger millet cultivars of cultivated crops are already lost from the study villages. Among the WNEPs one endangered (EN) species (*Aconitum heterophyllum*), one vulnerable (VU) species (*Paris polyphylla*), and one near threatened (NT) species (*Dioscorea hamiltonii*) warranting their inclusion in IUCN red list. Furthermore, *Dioscorea deltoidea* is included in the CITES Appendix II. Climatic and non-climatic drivers of change were mentioned as the reason of such lost. Among the climatic factors, erratic rainfall, less snow falls during winter, increase in temperature and long dry spell, land cover change was reported as the major concern. Declining interest in agriculture farming, seasonal out-migration for part time job/wage labour, access and availability of improved seeds, and the changing food preferences in households receiving remittances are considered as anthropogenic drivers of change leading to loss of diversity. Then there is the critical matter of government policy, research and extension not focusing on incentivizing the farmers who maintain diversity on farm. When crop diversity wanes, it narrows down the food and dietary diversity of the local communities and thus has an impact on health and wellbeing. A proper study and documentation of practical knowledge and understanding of these factors is necessary for identifying and co-developing solutions with the communities.

Such issues apart, the farmers in the study area have been adopting different practices for the promotion and conservation of crop diversity. Practices like domestication and *in situ*/*ex situ* conservation of crop diversities. Besides, the self-saving of seeds and exchanging them through informal networks played a significant role in the crop diversity management. Women play a crucial role in diversity management – they are the ones who manage seed selection, preservation, and exchange; they are also the decision makers when it comes to choose as to which crop should be grown.

There are diverse ways to revitalize the traditional crops and domesticate wild edibles; and these ways are important since they have a bearing on nutritional security as well on farm diversity. One of the ways is through well-designed governmental interventions and programmes – and these interventions and programmes ought to take on board the local communities' knowledge and opinions. Together with governments at all levels, the local communities can also pitch crop diversity and traditional culture and cuisine

as a tourism proposition. To start with, one of the primary priorities of such plans should be on home gardens that can domesticate some important species of wild plants. This will pave way for different livelihood options and different income sources. Preservation of crop diversity can also help in reinforcing cultural identities and in empowering these communities to create resilient food systems. In this regard, participatory planning and inclusion of activities related to management of crops/plant diversity in ward level local government plan is necessary. It is important for local governments and agriculture department to incentivize on-farm conservation by providing targeted support for farmers who grow and retain traditional crop cultivars.

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APPENDIX

Appendix 1: Research Question and hypothesis

Research questions

- What crop diversities (cultivated and wild and non-cultivated crops/plants) have been maintained and managed by households in their agroecosystems over the past decade? What has been their contribution to local food security and livelihood support?
- What are the spatio-temporal dynamics of the land use system in the KSL and how has agricultural land use there changed over time?
- What are the drivers of change affecting the choice and management of crop resources? How are the local communities coping with such changes?
- What indigenous/local knowledge and practices do the local communities possess about agricultural crop diversity management and who conserves crop diversity on farm? How is it done?

Hypothesis

- Farmers have been growing a diverse variety of crops to fulfil multiple household needs, but over time, there has been a change in the pattern of diversity – introduced species are contributing more to local food security.
- Wild and non-cultivated edible plants are important to support the livelihoods of local communities.
- The land use pattern in KSL has been altering both at spatial and temporal scales, with a decline in traditional crop diversity and an increase in modern/exotic crop species in the local agroecosystems.
- Various social, cultural, economic, and political factors have contributed to changes in *on-farm* crop diversity in the KSL and the people are coping in many ways with such changes.
- The local people's traditional knowledge and practices have helped in managing the landscape's wide diversity of agricultural crops

Appendix 2: Household Survey Questionnaire

Questionnaire ID number: _____

SECTION I: General Information/Household Information

Q. No.	Questions and Filters	Coding Categories	Codes	Skip
101.	District name	Darchula	1	
102.	VDC name	Khar	1	
103.	Ward no.	_____		
104.	Settlement name	_____		
105.	Household no.	_____		
106.	Name of interviewer	_____		
107.	Date of interview	_____		
108. a	**CONSENT STATEMENT** I am an enumerator hired by … located in Kathmandu, to conduct interviews of several households in your area as part of a survey to understand the socio-economic and ecological situation of your area. Through a scientific process, your household has been selected to participate in the study and there are other households in the area which will also participate in this study. The total time of the survey will be around 20 minutes. Your participation is completely voluntary. If you choose not to reply to any of the questions in this questionnaire, you are free to do so. If you decide to answer some or all the questions, we will use the information given by you only for the purpose of research. All your answers will be kept secret, and your name will			

	not appear in any data that is made publicly available. Your participation in this survey may not directly harm or benefit you, but the findings from this research will help in developing appropriate livelihood strategies. At any point of time during the interview, you are free to ask any question related to the survey. You will not get any monetary benefit for your participation in this survey. During the interview, if you have any doubt or question, you may interrupt and ask me without any hesitation. If you have any question related to the study, you may please contact … Kathmandu, Phone # +977-1- Would you like to participate in the study and do you agree to be interviewed? Yes No Signature of the Investigator_____		1 2	
109.	**Result**	Completed Partially completed No household member at home or no competent respondent at home at the time of visit Entire household absent for an extended period Refused Dwelling vacant/destroyed/not found Others (Specify)_____	1 2 3 4 5 6 7	
110.	Interview start time			

111.	Interview end time			
112.	Total persons in the household			
113.	Line number of respondent to the questionnaire			
114.	Cross-checked by:			

Now, I would like to gather some information from you about the people who are reside in your household.

Line No.	Please give me the names of the persons in your HH, with the HH head.	Is (NAME) male or female?	How old is (NAME)?
	115.	116.	117.
	Name	Male =1 Female =2	Completed Years
01			
02			
03			
04			
05			
06			
07			
08			
09			
10			
11			
12			
13			

Q. No.	Questions and Filters	Coding Categories	Codes	Skip
118.	What is the caste/ethnicity of the head of the household?	_____		
119.	What is the educational qualification of the household head? ?	Class		
		Less than class 1	00	
		Intermediate	12	
		Graduation	15	
		Master's	16	
		Don't know	98	
120.	What is the main type of work or occupation of the household head?			

SECTION II: Household Income

Instruction: First ask the respondent what about the different sources of income his or her household has had in the last 12 months. Ask for any other source once the respondent cites the sources spontaneously. Mark the income sources listed by the respondent and then ask about the share of income from each of those sources separately. Rank the sources of income the household depends on for its livelihood.

		What was the total amount the entire household earned in the past 12 months from (SOURCE), in terms of cash and in-kind payments?	Please rank the income source on the basis of its importance to your household's livelihood during the last 12 months. Please rank from the most important (1) to the least important (8).
	201.	202.	203.
	Sources	No income = 0 Don't know = 999998	No income = 0 **1**
INST.			**IF THE SOURCE DOES NOT CONTRIBUTE TO HOUSEHOLD INCOME, THEN RECORD "0"**
a.	Agriculture		
b.	Business		
c.	Remittance (service outside Nepal)		
d.	Service inside Nepal		
e.	Wage labour (daily agricultural labour, masonry, etc.)		
f.	Skilled labour & IGAs (e.g. tailoring, masonry carpentery)		
g.	yar-tsha- gunboo /NTFPs		
h.	Others (please specify)		

SECTION III: Agriculture and farming

Q. No.	Questions and Filters	Coding Categories	Codes	Skip
301.	How much area of agricultural land have the members of this household owned in the last 12 months? **INSTRUCTION: CONVERT LOCAL MEASUREMENT INTO HECTARES**	Hectares		
		Don't own any agricultural land Don't know	000 998	
302.	Has your household leased out any agricultural land to someone in the last 12 months? If yes, how much area of agricultural land have your household leased out to someone? **INSTRUCTION: CONVERT LOCAL MEASUREMENT INTO HECTARES**	Hectares		
		No leased-out land Don't know	000 998	
303.	Has your household leased any agricultural land from someone in the last 12 months? If yes, how much area of agricultural land have the members of this household leased from someone? **INSTRUCTION: CONVERT LOCAL MEASUREMENT INTO HECTARES**	Hectares		
		Have not leased land Don't know	000 998	
F1	**CHECK Q201, Q302 and Q303: DID THE HOUSEHOLD HAVE ANY ACCESS TO ANY LAND IN THE LAST 12 MONTHS?**	**Yes** **No**	**1** **2** ▶	317
304.	Out of the total land area, how much was for *khet* and *bari*? **Probe: How much under *khet*? How much under *bari*?**	*Khet* land		

	INSTRUCTION: WRITE "998" IF THE RESPONDENT DOES NOT KNOW ABOUT THE LAND AREA. **INSTRUCTION: CONVERT LOCAL MEASUREMENT INTO HECTARES**	Bari land		
305.	During the last 12 months, did your household own any land which it could not use for agriculture?	**Yes** **No**	**1** **2** →	307
306.	Out of the total land area that could not be used for agriculture in the last 12 months, how much area was _____? **INSTRUCTION: WRITE "998" IF THE RESPONDENT DOES NOT KNOW ABOUT THE LAND AREA.**			
a.	Private forest land	Hectares		
b.	*Khet* fallow land	Hectares		
c.	*Bari* fallow land	Hectares		
d.	Grassland (*kharbari*)	Hectares		
e.	Reason for fallow land	Hectares		
307.	Out of the land area that your household had access to in the last 12 months, how much land was irrigated? **INSTRUCTION: CONVERT LOCAL MEASUREMENT INTO HECTARES**	Hectares No irrigated land Don't know	 000 998	
308.	Did your household grow any crop during the last 12 months?	Yes No	1 2 →	317

	Which crops did you cultivate in the last 12 months?	Did you sell any raw or finished product of (CROP) during the last 12 months?	In total, how much did you earn (both in cash and kind) from the sale of fresh/raw (CROP)?	In total, how much did you earn (both in cash and kind) from the sale of processed/finished products (CROP)?	What were the processed/finished products that your household produced from (CROP) in the last 12 months?
	309.	310.	311.	312.	313.

	CROP	Yes = 1 No = 2	Don't know = 999998 Did not sell = 0	Don't know = 999998 Did not sell = 0	
INST		**IF "2" , ASK ABOUT THE NEXT CROP**		**IF "0" , ASK ABOUT THE NEXT CROP**	**MORE THAN ONE RESPONSE POSSIBLE**
01					
02					
03					
04					
05					
06					
07					
08					

Q. No.	**Questions and Filters**	**Coding Categories**			**Codes**	**Skip**
F2	**CHECK Q310: DOES THE HOUSEHOLD SELL RAW OR FINISHED PRODUCTS OF CROPS?**	**Yes** **No**			**1** **2→**	**315**
314.	Does your household _____? Would you say never, seldom, sometimes, often or always?					
		Never	Seldom	Sometimes	Often	Always
a.	Take the produce to the market yourself	1	2	3	4	5
b.	Sell the produce to the buyers who come to buy it at your home	1	2	3	4	5
c.	Sell the produce directly to a wholesaler	1	2	3	4	5
d.	Send the produce to a collection centre	1	2	3	4	5

315.	What are the seed sources that your household use for cultivation? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ RESPONSES. ASK, ANY OTHER?**	A. **Conserved seed** **Received or purchased seed from:** B. Market C. Agro-vets D. Government extension offices E. Research farms/NGOs F. Neighbours G. Relatives H. Dharchula and Indian side Y. Others (specify)_____	A B C D E F G H Y	
316.	In the last 12 months, who was usually responsible for seed management in your household? **Probe: Is this person under 15? What is the sex?**	Adult women Adult men Female child under 15 years Male child under 15 years Both adult men and women All members of the household No one specific Others (Specify)_____	11 12 13 14 15 16 17 97	
317.	Are you aware of agricultural crop diversity?	Yes No	1 2	
318.	Do you think traditional seed cultivars have decreased in the last 10 years?	Yes No	1 2→	 320

319.	What are the possible reasons for decline in the number of traditional seed cultivars? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ RESPONSES.**	A. Lower yield B. Long maturity period C. Land use change D. Introduction of improved variety E. Labour shortage F. Outmigration G. Less interest in agricultural activities Y. Others (specify)_____ Z. Don't know	A B C D E F G Y Z	
320.	Is conservation of local crop variety important? If yes, would you say it is slightly important, somewhat important or very important?	Not important Slightly important Somewhat important Very important	1→ 2 3 4	323
321.	Why is local crop diversity important? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ RESPONSES.**	A. Tradition B. Adaptive nature C. Nature of climate-stress tolerance D. Better taste E. Hardiness F. Low-risk cultivation G. Less labour intensive H. Less complicated I. Less input required J. Less expensive Y. Others (specify)_____	A B C D E F G H I J Y	

Now, I am going to ask you about the crop trend in the last 10 years.

		Has the area on which (CROP) was cultivated increased, decreased or remained the same in the last 10 years?	Why has the area on which (CROP) is cultivated changed in the last 10 years?	Has the production of (CROP) increased, decreased or remained the same in the last 10 years?	Why has the quantity of production changed in the last 10 years?
	323.	324.	325.	326.	327.
	CROP	Increased = 1 Not changed = 2 Decreased = 3	(A)	Increased = 1 Not changed = 2 Decreased = 3	(B)
INST		**IF "2", go to the next CROP**	**MORE THAN ONE RESPONSE POSSIBLE. DON'T READ RESPONSES.**	**IF "2", go to the next CROP**	**MORE THAN ONE RESPONSE POSSIBLE. DON'T READ RESPONSES.**
a.	Rice				
b.	Millet				
c.	Maize				
d.	Potato				
e.	Wheat				
f.	Buckwheat		=		
g.	Beans				

(A) Code for Q.325: Reason for change in land area	
A. Land-use practice changed	I. Better taste/less time required for cooking
B. Low interest in agriculture	J. Early maturing
C. Soil degradation	K. Good colour
D. Shortage of labour	L. High demand in market
E. Low market demand	M. Fetches good price

F. Less input required G. Prone to disease/insect/pest/crop failure H. Availability of other high-yielding variety	N. More input required O. Disease/insect/pest resistant Y. Others (specify) Z. Don't know
(B) Code for Q. 327: Reason for change in production	
A. Soil degradation B. Shortage of labour C. Less input invested D. Less resource (e.g. fertilizers, pesticides) available E. Low-yielding variety F. Disease/insect/pest/crop failure G. Natural disaster destroyed/damaged crop	H. Sufficient labour available I. More input invested J. More resources (e.g. fertilizers, pesticides) available K. High-yielding variety L. No disease/insect/pest/crop failure Y. Others (specify) Z. Don't know

SECTION IV: Food Security

Q. No.	Questions and Filters	Coding Categories	Codes	Skip
401.	In the last 12 months, was self-grown food sufficient to feed all the household members?	Yes No	1 → 2	501
402.	Which were the months when your household experienced shortage of self-grown food in the last 12 months? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ RESPONSES.**	A. January B. February C. March D. April E. May F. June G. July H. August I. September J. October K. November L. December M. All 12 months	A B C D E F G H I J K L M	
403.	What were the reasons your household experienced shortage of self-grown food in the last 12 months? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ THE RESPONSES. BUT ASK, ANY OTHER?**	A. Flood/drought B. Other natural disasters C. Low productivity of crops D. Injury to working member of the household E. Shortage of labour Y. Others (specify)_____ Z. Don't know	A B C D E Y Z	

404.	How did your household deal with the shortage of self-grown food in the last 12 months? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ THE RESPONSES. BUT ASK, ANY OTHER?**	A. Purchased food B. Sold livestock C. Sold jewellery D. Wage labour E. Worked for food F. Migrated to another place G. Received food aid H. Took loan to purchase food I. Mortgaged jewellery/property J. Borrowed from neighbour Y. Others (specify)_____ Z. Don't know	A B C D E F G H I J Y Z	

SECTION V: Perception on Climate Change, Anthropogenic Change, Impacts and Adaptation Strategies

Q. No.	Questions and Filters	Coding Categories	Codes	Skip
501.	Are you aware of climate change?	Yes No	1 2 →	 503
502.	What is the source from which you heard about climate change? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ THE RESPONSE CATEGORIES.**	A. Newspaper B. Training/Workshop C. Radio and TV D. School and college E. Colleagues/Relatives F. NGOs/INGOs G. Government entities Y. Others (specify)_____	A B C D E F G Y	
503.	What do you think are the reasons for the climatic changes you have seen? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ THE RESPONSE CATEGORIES.**	A. Deforestation B. More construction activities C. Use of explosives in construction D. Regular forest fires E. More open grazing F. Extension of green area under economic activity G. More use of wood for cooking H. Change in lifestyle I. More use of fossil fuel J. More industrial activities in the surroundings Y. Others (specify) _____ Z. Do not know	A B C D E F G H I J Y Z	

504.	What has been the impact of the changes in climate? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ THE RESPONSE CATEGORIES.**	A. Change in length of growing period B. Desertification C. Food insecurity D. Land-use change E. Pests and diseases F. Soil degradation G. Yield decline H. Erosion of local crop diversity I. Loss of special traits of crops/cultivars Y. Others (specify)_____ Z. Do not know	A B C D E F G H I Y Z	
505.	Have development interventions affected crop diversity management? By development intervention, I mean …	Yes No	1 2 →	F1
506.	How has it affected crop diversity management?	A. Availability of improved and hybrid variety B. Seasonal migration of human resources C. Access to road and market for resource availability D. High income from yar -tsha-gunboo and NTFP collection E. People's interest in agricultural work waning Y. Others (specify)_____ Z. Do not know	A B C D E Y Z	

F1	**CHECK Q501 & Q505: DOES THE HOUSEHOLD KNOW ABOUT CLIMATE CHANGE OR DOES IT THINK THAT DEVELOPMENT INTERVENTION AFFECTS CROP DIVERSITY MANAGEMENT?**	Yes No	1 2 →		601
507.	Were any local-level initiatives adopted to minimize the impacts of the aforementioned factors?	Yes No	1 --▶ 2		601
508.	Did your household _____		Y	N	
a.	Planted different cultivars of existing crops		1	2	
b.	Planted new crops altogether		1	2	
c.	Changed cropping system		1	2	
d.	Planted fast-maturing cultivars		1	2	
e.	Planted disease-resistant cultivars		1	2	
f.	Changed planting locations of crops		1	2	
g.	Changed planting time		1	2	
h.	Moved crops across land		1	2	
i.	Kept more livestock, instead of depending on crops		1	2	
j.	Planted trees		1	2	
k.	Did more water harvesting		1	2	
l.	Did more off-farm work		1	2	
m.	Soil management		1	2	
n.	Weather forecasts		1	2	
o.	Risk management instruments		1	2	
p.	Livelihood diversification		1	2	
q.	Land use and management		1	2	
r.	Others (Specify)		1	2	

509.	Has the traditional knowledge about crops and cropping practices been maintained for coping with change? If maintained, who has played the more important role, men or women?	Maintained by men and women equally Maintained, but men played the more important role Maintained, but women played the more important role Not maintained	1 2 3 4--▶	 601
510.	Why have you maintained traditional cropping knowledge? **INSTRUCTION: MORE THAN ONE RESPONSE POSSIBLE. DON'T READ THE RESPONSE CATEGORIES.**	A. Own variety B. Linked with our tradition and culture C. Better taste D. More nutritious E. More adaptive/resistant to disease/ pest Y. Others (specify)_____ Z. Don't know	A B C D E Y Z	

SECTION VI: Information, Communication and Trainings

Q. No.	Questions and Filters	Coding Categories	Codes	Skip
601.	Has any household member participated in trainings related to conservation and management in the last 12 months?	Yes No	1 2→	 603
602.	How many times have your household members participated in trainings related to conservation and management in the last 12 months?	Number of times		
603.	Has any household member participated in trainings related to agricultural practices in the last 12 months?	Yes No	1 2→	 605
604.	How many times have your household members participated in trainings related to agricultural practices in the last 12 months?	Number of times		
605.	How many times have you or your household members been part of exposure visits in the last 12 months?	Number of times		
		Have not participated Don't know	00 98	

606.	How important is _____ as a source of information for your household? Would you say never, seldom, sometimes, often or always?					
		Not at all important	Somewhat important	Important	Fairly Important	Very important
a.	Radio/ Radio programmes	1	2	3	4	5
b.	NGOs/GOs/Project (Staff)	1	2	3	4	5
c.	*Anka* office	1	2	3	4	5
d.	Education (formal)	1	2	3	4	5
e.	Own experience	1	2	3	4	5
f.	Reading material (e.g. newspaper, magazines)	1	2	3	4	5

607.	Are information centres available and accessible in your community?	Yes No	1 2	
608.	If yes, please tell me their name.			

Once again, thank you very much for your time and effort.

Appendix 3: Descriptors for *Phaseolus vulgaris* L. (adopted and modified from IBPGR, 1982)

SN	Characters	No. of Samples	Methods	Rank of Measurement uUnit	Remarks
1	Planting date	Block		Date	
2	Germination type		Observation	1: Epigeal 2: Hypogeal 3: Intermediate 74: Mixed 9: Others	
3	Stem colour			1: Green 2: Purple 3: Mixed 9: Others	Observe stem colour when the primary and secondary leaves open
4	Main stem length	10 plants	Measurement	Cm	Only for erect-plant type accession
	Flower				
4	Date of 50% flowering		Observation	Date	Date when the first flower opens in 50% of the plants
5	Flower colour, shape and size (standard)		Observation	1: Red 2: Purple 3: Pale purple 4: Yellow 5: Greenish yellow 6: Cream 7: White	In the case of colour not being found in the list, choose 9 and describe the colour in observer's comments. In the case of seeds with different colours being mixed, choose 9 and describe the situation in observer's comments.

				8: Blue 9: Others	
6	Flower colour (wing)	Block	Observation	1: Red 2: Purple 3: Pale purple 4: Yellow 5: Greenish yellow 6: Cream 7: White 8: Blue 9: Others	In the case of the colour not being found in the list, choose 9 and describe the colour in observer's comments
7	Flower color (keel)	Block	Observation	1: Red 2: Purple 3: Pale purple 4: Yellow 5: Greenish yellow 6: Cream 7: White 8: Blue 9: Others	In the case of the colour not being found in the list, choose 9 and describe the colour in observer''s comments
6	Growth habit with size		Observation	1: Determinate bush 2: Indeterminate bush 3: Indeterminate semi-climber 4: Indeterminate climber	
8	Leaf size		Measurements		

7	No. of pod		Observation/Count		Count the number of pods
8	Date of 50% pod maturity		Observation	Date	Date when 50% of the plants have the first mature Pod
9	Shattering in the field		Observation	1: No 2: Yes	
10	Colour of mature pod		Observation	1: Black 2: Blackish brown 3: Brown 4: Pale brown 5: Greyish white 6: Purple 7: Red 8: Light red 9: Others	In case the colour is not found in the list, choose 9 and describe the colour in observer's comments. In case of pods with different colours being mixed, choose 9 and describe the situation in observer's comments.
11	Seeds per pod	10 pods	Count		Average number of seeds from 10 pods
12	100-seed weight	100 seeds, 3 replications	Measurement	Gram	Use 100 air-dried seeds (with no more than 16% water content) with 2 replications

13	Seed-coat colour		Observation	1: Black 2: Blackish brown 3: Brown 4: Pale brown 5: Reddish brown 6: Purple 7: White 8: Others	Base-seed coat colour. In case the colour is not found in the list, choose 9 and describe the colour in observer's comments. In case of seeds with different colours being mixed, choose 9 and describe the situation in observer's comments.
14	Observer's special comments				Note if observers noticed some diseases, pests or special characters of the accession. Note if seed-dormancy break treatment and flower-initiation treatments such as short-day or long-day treatments are conducted.

Appendix 4: Cultivated Crop Diversity

S.N	Nepali Name	English Name	Botanical Name	Family	Cultivar Name
1	*Dhaan*	Rice	*Oryza sativa* L.	Gramineae	*Khasare*
					Sali
					Chamade
					Takmaro
					Roti dhaan
					Choti dhaan
					Jaili dhaan
					Jumli dhaan
					Kirmuli dhaan
					Jau dhaan
					Mangali dhaan
					Rato dhaan
2	*Makai*	Maize	*Zea mays* L.	Gramineae	*Bhabari*
					Rato
					Murali
					Temase
					Pahelo
					Seto
					Bhate
					Ragese
					Airkoti
					Male
					Baktado

					Ghar
					Baure
					Marudi
					Bikasi
3	*Gau*	Wheat	*Triticum aestivum* L.	Gramineae	*Dautkhane*
					Bhote
					Rato
					Thulo
					Jhuse
					Geru
					Moto
					Haasa
					Lide
					Jumli Bhoto
					Nangri Bhoto
4	*Jau*	Barley	*Hordeum vulgare* L.	Gramineae	*Jhuse*
					Mankare
					Uwa
					Kalo
					Seto
					Thang jau
5	*Kodo*	Finger millet	*Eleusine coracana* (L) Garetn.	Gramineae	*Nang kate*
					Kalo
					Rato

					Temase
					Tiuli
					Mutke
					Kodekauli
6	*Kaguno*	Foxtail millet	*Setaria italica* (L.) Beauvois	Gramineae	*Seto*
					Rato
					Banare
7	*Chino*	Proso millet	*Panicum miliaceum* L.		
8	*Marse*	Amaranth	*Amaranthus caudatus*	Amaranthaceae	*Rato*
					Seto
9	*Faphar*	Buckwheat	*Fagopyrum esculentum* Moench.	Polygonaceae	*Faphar*
10	*Tite faphar*	Tatary buckwheat	*Fagopyrum tataricum* (L) Gaertn.		*Tite faphar*
11	*Karela*	Bitter gourd	*Momordica charantia* L.	Cucurbitaceae	*Tite karela*
					Thulo
					Desi
					Nano karela
12	*Rayo*	Broadleaf mustard	*Brassica juncea* (L.) Czem.	Cruciferae	*Kalo*
					Marmale
					Chinese *(seto paat)*
					Ghariya
13	*Kakra*	Cucumber	*Cucumis sativus* L.	Cucurbitaceae	*Bele*
					Bote
					Makalpure

					Bhaktapure
14	*Farsi*	Pumpkin	*Cucurbita maxima*. Duchesne	Cucurbitaceae	*Kalo*
					Seto (dalle)
					Bote
					Rato
					Aalu
					Katte
15	*Aalu*	Potato	*Solanum tuberosum* L.	Solanaceae	*Rato local*
					Rato bikase
					Topiyes
					Banshankar
					Seto gharelu
16	*Lasun*	Garlic	*Allium sativum* L.	Amaryllidaceae	*Hade*
					Dhudhe
					Ghade
					Machelsun
					Byaas
17	*Pidaalu/Karkalo*	Taro	*Colocasia esculenta* (L.) Schott.	Araceae	*Kuche*
					Lakde
					Gume
					Bhabare

					Acher
18	*Mula*	Radish	*Raphanus sativus* L.	Cruciferaceae	*Byasi*
					Dalle, Gyante
					Choto
19	*Chamsur*	Cress	*Lepidium sativum* L.	Cruciferaceae	*Rato*
20	*Pyaaj*	Onion	*Allium cepa* L.	Amaryllidaceae	
21	*Tori*	Mustard	*Brassica campestris* var. *toria*	Cruciferaceae	*Todo*
22	*Sarsiyau*	Indian colza, Sarsyun	*Brassica campestris* L. var. sarson Prain	Cruciferaceae	*Sarsiyau*
23	*Palungo*	Spinach	*Spinacia oleraceae* L.	Chenopodiaceae	
24	*Bhanta*	Eggplant, Guinea squash	*Solanum melongena* L.	Solanaceae	*Kala dalle bhanta*
25	*Tamatar*	Tomato	*Lycopersicum esculentum* L.	Solanaceae	*Barse chuche dana*
					Barmas
					Hiude (golo)
					Bote
					Golbheda
26	*Gaajar*	Carrot	*Daucus carota* L.	Umbelliferaceae	

27	*Tarul*	Yam	*Doiscorea alata* L.	Dioscoreaceae	*Ghar tauda*
28	*Ghiraula*	Spongegourd	*Luffa cylindrica* (L.) Roem.	Cucurbitaceae	
29	*Kubindo*	White gourd	*Benicasa hispida* (Thunb.) Cogn.	Cucurbitaceae	
30	*Sakarkhanda*	Sweet potato	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	
31	*Lauka*	White flower gourd	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae	
32	*Koiralo*	Pink bauhinia	*Bauhinia purpurea* L.		
33	*Bhyaakur*	Cush-cush yam	*Dioscorea bulbifera*	Dioscoreaceae	
34	*Bhindi*	Okra	*Hibiscus esculentus* L.	Malvaceae	
35	*Cauli*	Cauliflower	*Brassica oleraceae* var. botrys L.	Cruciferaceae	
36	*Bandagobi*	Cabbage	*Brassica oleraceae* var. capitata L.	Cruciferaceae	
37	*Toraiya*	Chinese okra, Dishcloth gourd	*Luffa acutangular*	Cucurbitaceae	
38	*Okhar*	Walnut (thin shell walnut)	*Juglans regia* L.	Juglandaceae	*Daate*
		Walnut	*Juglans regia* L.	Juglandaceae	*Haade*
39	*Naaspati*	Pear	*Pyrus communis* L.	Rosaceae	
40	*Amilo*		Citrus limon (L.) Burn. F.	Rutaceae	*Gargalo chuka*
42	*Kagati*	Lime	*Citrus aurantifolia* (Christm.) Swingle	Rutaceae	*Local*
43	*Suntala*	Mandarin	*Citrus reticulata* Blanco.	Rutaceae	
44	*Katus*	Chestnut	*Castanopsis indica* (Roxb.) Mig.	Fagaceae	
45	*Aaru bakhada*	Plum	*Prunus domestica* L.	Rutaceae	
46	*Kera*	Banana	*Musa paradisiaca* L.	Musaceae	*Muse*
					Malauto
					Hajari
47	*Ukkhu*	Sugarcane	*Saccharum officinarum* L.	Gramineae	*Kalo ginne*

					Seto
					Baas ginna
					Fulle
					Sinne
					Nyaale
48	*Kafal*	Box myrtle	*Myrica esculenta*. Buch	Myricaceae	
49	*Anaar*	Pomegranate	*Punica granatum* L.	Puniaceae	
50	*Daarim*	Pomegranate	*Punica granatum* L.	Puniaceae	
51	*Syaau*	Apple	*Pyrus malus* L.	Rosaceae	
52	*Badam*	Groundnut, Peanut	*Arachis hypogaea* L.	Leguminosae	
53	*Aaru*	Peach	*Prunus persica* (L.) Batsch	Rosaceae	*Desi*
					Gobar
					Aam aaru
					Kusme aaru
					Tilmada
					Khumane
54	*Angur*	Grapes	*Vitis vinifera* L.	Vitaceae	*Kalo*
					Hariyo
55	*Amala*	Indian Gooseberry	*Phyllanthus emblica* L.	Euphorbiaceae	
56	*Amba*	Guava	*Psidium guajava* L.	Myrtaceae	
57	*Mewa*	Papaya	*Carica papaya* L.	Caricaceae	
58	*Ampa*	Mango	*Mangifera indica* L.	Anacardiaceae	
59	*Pangar*		*Aesculus indica* (Colebr.ex Cambess)	Hippocastanaceae	
60	*Bhaang*	Marijuana	*Cannavis sativa* L.		*Ban bhang (Sano)*
					Ghar bhang (Thulo)

61	*Teel*	Sesame	*Sesamum indicum* L.	Pedaliaceae	*Seto*
					Kalo
62	*Silaam*	Perilla	*Perilla frutescens* (L.) Britt.	Labiatae	
63	*Timur*	Nepal pepper, Prickly ash	*Zanthoxyllum armatum* DC.	Rutaceae	
64	*Aduwa*	Ginger	*Zingiber officinale* Rosc.	Zingiberaceae	*Kachare*
65	*Besar*	Turmeric	*Cucurma domestica*	Zingiberaceae	
66	*Pudina*	Mint	*Mentha arvensis* L.	Labiatae	
67	*Saufa*	Fennel	*Foeniculum vulgare* Mill.	Umbelliferae	
68	*Zeera*	Cumin	*Cuminum cyminum* L.	Apiaceae	
69	*Dalchini*	Cinnamon bark	*Cinnamomum zeylanicum* Breyn.	Lauraceae	
70	*Alaichi*	Cardamom	*Amomum subulatum*	Zingiberaceae	
71	*Methi*	Fenugreek	*Trigonella foenum-graecum* L.	Papilinaceae	
72	*Jimbu jhar*		*Allium wallichi* Kunch.	Amaryllidaceae	
			Allium sp.	Amaryllidaceae	
73	*Dhatelo*		*Prinsepia utilis* Royle	Rosaceae	
74	*Jywaano*	Ajwain lovage	*Trachyspermum ammi* (L.) Sprague	Umbelliferae	
75	*Suryamukhi*	Sunflower	*Helianthus annus* L.	Compositae	
76	*Khursani*	Bell pepper	*Capsicum frustescens* var. *grossum*	Solanaceae	*Bhede*
77	*Dhaniya*	Coriander	*Coriandrum sativum* L.	Umbelliferaceae	*Kathe*
78	*Filinge*	Niger	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae	*Local*

Appendix 5: List of Wild and Non-cultivated Edible Plants Collected from the Study Area

S. N	Family	Botanical name	IUCN category	English name	Nepali name	Use [a]	Parts used [b]	Remarks
1	Acoraceae	*Acorus calamus* L.	LC	Flag root, myrtle flag	Bojho	M	R	Dried rhizome used to treat sore throat, coughs, and colds
2	Adoxaceae	*Viburnum erubescens* Wall.	NE		Bajrang	F	F	Fruit eaten
3	Adoxaceae	*Viburnum mullaha* Buch. - Ham.ex D. Don	LC		Kavase	F	F	Fruit sour but eaten
4	Amaranthaceae	*Amaranthus blitum L.*	NE	Amaranth	Marshi	V	L, Sh	Leaves and young shoots eaten as a green vegetable
5	Amaranthaceae	*Amaranthus spinosus* L.	NE	Amaranth	Marshi	V	L, Sh	Young leaves and shoots eaten as a green vegetable
6	Amaranthaceae	*Amaranthus viridis* L.	NE	Amaranth	Marshi	V, O	L, Sh, Se	Young shoots and leaves eaten as a green vegetable; seeds ground to flour and used to make chapattis; seeds fried in ghee and honey and made into round balls to eat (ladoo/geda)
7	Amaryllidaceae	*Allium* sp.				S	L	Dried plant leaves used in curries

8	Amaryllidaceae	*Allium wallichii* Kunth	NE	Jimbur or Himalayan onion	Jimbu Jhar	S	W	Dried plant used in dal and curries
9	Anacardiaceae	*Pistacia chinensis subsp. integerrima (J.L. Stewart) Rech.f.*	NE	Insect gall in Pistacia	Kakarsingee	M	Gall	Gall used to treat snake and scorpion bites
10	Apiaceae	*Angelica archangelica* L.	LC			S, M	R, Se	Root ground and made into soup to treat stomach pain. Seeds ground to flour and used as spice in curry
11	Araceae	*Arisaema flavum* (Forssk.) Schott	NE		Bako	V	T	Corms (tubers) boiled in ash and salt to remove toxic elements, cleaned, made into a paste, and mixed with buckwheat flour to prepare curry
12	Araceae	*Arisaema tortuosum* (Wall.) Schott	NE	Whipcord cobra lily	Bako	V	T	Boiled tubers eaten as vegetable
13	Araceae	*Colocasia esculenta* (L.) Schott.	LC	Taro	Pidaalu	V	R, S, L	Rhizome boiled and eaten as a vegetable; young stem and leaves used as a vegetable and in pickle
14	Arecaceae	*Phoenix loureiroi Kunth*	NE		Thakal	F, O	F, S	Fruit eaten; pith from stem eaten; stem used to make thatched roofs
15	Asparagaceae	*Asparagus racemosus* Willd.	NE	Asaparagus, Wild Asparagus	Kurilo	V, M	R, Sh	Shoots and leaves eaten as a vegetable; roots used to treat urinary and liver problems
16	Asteraceae	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob.	NE	Crofton weed	Banmara	M	L	Juice from crushed leaves used to treat wounds and cuts

17	Asteraceae	*Ageratum conyzoides* L.	LC	Billygoat-weed	Gandhe	M	L	Leaves crushed and juice used to treat cuts and wounds
18	Asteraceae	*Artemisia indica* Willd.	NE	Mug-wort, Indian worm wood fleabane	Titepati	R, M	L	Leaves used in death ceremonies; leaves crushed, and juice used to treat skin problems (irritation)
19	Berberidaceae	*Berberis aristata* DC.	LC	Barberry/ Nepal Barberry/common Barberry	Chutro	F, O, M	F, Ba	Fruit eaten; bark used as a dye and to treat diarrhoea, piles, and malaria
20	Berberidaceae	*Berberis asiatica* Roxb. ex DC.	NE	Barberry/ Nepal Barberry	Kirmando	F, O	F, Ba	Fruit eaten; bark used as a dye
21	Bombacaceae	*Bombax ceiba* L.	LC	Silk cotton tree, Simal tree	Simal	V	Fl	Flowers used in a vegetable curry
22	Cannabaceae	*Cannabis sativa* L.	NE	True hemp, Indian hemp, marijuana	Bhang	O, M	Se, L	Roasted seeds used to make pickle or eaten raw; green leaves occasionally used to make snacks (pakauda); green leaves made into a paste and applied to the forehead to treat high fever

23	Amaranthaceae	*Chenopodium album* L.	NE	Lamb's quarter	Bethe sag	V	L	Leaves and young shoots eaten as a green vegetable
24	Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	LC	Belleric myrobalan	Barro	F, M	Se, F	Ripe fruit eaten; seeds used to treat coughs and colds
25	Combretaceae	*Terminalia chebula* Retz.	LC	Chebulie myrobalan, yellow myrobalan	Harro	F, M	Se, F	Fruit eaten; fruit and seeds used to treat coughs and colds
26	Commelinaceae	*Commelina benghalensis* L.	LC	Day flower	Kane Sag	V	L, Sh	Young leaves and shoots eaten as a green vegetable
27	Convolvulaceae	*Cuscuta reflexa* Roxb.	LC	Dodder	Aakas beli	M	W	Whole plant used to prepare medicine to treat livestock with cough and throat allergy
28	Cucurbitaceae	*Coccinia grandis* (L.) Voigt	NE	Ivy gourd, Kavai fruit	Golkakri	V	F	Fruits eaten as a vegetable
29	Cucurbitaceae	*Momordica dioica* Roxb. ex Willd.	NE		Bankarela	V,	F	Immature fruit eaten as a green vegetable
30	Dioscoreaceae	*Dioscorea bulbifera* L.	NE	Palmate leaved yam	Githi	V	T	Tubers boiled and eaten as a vegetable
31	Dioscoreaceae	*Dioscorea deltoidea* Wall. ex Griseb.	NE,	Cush-cush yam	Bhyakur	V,	B, T	Bulbil and tubers boiled and eaten as a vegetable

32	Dioscoreaceae	*Dioscorea hamiltonii* Hook.f.	NT	Air potato, Potato yam	Ban tarul	V, R	B, T	Tubers and bulbils cooked and eaten. Boiled tubers used during religious event first day of Nepali Month Magh (January)
33	Dryopteridaceae	*Dryopteris cochleata* (D. Don) C. Chr.	NE	Edible fern shoot	Niuro	V, O	L, Sh	Young coiled fronds and shoots cooked and eaten as a vegetable; sold in urban markets (high demand)
34	Elaeagnaceae	*Elaeagnus parvifolia* Wall.	LC	Oleaster	Kankoli	F	F	Fruit eaten
35	Ericaceae	*Rhododendron arboreum* Sm.	LC	Rhododendron	Laligurans	M, O	Fl	Flowers eaten; nectar used to treat diarrhoea and dysentery
36	Phyllanthaceae	*Phyllanthus emblica* L.	LC	Indian gooseberry	Amala	F, M	F	Fruit eaten raw and dried; fruit used in preparation of some Ayurvedic medicines for treating indigestion
37	Fabaceae	*Albizia procera* (Roxb.) Benth.	LC	White siris	Siris	O	L	Leaves used to cover bananas to ripen them
38	Fabaceae	*Bauhinia variegata* L.	LC	Mountain ebony, White bauli	Koiralo	V, M	Bu, Fl	Buds and flowers used as a vegetable and in pickle; flowers used to make soup to treat bacillary dysentery
39	Fagaceae	*Castanopsis tribuloides* (Sm.) A.DC.	NE	Chestnut	Katus	F, R	F	Fruit eaten and offered to gods during rituals

40	Fagaceae	*Quercus lanata* Sm.	LC	Woolly-leaved oak	Baanjha	F	F	Fruit (lekaal) eaten
41	Gentianaceae	*Swertia chirayita* (Roxb.) H. Karst.	NE	Chiretta	Chiraita	M	W	Whole plant used to treat fever, diabetes, and skin diseases
42	Sapindaceae	*Aesculus indica* (Wall. ex Cambess.) Hook.	LC	Indian Horse Chestnut	Pangar	M, O	F	Roasted fruit eaten to kill stomach worms; fruit used for washing clothes
43	Juglandaceae	*Juglans regia* L.	LC	Walnut	Okhar	F, R	F	Fruit eaten and offered to gods during festivals
44	Lamiaceae	*Mentha arvensis* L.	LC	Mint	Pudina	S, M	L	Leaves used in pickle; juice from leaves used for cooling in summer
45	Lamiaceae	*Mentha spicata* L.	LC	Mint	Pudina	S, M	L	Leaves used as spice in pickle; leaves used as medicine to reduce 'body heat'
46	Lamiaceae	*Perilla frutescens* (L.) Britton	LC	Perilla	Silame	S	Se	Seeds roasted and ground to use in pickle
47	Lardizabalaceae	*Stauntonia latifolia* (Wall.) Christenh.	NE			F	F	Ripe fruit eaten
48	Lauraceae	*Cinnamomum glanduliferum* (Wall.) Meisn.	LC	Nepal camphor tree	Sunghand haakokila	M, R	Ba, F	Bark and fruit used to treat coughs and colds, toothache, and swelling of

								muscles; leaves and fruit offered to gods during rituals
49	Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	LC	Bay leaf	Tejpaat	S	L	Dried leaves used as spice for curries to add flavour and smell
50	Loranthaceae	*Helixanthera odorata* (Wall.) Rajasek.	NE		Ajeru	F	F	Fruit very tasty
51	Moraceae	*Ficus auriculata* Lour.	LC	Eye's apron, Moretan-bay fig	Timilo	F	F	Fruit eaten
52	Moraceae	*Ficus hispida* L.f.	LC		Khasreto	F	F	Fruit eaten
53	Moraceae	*Ficus virens* W. T. Aiton	LC		Kabhro	V	Bu, Fl	Buds and flowers boiled and eaten as a vegetable and pickle
54	Moraceae	*Ficus neriifolia* Sm.	NE		Dudhilo	V, F	Sh, F	Young shoots eaten as a vegetable; fruit eaten
55	Moraceae	*Ficus semicordata* Buch.-Ham. ex Sm.	LC	Nepal fodder fig	Khaniyo	F	F	Fruit eaten
56	Moraceae	*Ficus subincisa* Buch.-Ham. ex Sm.	LC		Berlo	F	F	Ripe fruit eaten
57	Moraceae	*Morus serrata* Roxb.	LC	Mulberry	Kimbu	F, O	F, L	Fruit eaten, very popular among children; leaves used as fodder, preferred by goats

58	Musaceae	*Musa balbisiana* Colla	LC	Banana	Bankera	F, R	F	Ripe fruit eaten and offered to gods during rituals
59	Myricaceae	*Myrica esculenta* Buch.-Ham. ex D. Don	NE	Box byrtle	Kafal	F	F	Fruit tasty and popular
60	Myrtaceae	*Syzygium cumini* (L.) Skeels	LC	Black plum, Java plum, Indian black berry	Jamun	F	F	Fruit eaten
61	Myrtaceae	*Syzygium* sp.				F	F	Fruit eaten
62	Nephrolepidaceae	*Nephrolepis cordifolia* (L.) C. Presl	NE	Sword fern	Pani amala	M	T	Tubers eaten to treat worms
63	Oxalidaceae	*Oxalis corniculata* L.	NE	Indian sorrel, Creeping sorrel	Chari amilo	S	L	Leaves used in preparing pickle
64	Paeoniaceae	*Paeonia emodi* Royle	LC			V	L, Sh	Young shoots and leaves eaten as a green vegetable, fresh or sundried, rehydrated, and cooked (in winter)
65	Phytolaccaceae	*Phytolacca acinosa* Roxb.	NE		Jarko	V, M	L, R	Young leaves and shoots eaten as a green vegetable; root used to treat

								sickness after eating buckwheat leaves
66	Pinaceae	*Pinus roxburghii* Sarg.	LC	Chir Pine, Himalayan long leaved pine	Salla	M	La	Resin used to clear blood clots
67	Poaceae	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro	NE	Tufted bamboo	Bans	V	Sh	Young shoots (tama) eaten as a vegetable
68	Poaceae	*Drepanostachyum falcatum* (Nees) Keng f.	NE	Himalayan Bamboo	Nigaalo	V, O	S, Sh	Stem used to make mats; young shoots eaten as a vegetable
69	Polygonaceae	*Fagopyrum esculentum* Moench	NE	Buckwheat	Phapar	V	L, Sh	Young shoots and leaves eaten as a vegetable
70	Polygonaceae	*Fagopyrum tataricum* (L.) Gaertn.	NE	Buckwheat	Phapar	V	L	Young shoots and leaves eaten as a vegetable
71	Polygonaceae	*Polygonum* sp.				S	L	Yound leaves used to make pickle
72	Polygonaceae	*Polygonum verticillatum* Biroli ex Colla	NE		Nigali sag	V	L	Young leaves eaten as a vegetable
73	Ranunculaceae	*Aconitum heterophyllum* Wall. ex Royle	EN	Aconite	Atis	M	W, R	Whole plant and roots used to treat high fever and abdominal pain
74	Rosaceae	*Fragaria nubicola* Lindl. ex Lacaita	NE			F, R, M	F, W	Fruit eaten; whole plant used in death rituals; whole plant used to treat stomach disorders

75	Rosaceae	*Pyracantha crenulata* (D.Don) M. Roem.	NE	Fire horn	Ghangyaru/ kaatha gedi	F	F	Ripe fruit eaten in large quantities
76	Rosaceae	*Pyrus pashia* Buch.-Ham. ex D.Don.	LC		Mayal	F	F	Fruit eaten
77	Rosaceae	*Rubus ellipticus* Sm.	LC	Golden evergreen raspberry	Ainselu	F	F	Fruit very popular
78	Rosaceae	*Rubus niveus* Thunb.	NE	Rasberry	Ainselu	F, R	F, L, W	Fruit eaten; leaves or whole plant used in death ceremonies
79	Rosaceae	*Rubus niveus* Thunb.			Ainselu	F	F	Fruit eaten
80	Rubiaceae	*Rubia manjith* Roxb. ex Fleming	NE	Indian madder	Majitho	M	S, L	Stem and leaves used to treat cuts and wounds
81	Rutaceae	*Aegle marmelos* (L.) Corrêa		Bael fruit	Bel	F, R	F, L	Fruit pulp eaten; leaves used for religious purposes, especially offering to gods during rituals
82	Rutaceae	*Zanthoxylum armatum* DC.	LC	Nepal pepper, prickly ash	Timur	S, M	F	Fruit dried and used as a spice in pickles and curries; dried fruit used in various allopathic medicines like indigestion and nausea
83	Sapindaceae	*Sapindus mukorossi* Gaertn.	LC	Soap nut	Reetha	O	F	Fruit pulp used to wash hair

84	Sapotaceae	*Diploknema butyracea* (Roxb.) H.J.Lam	NE	Nepal butter fruit Phulwara	Chiuri	O, F	Fl, F, Se	Nectar from flowers and ripened fruit (bhina) eaten; seeds used to make a butter for cooking vegetables and others
85	Actinidiaceae	*Saurauia napaulensis* DC.	LC		Gogan	F	F	Fruit eaten
86	Saxifragaceae	*Bergenia ciliata* (Haw.) Sternb.	LC	Rock foil	Pakhanbed	M	R	Rhizome used to make medicine to treat kidney stones
87	Schisandraceae	*Schisandra grandiflora* (Wall.) Hook.f. & Thomson	NE	Magnolia Vine		F	F	Ripe fruit eaten
88	Smilacaceae	*Smilax aspera* L.	LC	Green briers	Kukurdaino	F, V	Sh,F	Fruit eaten; young shoots eaten as a vegetable
89	Smilacaceae	*Smilax ovalifolia* Roxb. ex D.Don	NE	Green briers	Kukurdaino	F, V	Sh,F	Fruit eaten; young shoots eaten as a vegetable
90	Solanaceae	*Solanum nigrum* L.	NE		Kalokamai	F	F	Fruit eaten
91	Melanthiaceae	*Paris polyphylla* Sm.	VU		Satuwa	V, M	L, R	Tender leaves eaten as a vegetable; root made into paste and applied to snake bite to control the poison
92	Urticaceae	*Pouzolzia rugulosa* (Wedd.) Acharya & Kravtsova	NE		Getha	O	Ba	Bark paste/powder mixed with rice flour to prepare sel roti (a form of rice doughnut); bark paste used as soda and to wash clothes

93	Urticaceae	*Debregeasia saeneb* (Forssk.) Hepper & Wood	LC		Tusaare	F	F	Fruit eaten
94	Urticaceae	*Girardinia diversifolia* (Link) Friis	NE	Himalaya n Nettle	Allo Sisnu	V, O	L, Sh, S,	Young leaves and shoots eaten; fibre extracted from stems used to make clothes and bags
95	Urticaceae	*Gonostegia hirta* (Blume) Miq.	NE			O	R	Ground root used to prepare chapatti; ground root used for washing hair.
96	Urticaceae	*Urtica dioica* L.	LC	Stinging nettle	Sisnu	V	L, Sh	Young leaves and shoots used as a vegetable
97	Lamiaceae	*Callicarpa arborea* Roxb.	LC	Beauty berry	Guyalo	F	F	Tasty fruit
98	Violaceae	*Viola vetonicifolia* Smith.	LC	Arrohead Violet		M	L, R	Leaves and roots used to treat worms in children
99	Vitaceae	*Tetrastigma* sp.				F	F	Fruit eaten

Note: Use (a): F = fruit, V = vegetable, M = medicine, O = other, R =religious, S = spice

Parts used (b): W = whole plant, B = bulb, Ba = bark, Bu = buds, F = fruit, Fl = flowers, La = latex, L = leaf, O = other, R = root/rhizome, S = stem, Se = seeds, Sh = shoots, T = tuber/corm

IUCN Red list categories: EN= Endangered; VU= Vulnerable; NT= Near Threatened; LC= Least Concern; NE= Not evaluated

Appendix 6: Photographs of threatened grain amaranthus and commonly use wild vegetable species

Amaranthus caudatus, locally known as *Marsi*

Amaranthus hypochondriacus, locally known as *Marsi*

Paeonia emodi Royle, locally known as *Hetto*

Dryopteris cochleata (D. Don) C. Chr., locally known is *Liund*o

Appendix 7: Scientific publications and participation in national international workshop/symposium/seminars

1. **Aryal, K.**, Poudel, S., Chaudhary, P., Chaudhary, R. P., Ghimire, K.H., Shrestha, D.S., & Joshi, B.K. (2020). Agro-morphological diversity of high-altitude bean landraces in the Kailash Sacred Landscape of Nepal. *Journal of Nepal Agricultural Research Council*, **6**, 1–13.

2. **Aryal, K. P**., Poudel, S., Chaudhary, R.P., Chettri, N., Chaudhary, P., Ning, W., & Kotru, R. (2018). Diversity and use of wild and non-cultivated edible plants in the Western Himalaya. *Journal of Ethnobiology and Ethnomedicine*, **14**(1), 1–18.

3. **Aryal, K**., Poudel, S., Chaudary, R.P., Chettri, N., Ning, W., Shaoliang, Y., & Kotru, R. (2017). Conservation and management practices of traditional crop genetic diversity by the farmers: A case from Kailash Sacred Landscape, Nepal. *Journal of Agriculture and Environment*, **18**, 15–28.

4. **Aryal, K.P**., Chaudhary, R.P., & Poudel, S. (2021). Food from farm and forest, a case study from Kailash Sacred Landscape. In Romeo, R., Manuelli, S.R., Geringer, M. and Barchiesi, V. (eds) *Mountain Farming Systems – Seeds for the Future. Sustainable Agricultural practices for Resilient Mountain Livelihoods* (pp. 70–72). Rome: FAO. https://doi.org/10.4060/cb5349en

5. **Aryal, K**. (2017). Management of local crop diversity: A concern (Blog **article: https://www.icimod.org/management-of-local-crop-diversity-a-concern/)**

Participation in national and international workshops/symposiums/conferences

- Participated in 7th National Conference on Science and Technology organised by Nepal Academy of Science and Technology from March 29-31, 2016. (Paper presented)

- Participated in "International workshop on plant diversity and conservation of the belt and road countries" held during 9-22 September 2018 in Kunming, Yunan, China. (Paper presented)

- Participated in Regional symposium on "organic agriculture: youth engagement and enterprise development" held in Paro Bhutan from 18-20, December 2019

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Agro-morphological Diversity of High Altitude Bean Landraces in the Kailash Sacred Landscape of Nepal

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ABSTRACT

Many varieties of bean are widely grown across diverse agro-ecological zones in Nepal. And opportunities exist for improving the crops and enhancing their resilience to various biotic and abiotic stressors. In this context, an experiment was conducted from June to October 2016 in Khar VDC of Darchula district to study the phenotypic traits of nine landraces of bean (*Phaseolus vulgaris* L.). The bean landraces were planted using randomized complete block design in three sites (Dhamidera, Dallekh and Sundamunda villages), with three replications in each site for their comparative analysis. The study considered the following phenotypic traits: days to emergence, days to 50% flowering, days to 90% pod maturity, number of nodes, pod length, pod width, number of pods, number of seeds per pod and weight and grain yield for 100 seeds. Kruskal-Wallis test showed significant differences in the landraces both within and among locations. KA-17-08-FB and KA-17-04-FB were late flowering (63 and 65 days respectively) compared to other landraces whereas KA-17-07-FB flowered earliest (within 42 days). In all three sites, three landraces namely KA-17-07-FB, KA-17-04-FB and KA-17-06-FB were found to be relatively more resistant to pest and diseases than other landraces. Eight out of nine landraces in Dhamidera and Dallekh villages and seven out of nine in Sundamunda village produced seeds greater than 1.0 t/ha. Among the nine varieties KA-17-02-FB was the highest yielding variety, with an average yield of 3.8 t/ha. This study is useful for identifying suitable landraces for future promotion based on their maturity, grain yield, diseases resistance and other qualitative and quantitative characteristics.

Keywords: Common bean, Landrace, Diversity, Kailash Sacred Landscape, Phenotype

सारांश

सिमी नेपालको विभिन्न कृषि पर्यावरण भएको ठाउंमा लगाउने प्रचलन छ र त्यसको सहि तरिकाको विकास र अनेक किसिमका जैविक तथा अजैविक समस्याहरुसंग जुध्न तथा अनुकूलीत गर्ने सम्भावनाहरु प्रचुर छ । विरुवाको आवरणको आधारमा अध्ययन गर्ने उद्देश्यले दार्चुलाको खार गा.वि.स. मा ९ वटा सिमीका स्थानीय जातहरु २०७४ को असार देखि कार्तिक महिनासम्म लगाइको थियो । ती सिमीका जातहरु तुलनात्मक अध्ययनको उद्देश्यले randomized complete block design (RCBD) विधिद्वारा तिन स्थानमा (धामिडेरा, दल्लेख र सुन्डमुन्ड गाउंमा) लगाइको थियो र हरेक जात प्रत्येक स्थानमा तिन ठाउंमा लगाइएको थियो । अध्ययनले निम्न आवरणसम्बन्धी गुणहरु समेटेको थियो: उम्रिन लाग्ने दिन, ५० प्रतिशत फूल फूल्ने दिन, ९० प्रतिशत कोषा पाक्ने दिन, गांठोको संख्या, कोषाको लम्बाइ, कोषाको चौडाइ, कोषा संख्या, प्रति कोषा विउ संख्या र १०० दानाको तौल । डाटा विश्लेषण गरी सिमीहरुको जातको बीचमा विशिष्ट रुपले फरक छ छैन हेर्न Kruskal-Wallis विधि अपनाइएको थियो । नौ वटा मध्ये KA-

17-08-FB र KA-17-04-FB (क्रमशः ६३ दिन र ६५ दिनमा फूल्ने) जातहरु अलि ढीलो फूल्ने पाइयो भने KA-17-07-FB सबैभन्दा चांडै फूल्ने (४२ दिन) पाइयो । सबै ठाउंमा तिनवटा जातहरु जस्तै: KA-17-07-FB, KA-17-04-FB and KA-17-06-FB अरु जातको तुलनामा अलि बढी रोग र किरा सहन सक्ने पाइयो । बीउको उत्पादनको हकमा, धामिडेरा र दल्लेखमा नौ वटा मध्ये अठवटा र सुन्डमुन्डमा नो वटामध्ये सातवटा जातहरु १ टन प्रति हेक्टरभन्दा बढी भएको पाइयो । नौवटा मध्ये KA-17-02-FB सबैभन्दा बढी उत्पादन दिने पाइयो जसको उत्पादन ३.८ टन प्रति हेक्टर मापन गरिएको थियो । यस अध्ययनले पाक्ने समय, उत्पादन, रोग किराको प्रकोप र अन्य गुणहरुको आधारमा स्थानीय ठाउंमा सुहाउदो जातहरु छनौट गर्न मद्दत गर्नेछ ।

INTRODUCTION

Nepal makes for about 0.4% of the world's pulse-growing area and production capacity. The country's varied climatic and environmental conditions provide prospects for growing many different species of legumes. In Nepal, pulses (including soybeans) are farmed on 10% of the total cultivated land area, and they rank fourth in terms of cultivated-area size, after rice, wheat, and maize. In total, grain legumes are grown on 311,382 ha of land, with production and productivity figures of 368,741 tons and 1.18 t/ha, respectively (http://agrinepal.blogspot.com/2013/07/status-and-future-prospects-of-pulses.html). Different types of legumes are cultivated and consumed as vegetables and pulses in Nepal. Legumes are very important source of protein for marginal farmers as well as vegan people. They also enrich nitrogen and organic matter to the soil. About 32.2% higher nitrogen was found in the fields where legume was inter-cropped with maize than the mono-cropped maize fields (Shrestha et al 2008).

Common bean (*Phaseolus vulgaris* L.) is an important legume cash crop cultivated in a wide range of agro-climatic conditions from Tarai (300m amsl) to high hill (2500m amsl) of Nepal, especially in mountain districts such as Jumla, Humla, Mustang, Rasuwa, Solukhumbu, etc, where mixed landraces with varying morphologies are cultivated. Nepal's hills and mountains are rich in bean diversity, and some landraces have unique characteristics (KC et al 2016, Joshi et al 2017a). Common beans grown in high-hill have better taste and are considered more nutritious compared to the beans grown in Terai region of Nepal. More recently, this crop is commonly grown along with kidney bean, fetches good return and have well established market (Neupane et al 2008, Muchui et al 2008, Shrestha et al 2011, Neupane and Vaidya 2002).

People from low plains (below 500 m asl) usually plant red kidney beans in the winter as monoculture and it is an important part of cuisine. In the hill (500 – 1600 masl) french beans, both pole and bush types, are cultivated usually during summer to autumn for consuming leaves and fresh green pods as green vegetables. In the high hills and mountains (1600- 2500 masl) dried shelling beans are planted during summer to autumn along with maize and also in apple orchards (Pandey et al 2011).

The research solely on grain legumes is relatively low in Nepal. Limited studies are conducted on french beans in different parts of the country but multi-location trials are rarely done. For instance, Neupane et al (2008) investigated 100 accessions of local and exotic beans using agro-morphological characteristics in order to assess variability and potentials of germplasm for varietal improvement programs. An on-farm evaluation in participatory varietal trials suggested that Jumli farmers preferred PB0001, PB0002, and PB0048 genotypes among the evaluated accessions due to medium growth habit, tolerance to disease early maturing nature, high yielding, good seed size and color (Chhetri and Bhatta 2017). A study conducted at Regional Agriculture Research Station (RARS) Lumle, Kaski by Pandey et al (2011) on 18 exotic and indigenous french bean genotypes of western hills, revealed that there is good variation in bean genotypes. Another study by Pandey et al (2012), conducted to understand the response of pole type french beans to sowing dates, showed significant effects in yield and yield attributes among three different varieties studied. All the yield attributes such as early flowering, widest pods, fresh pod yield, and longest pods were highest in all the varieties planted in mid-August. Mid-August was considered the best time for sowing the crop to obtain the highest pod yield in mid-hill.

The study of agronomical characteristics of genotypes is very important to identify suitable genotypes for an area which can fulfill the needs of marginalized farmers (Sheikh et al 2017) and because of just only two modern varieties (Joshi et al 2017b) in the country. Characterization of agronomical traits also helps to find out useful characters which could be used in breeding programme to enhance grain yield and biotic and abiotic stress tolerance. The main objective of the study was to assess the agro-morphological characteristics of the bean landraces available in the study sites and select most suitable landraces for future promotion. It also aimed to produce seeds of the local rare and economically important landraces for the future out-scaling and up-scaling.

MATERIALS AND METHODS

Geographical location of study area

The study was conducted in three villages namely Dallekh (2146 masl), Sundamunda (1862 masl) and Dhamidera (1536 masl) of Khar VDC, Darchula, Nepal (**Figure** 1). The sites were selected as they represent three different elevation gradients with the difference of about 300 meters from Dhamidera to Sundamunda and Dallekh. The sites having similar aspects (Southeast face), soil and nutrients condition and water availability were identified for the experiments. The site selection was carried out with combined objectives of conducting the experiment and also for the demonstration.

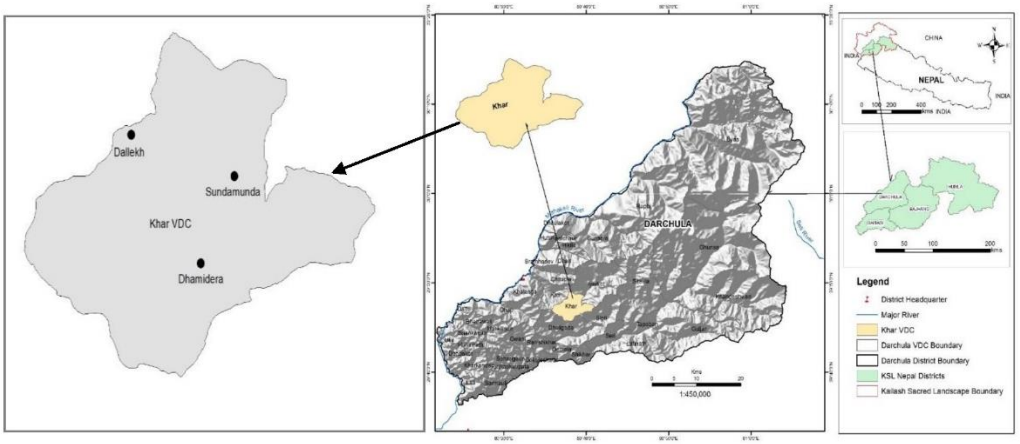

Figure 1. Experimental research sites in Khar.

Establishment of diversity blocks and experimental plots

The diversity blocks and experimental plots of nine bean varieties were established in three different sites of Khar VDC. The diversity blocks were meant for the display of different varieties of beans grown by the farmers in and around the VDC in order to increase awareness among people. A total of 20 seeds of each variety were sown in the diversity blocks. The beans were planted on 27th June 2016. The maximum and minimum temperature range during the crop growing period was 22 °C and 13 °C in June to 16°C and 5 °C in October.

Besides the diversity blocks, experimental plots were arranged in a randomized complete block design with three replications. The plant to plant distance for the determinate bush type was maintained 60 cm × 20 cm and the indeterminate type was 75 cm × 30 cm. One treatment consisted of mixed varieties of beans, which was used as control. The cultivation of bean mixture is a common practice in high mountains and especially with landraces. The experimental blocks were managed using local farmers' practice making sure that all the plots in all three sites received same inputs and treatments except

genotype. All the seeds planted are collected from farmers from Khar VDC (See **Table** 1). The beans planted along with the collection number from Genebank are in **Table** 1.

Table 1. Details of 9 bean landraces tested along with the collection number from the Genebank

Collection number	Local name	Collection from			Grain color
		District	VDC	Altitude (m)	
KA-17-08-FB	Seto sotta	Darchula	Khar	1500-2150 masl	Creamy White
KA-17-07-FB	Temase rato	Darchula	Khar	1500-2150 masl	Maroon
KA-17-02-FB	Kaleji kirmire	Darchula	Khar	1500-2150 masl	Dark blood with white spots
KA-17-05-FB	Marma sotta	Darchula	Khar	1500-2150 masl	Yellow peach
KA-17-09-FB	Asali rajma (Seto kirmire)	Darchula	Khar	1500-2150 masl	White with black and red stripes
KA-17-03-FB	Rato kirmire	Darchula	Khar	1500-2150 masl	Bran Red with white dots
KA-17-04-FB	Ankhe thulo	Darchula	Khar	1500-2150 masl	Light maroon with black shaded
KA-17-01-FB	Batulo sotta	Darchula	Khar	1500-2150 masl	Yellow flax
KA-17-06-FB	Local kalo	Darchula	Khar	1500-2150 masl	Black

Phenotypic characterization

Both qualitative and quantitative traits were considered for the characterization of bean landraces. For qualitative traits, we took into account plant type (germination type, plant growth habit and leaf shape), pod characters (immature pod color, pod color at maturity, pod curvature of fully expanded immature pod, pod break orientation, pod break position, pod surface of fully expanded immature pod), seed characters (seed shape and color) and occurrence of disease and pests. For quantitative traits, we considered days to germination, days to flowering, days to pod maturity, seed per pod, 100 seed weight and yield. For each genotype, five plants per replication were measured. The data were noted at regular intervals on all three sites. Scoring and measurements of agro-morphological characters were done based on the international descriptor developed by IBPGR (International Board for Plant Genetic Resources) descriptors for *Phaseolus vulgaris* (IBPGR 1982).

The date of germination, flowering and pod maturity were recorded based on the 50% occurrence. The date when 80% of the pods matured was noted for pod maturity. Node number was recorded after flower set from base to first axillary inflorescence in the indeterminate type and from base to terminal inflorescence in the determinate type. The average was taken from mean of 5 randomly selected plants. The measurement of pod length and width was taken at the broadest part of the pod and measurements were averaged from 5 randomly selected plants of each landrace. The number of seeds per pod was also averaged from 5 randomly selected plants. For the seed weight, 100 healthy seeds were selected and weighed in the weighing machine in seed laboratory of Genebank, NARC and the average weight was taken from 5 samples for each landrace of bean.

Statistical analysis

The important qualitative characteristics noted for the study were germination type, plant growth type, leaf color, pod color (immature and mature), seed color, seed shape, pod curvature, beak orientation, etc. The quantitative characteristics analyzed were days to germination, days to 50% flowering, days to 50% pod maturity, pod length, pod breadth, number of seeds per pod, 100 seed weight and node number. The yield per square meter was calculated and then converted into tons per hectare (t/ha).

The analysis was done using Excel and statistical software R 3.1.3 for Windows. The comparison between varieties and differences in quantitative characteristics in three different sites were done using Krushkal-Wallis test (Kruskal and Wallis 1952). Kruskal-Wallis test, a rank-based nonparametric test, allows comparison among more than two independent samples or groups of an independent variable

unlike Mann Whitney test that allows only two samples. Since varieties and sites are independent and their numbers are more than two, we used Kruskal-Wallis test.

RESULTS

The phenotypic characterization of beans planted in Khar showed significant differences in various characteristics. This means each bean variety has its own significance and character. The analysis of different morphological characters of nine landraces is shown in **Table** 2 below.

Qualitative characteristics

Qualitative characters used in this study such as germination type, plant growth type, leaf shape, immature pod color, pod color at maturity, pod curvature of fully expanded immature pod, pod beak position, pod beak orientation, pod surface of fully expanded immature pod, seed shape and seed color, occurrence of disease and pest are summarized in **Table** 2. The evaluation of the qualitative variables was carried out based on the descriptors developed by IBPGR, 1982

Table 2. Comparison of bean landraces for various qualitative traits

NS	GT	PT	PS	IP	PCM	PCEIP	PBO	PBP	Seed shape	Seed color	Leaf shape
KA-17-08-FB	E	IC	G	NG	Y	SC	St	M	C	PW	T
KA-17-07-FB	E	IC	G	CR	R	SC	D	M	C	M	T
KA-17-02-FB	E	IC	G	CSG	PYCS	SC	St	NM	C	DRCS	Q
KA-17-05-FB	E	IC	P	DG	PY	S	St	M	KS	LB	T
KA-17-09-FB	E	IC	G	PSG	Y	S	D	M	C	LBPS	T
KA-17-03-FB	E	DBG	G	NG	Y	S	U	NM	KS	RLBS	Q
KA-17-04-FB	E	IC	P	NG	Y	C	D	M	C	PBS	R
KA-17-01-FB	E	IC	G	NG	Y	S	D	M	Ro	LB	Q
KA-17-06-FB	E	IC	G	PSG	PY	S	St	M	C	PB	T

Note: Name of Species (NS); Germination Type (GT): Epigeal (E); Plant Type: Indeterminate Climber (IC), Determinate Bushy Growth (DBG); Pod Surface (PS): Glabrous (G), Pubescent (P); Immature pod (IP): Normal Green (NG), Carmine Red (CR), Carmine Stripe on Green (CSG), Dull Green (DG), Purple Stripe on Green (PSG); Pod Colour at Maturity (PCM): Yellow (Y), Red (R), Pale Yellow Colored Stripes (PYCS), Pale Yellow (PY); Pod curvature of expanded immature pod (PCEIP): Slightly Curved (SC), Straight (S), Curved (C); Pod Beak Orientation (PBO): Straight (St), Downward (D), Upward (U); Pod Beak Position (PBP): Marginal (M), Non-marginal (NM); Seed Shape (SS): Cuboid (Cu), Kidney Shaped (KS), Round (R); Seed Color (SCo): Pure white (PW), Maroon (M), Dark red with cream streaks (DRCS), Light Brown (LB), Pure Black (PB), Purple with black streaks (PBS), Red with light brown streaks (RLBS); Leaf Shape: Triangular (T), Quadrangular (Q), Round (R), Light brown with purple streaks (LBPS)

Plant type: All the nine varieties grown for the experiment had an epigeal type of germination which shows that these are all *Phaseolus vulgaris* L. species. Eight out of nine varieties of beans showed indeterminate climbing growth type and only one variety (KA-17-03-FB) showed determinate bushy growth type. Similarly, five varieties had the triangular shape of leaves, three varieties (KA-17-03-FB, KA-17-01-FB and KA-17-02-FB) had quadrangular shape and KA-17-04-FB had round-shaped leaves.

Pod characteristics: Regarding immature pod color, pods were classified as dark green, normal green, carmine red or other colors. Most of the evaluated genotypes had normal green pods. These were KA-17-08-FB, KA-17-03-FB, KA-17-04-FBand KA-17-01-FB. KA-17-07-FB produced Carmine red pods and KA-17-02-FB had carmine stripe on green pods. Only KA-17-09-FB produced purple stripe on green pods. KA-17-05-FB produced dull green pods. Mature pods or pod color at maturity can be classified as yellow, red or other colors. Most of the evaluated genotypes (five) had yellow colored pods. These were KA-17-08-FB, KA-17-09-FB, KA-17-03-FB, KA-17-04-FB, and KA-17-01-FB. KA-17-07-FB had red-colored matured pods and KA-17-06-FB had pale yellow. Only KA-17-02-FB had pale yellow pods with

colored stripes. Likewise, curvature of fully expanded immature pod was categorized as straight, slightly curved, curved (**Figure** 2). The difference in pods curvature was noted among different varieties.

Figure 2. Pod curvature of expanded immature pod.

The position of the pod was straight in KA-17-05-FB, KA-17-03, KA-17-01-FB and KA-17-06-FB, slightly curved in KA-17-08-FB, KA-17-07-FB, KA-17-02-FB and KA-17-09-FB and curved in KA-17-04-FB. The results showed that the pod curvature was found the same for slightly curved (4) and straight (4) with only one in a curved category.

Pod beak orientation in beans is upward, downward and straight. Most of the genotypes studied were categorized by straight or downward pod beak orientation. It was upward in KA-17-03-FB, straight in KA-17-08-FB, KA-17-02-FB, KA-17-05-FB and KA-17-06-FB and downward in KA-17-07-FB, KA-17-09-FB, KA-17-04-FB and KA-17-01-FB. The pod beak position is categorized as marginal and non-marginal. The pod beak orientation was straight orientation in 4, downwards in 4 and upwards in only one variety. The position of pod beak was marginal in seven varieties: KA-17-08-FB, KA-17-07-FB, KA-17-09-FB, KA-17-05-FB, KA-17-04-FB, KA-17-01-FB and KA-17-06-FB and non- marginal in 2 varieties which are KA-17-02-FB and KA-17-03-FB.

When the surface of fully expanded immature pod of all the varieties were analyzed, seven varieties had glabrous surface (smooth surface without hair) which are KA-17-08-FB, KA-17-07-FB, KA-17-02-FB, KA-17-09-FB, KA-17-03-FB, KA-17-01-FB and KA-17- 06-FB and two varieties namely KA-17-05-FB and KA-17-04-FB had pubescent pod surface (hairy surface).

Seed characteristics: Regarding seed shape and color, out of 9 varieties, six varieties had cuboid seed shape (KA-17-08-FB, KA-17-07-FB, KA-17-02-FB, KA-17-09-FB, KA-17-04-FB and KA-17-06-FB), one round shape (KA-17-01-FB) and two kidney-shaped (KA-17-05-FB and KA-17-03-FB). All the nine varieties had variable seed color which is one of the identifying characteristics and all the local names are derived based on the seed color (**Figure** 3). Three varieties had only one colored seed color i.e. KA-17-08-FB, KA-17-01-FB and KA-17-06-FB. All other varieties had two colors one of which was dark-colored and the other was lightcolored.

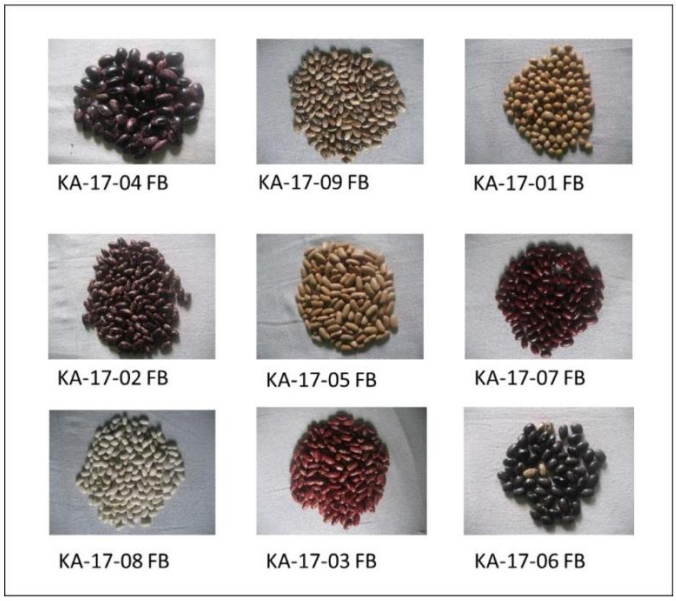

Figure 3. Seed shape and color of beans landraces.

Occurrence of disease and pests: The occurrence of diseases and pest were found different in different varieties of beans as shown in **Table** 3. Only three varieties namely KA-17-07-FB, KA-17-04-FB and KA-17-06-FB were found to be pest and disease resistant in all three sites. KA-17-08-FB suffered with dark spots in pods and the pods could not mature properly. For KA-17-09-FB in Dallekh site, pods turned black and pest was seen. In KA-17-05-FB, pest was seen and green pods dried due to disease in all three sites. Other varieties such as KA-17-02-FB, KA-17-03-FB and KA-17-01-FB suffered little harm from the pest.

Table 3. Name of varieties with the occurrence of disease and pest in three sites.

Name of the varieties	Occurrence of disease/pest		
	Dhamidera	Sundamunda	Dallekh
KA-17-08-FB	+	+	+ (dark spots in pods)
KA-17-07-FB	-	-	-
KA-17-02-FB	+	+	+
KA-17-05-FB	+ (pods dried of disease)	+ (pods dried of disease)	+ (pods dried of disease)
KA-17-09-FB	-	-	+ (green pods turned black)
KA-17-03-FB	+	+	+
KA-17-04-FB	-	-	-
KA-17-01-FB	+	+	+
KA-17-06-FB	-	-	-

Note: + pest seen; - pest not seen

Quantitative characteristics

Quantitative characteristics are summarized in **Table** 4 and described below

Plant growth behavior: Days to germination determines which variety germinates early and which germinates late. All the varieties took 3 to 4 days to germinate in Dhamidera and 4 to 6 days in Sundamunda and Dallekh. The 50% flowering dates differed in different varieties and in three sites. The 50% flowering occurred earliest in Dhamidera in all the varieties and late in Dallekh. KA-17-08-FB and KA-17-04-FB were very late flowering varieties compared to all other varieties which normally took fewer days to flower. In Dhamidera, KA-17-08-FB took 61 days and KA-17-04-FB took 63 days and the other seven varieties flowered 50% between 40 to 42 days. In Sundamunda, KA-17-08-FB took 65 days and KA-17-04-FB took 66 days and others took 40 to 45 days to flower 50%. In Dallekh, KA-17-08-FB took 64 days and KA-17-04-FB took 67 days and other varieties took 42 to 46 days. In average in all three sites, KA-17-08-FB (Seto sotta) and KA-17-04-FB (Ankhe thulo) took 63 and 65 days respectively as compared to 40 to 46 days to flower for rest of the landraces. All other varieties belonged to medium maturing category.

Regarding days to pod maturity, days to 50% pod maturity of a particular variety also describes whether the variety is early, medium or late-maturing and determines which varieties can be harvested early. Days to 50% pod maturity varied in different varieties and the three sites as well. The pod maturity occurred earliest in Dhamidera in all varieties and Sundamunda a bit late and very late in Dallekh. In Dhamidera, KA-17-08-FB and KA-17-04-FB took 96 days and KA-17-01-FB took 92 days for 50% pod maturity which were very late maturing compared to other varieties which took 72 to 77 days for pod maturity. In Sundamunda, KA-17-08-FB and KA-17-04-FB took 98 days and KA-17-01-FB took 97 days while other varieties took 76 to 80 days to pod maturity. In Dallekh, KA-17-08-FB took 102 days and KA-17-04-FB and KA-17-01-FB took 98 and 96 days respectively, while other varieties pod matured in 79 to 85 days.

Seed characteristics: Different varieties had the different numbers of seeds per pod which shows each variety had a distinct number of seeds per pod. Five varieties (KA-17-08-FB, KA-17-07-FB, KA-17-02-FB, KA-17-01-FB and KA-17-06-FB out of nine had 7 seeds per pod which was more or less consistent in all the three sites. Only KA-17-05-FB variety had five seeds per pod in all the three sites and KA-17-09-FB had 6 seeds per pod. The lowest number of seeds per pod was of KA-17-04-FB which had considerably larger seeds which might be the reason for having only four seeds per pod. Different varieties had different 100 seed weight. Local kalo KA-17-06-FB had the lowest 100 seed weight (30.32 g) and KA-17-04-FB had the highest weight of 98.03 g. Six varieties had 100 seed weight between 30 to 50 g and two varieties had between 50 to 70 g Large seeded genotypes were KA-17-04-FB (98.03 g), KA-17-02-FB(51.225 g) and KA-17-05-FB (64.33 g) having 100 seed weight >50 g.

Table 4. Mean performance of various parameters of evaluated landraces in three sites

Characteristics	KA-17-08 FB	KA-17-07 FB	KA-17-02 FB	KA-17-05- FB	KA-17-09 FB	KA-17-03 FB	KA-17-04 FB	KA-17-01 FB	KA-17-06 FB
Dhamidera									
days of germination	4.3	4.67	5	5	5	5	5.67	6	3
days of 50% flowering	61	41	49	41	49	46	63	41	40.33
days of 50% pod maturity	96	61	69	68.67	70	74	96	92.67	74
days of 90% pod maturity	109	104	104	104	104	104	104	104	104

Characteristics	KA-17-08 FB	KA-17-07 FB	KA-17-02 FB	KA-17-05- FB	KA-17-09 FB	KA-17-03 FB	KA-17-04 FB	KA-17-01 FB	KA-17-06 FB
pod number	9.16	23.3	31.3	32.33	18.33	16.67	9.5	29.67	13.67
pod length	12.56	14.4	17.03	16.86	11.83	13.16	15.37	14.23	12.67
pod breadth	1	1.5	1.5	1.5	1	1	2.5	1.5	2
seed per pod	7	7	7	5	6.33	4	4	7	7
100 seed weight(gm)	32	37.87	51.22	64.33	37.18	44.96	98.03	48.93	30.32
Sundamunda									
days of germination	4.33	4.33	5	5	5	5	5.67	6	5
days of 50% flowering	65	41	49	41	49	46	66	41	41
days of 50% pod maturity	98	67.33	70	69.67	70.67	76.33	98	91	75
days of 90% pod maturity	109	104	104	104	106	104	104	104	104
pod number	12.33	17	29.33	19.33	15.67	12.67	7.83	23	12
pod length	13.4	14.06	17.1	16.67	11.46	12.3	14.16	14.13	11.67
pod breadth	1	1	1.5	1.5	1	1	2.5	1.5	2
seed per pod	6.67	7	7	5	6	4	4	7	7
100 seed weight(gm)	33	37.2	50.67	63.76	36.43	44.53	97.36	49	29.73
Dallekh									
days of germination	4	5	4.3	4.67	4.3	4.3	4.67	5	5
days of 50% flowering	64	42	41	41	41	43	67	42.3	41
days of 50% pod maturity	102	67.3	90	69.67	71.67	75	98	96	75
days of 90% pod maturity	109	104	104	94	104	97	104	104.67	104
pod number	9.67	14	20.33	18	12	15.33	10.33	20.67	12.67
pod length	13.93	15	16.93	15.67	11.67	12.83	12.9	14.56	12
pod breadth	1	1.5	1.78	1.5	1	1.93	2.16	2.1	1.93
seed per pod	7	8.3	6	5	5.67	4	4	7	7
100 seed weight(gm)	35.33	36.76	51.4	63.36	37	43.43	96.95	48.51	30.3

Yield parameters: The yield for all the nine varieties was calculated and significant differences were noted. There was a significant difference in yield in three sites as well. All the varieties except KA-17-08-FB (highest in Sundamunda) had the highest yield in Dhamidera compared to Dallekh and Sundamunda. This shows that the increase in temperature leads to good production of beans in Dhamidera than in Sundamunda and Dallekh. KA-17-02-FB had the highest yield of 4.48(t/ha) in Dhamidera and 4.16 (t/ha) in Sundamunda and had the highest yield of 2.80 (t/ha) in dallekh. KA-17-02-FB was the best yielding variety among the nine varieties. Among nine varieties, KA-17-08-FB had the lowest yield in two sites i.e. Dhamidera (0.82 t/ha) and Dallekh (0.95t/ha) and KA-17-03-FB (0.90t/ha) had the lowest yield in Sundamunda. Varieties yielding more than 2 t/ha in Dhamidera were: KA-17-07-FB, KA-17-02-FB, KA-17-05-FB and KA-17-01-FB and both in Sundamunda and Dallekh were: KA-17-02-FB, KA-17-05-FB and KA-17-01-FB. Eighty-nine percent of varieties produced more than 1.0 t/ha seed yield in Dhamidera and Dallekh and seventy-eight percent in Sundamunda.

Pod characteristics: The number of pods is of major importance in case of bean yield and selection of a variety. KA-17-05-FB had the highest number of pods (32) in Dhamidera, whereas KA-17-02-FB performed best with 29 pods in the Sundamunda site and KA-17-01-FB (21) had highest in Dallekh site. In both Dhamidera and Dallekh, KA-17-08-FB had least number of pods i.e. 9 and 10 and KA-17-04-FB had least in Sundamunda site (8). In terms of production of pods, KA-17-08-FB was found to be the least productive. As the local people from Khar had also complained that KA-17-08-FB does not perform well compared to other bean varieties despite being an older variety.

Average pod length in three sites showed a significant difference in different genotypes. In all three sites, KA-17-02-FB produced the longest pods (17.03cm, 17.1 cm and 16.93 cm) in Dhamidera, Sundamunda and Dallekh respectively and the shortest pods were of KA-17-09-FB in all three sites. The results display clearly that the pod length of the variety was influenced by the genotype. Pod width also varied in different genotypes. The widest pods were produced by KA-17-04-FB (2.5cm). All other genotype's pod width ranged from 1 mm to 2 mm.

Table 5. Kruskal-Wallis test for characteristics studied in different varieties in the study sites

Characteristics	Kruskal-Wallis test		
	Chi- square value	df	p value
Days of germination vs varieties	8.794	8	0.36
Days of 50% flowering vs varieties	58.5971	8	<0.0001
Days of 50% pod maturity vs varieties	58.204	8	<0.0001
Pod number vs varieties	55.5019	8	<0.0001
Pod length vs varieties	65.685	8	<0.0001
Pod breadth vs varieties	15.1108	8	0.057
100 seed weight vs varieties	78.137	8	<0.0001
Seed per pod vs varieties	17.2299	8	0.027
Number of nodes vs varieties	38.0316	8	<0.0001
Yield vs varieties	22.8042	8	0.003

Table 6. Kruskal-Wallis test for characteristics studied in three sites (Dhamidera, Sundamunda and Dallekh)

Characteristic	Kruskal-Wallis test		
	Chi- square value	df	p value
Days of germination vs site	35.8277	2	<0.0001
Days of 50% flowering vs site	16.4558	2	0.0002
Days of 50% pod maturity vs site	18.8176	2	< 0.0001
Pod number vs site	5.2943	2	0.07
Pod length vs site	0.5604	8	< 0.0001
Pod breadth vs site	39.5209	2	< 0.0001
100 seed weight vs site	0.2311	2	0.89
Seed per pod vs site	33.9386	2	< 0.0001
Number of nodes vs site	5.494	2	0.064

Kruskal- Wallis test was performed to find out whether there are significant differences between the nine varieties and the different characteristics measured and also to see the differences in different plots as shown in **Table** 5 and **Table** 6. Significant differences were noted between the varieties and the characteristics. Among the ten characteristics compared with the varieties, except days to germination, all studied traits showed significant variation among the genotypes. Similarly, Kruskal- Wallis test was also performed to find out whether there is a statistically significant difference between each variety's characteristics in three different sites as shown in **Table** 4. Analyzing all the characteristics for KA-17-08-FB showed that only three characteristics (Days of 50% flowering, Days of 50% pod maturity and

node number) showed a difference in terms of site. In case of KA-17-07-FB, five characteristics (Days of 50% flowering, days of 50% pod maturity, pod number, pod breadth and seed per pod) were significantly different in three sites.

KA-17-02-FB had also differences in days of 50% flowering and pod maturity, pod number, pod breadth, seed per pod and node number in three sites. For KA-17-05-FB, there were differences in days of germination, days of 50% flowering and pod maturity and node number. In the case of KA-17-09-FB, days of 50% flowering, pod maturity and pod number had a difference in three sites. KA-17-03-FB showed differences in days of germination, days of 50% flowering, pod maturity and pod breadth. Days of germination, days of 50% flowering, pod maturity and node number showed differences in three sites for KA-17-04-FB. For KA-17-01-FB, days of germination, days of 50% flowering and pod maturity. KA-17-06-FB had differences in days of germination, days of 50% flowering and days of 50% pod maturity. Most of the varieties had differences in flowering days and pod maturity in three sites as the elevation might play an important rolein the flowering and maturation of the pods of the varieties.

DISCUSSION

Beans are locally called "sotta" and are an integral part of the diet of the people of Khar. They are consumed as whole seeds or in grinded forms, both as curry or 'daal'. These are usually planted by mixing all the varieties together. Beans, regarded as healthy proteins, are consumed by all households. Indeed, black bean soup is given to their sick as an energy supplement. Today, farmers of Khar VDC grow early maturing bean varieties of larger seed sizes that fetch good market value (Aryal et al 2017). Farmers in Nepal preferred bean landraces that are medium growth habit, early maturing nature, high yielding, good seed size and color and are high demand in the market (Chhetri and Bhatta 2017, Neupane et al 2008). A similar study was done in bean growing area in Malawi to understand the farmer's specifications for variety selection showed that farmers looked on grain color, cooking time, taste, grain size as well as grain brightness to choose the varieties (Chirwa and Phiri 2005).

We observed agro-morphological variations in the local varieties planted in three sites which shows that there is scope for selection of suitable landraces in the study area, which corroborate with the observations and inferences made by Razvi et al (2018). Similarly, Stoilova et al. (2006) found that out of many accessions studied, some accessions with an erect habit, a shorter period to reach maturity had higher number of pods and seeds per plant as these genotypes escaped unfavorable conditions of high daily temperature and low humidity during the flowering and pod formation periods. A combination of agro-morphological and molecular data collection methods for plant germplasm is also suggested by Chiorato et al (2006) and Lyngdoh et al. (2018) but our study had a limitation to do this. In our study too, the same variety had different flowering and pod maturity times even they were planted on the same date. Flowering and pod maturity occurred earliest for all the varieties in the lower elevation site (Dhamidera), followed by the middle (Sundamunda) and highest site (Dallekh). This clearly indicates the environment particularly the temperature played an important role in physiological and phenological growth of the varieties included in the study. Similar study on 70 common bean landraces of Mexico showed there were significant differences in the morphological and physiological traits of the plant, pod and grain among different geographic regions which were also associated with different indigenous groups (Chavez-Servia et al 2016).

KA-17-08-FB and KA-17-04-FB are very late flowering and maturing landraces. This is one of the reasons local people preferred less compared with landraces like KA-17-07-FB which flowered earliest (within 42 days in all the three sites) which shows it is an early maturing variety. It might be because, due to an early onset of winter in the high altitude, the late maturing variety cannot complete the life cycle or cannot give proper yield due to cold stress (Neupane et al. 2008). There was a difference in the pod yield of the nine varieties. KA-17-08-FB had the lowest yield in both Dhamidera and Dallekh and KA-17-03-

FB had lowest in Sundamunda. The local varieties such as KA-17-06-FB and KA-17-08-FB are disappearing perhaps due to low yield although the later is considered as the most delicious variety. KA-17-08-FB can be promoted using awareness, value addition and market linkage techniques. The most successful variety in terms of yield was KA-17-02-FB having the highest yield in Dhamidera and Sundamunda and KA-17-01-FB got highest in Dallekh. Thus, KA-17-01 and KA-17-02 can go for scaling up in the region and in similar environments in the country. A similar study on the evaluation of 12 varieties of *P.vulgaris* by Gereziher et al 2017 from Raya valley, Northern Ethiopia showed Nasir variety performing well compared to other varieties to the valley conditions and was recommended for scaling up and widespread dissemination.

CONCLUSION

A variety of beans with diverse agro-morphologies are grown in different agro-ecological zones in Nepal which gives an opportunity for crop improvement and material exchange. Our attempt to assess diversity suggests that variations in beans occur in both quantitative and qualitative traits. They differ in germination, flowering and maturity time as well as pod, plant and seed characteristics. Differences were also observed in disease resistance and yield. These were the basis for farmers to choose one variety over the other. Therefore, there is an opportunity to select high yielding, early maturing, disease-resistant and locally preferred varieties from the locality. The variations also indicate the possibility of producing new varieties with combined traits transferred from different varieties through breeding methods (e.g. crossing).

Variation has also been observed among locations, which is likely due to environmental differences between the locations. This clearly suggests that materials can be exchanged between sites and adaptive research can be done to assess the adaptability of different landraces varieties. An appropriate seed supply system needs to be established for proper seed production and exchange between different ecological zones.

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DISCLAIMER

The views and interpretations in this publication are those of the authors and they are not necessarily attributable to their organisations.

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RESEARCH Open Access

Diversity and use of wild and non-cultivated edible plants in the Western Himalaya

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Abstract

Background: Local people in the Himalayan region use a wide range of wild and non-cultivated edible plants (WNEPs) for food, spice, medicinal, and cultural purposes. However, their availability, use, status and contribution to livelihood security are poorly documented, and they have been generally overlooked in recent agro-biodiversity conservation and management programmes. The study aimed to investigate WNEP diversity and current status in a part of the Kailash Sacred Landscape—a transboundary landscape shared by Nepal, India and PR China—in terms of collection, use, management and conservation initiatives.

Methods: Multiple methodologies and tools were used for data collection. A series of participatory tools (45 key informant interviews, 10 focus group discussions, a crop diversity fair, direct observation of species through a transect walk and rapid market assessments) was followed by a household survey (195 respondents) and complemented by a literature review.

Results: The study recorded 99 WNEPs belonging to 59 families of which 96 were angiosperms, one gymnosperm and two pteridophytes. Species were used for food, spice, medicine, rituals and income generation. Thirty-five species had multiple uses, including these: 40 species were used for fruit and 31 for vegetables. WNEPs contribute significantly to daily food requirements, especially the vegetables. The use value of *Dryopteris cochleata* was found highest (0.98) among frequently used vegetable species. The values of informant consensus factor were found maximum for worms in the stomach (0.99) and minimum for skin disease treatment (0.67). Nearly 85% of households depended exclusively on WNEPs for at least more than a month per year. Results on the importance and use of different species, gender roles in WNEP activities and conservation approaches are presented.

Conclusions: People living in the Kailash Sacred Landscape depend significantly on WNEPs, and this is especially critical in times of food shortage. The WNEPs have considerable potential as an important supplement to cultivated food crops. Farmers prioritise species with multiple use values and popular vegetables. However, there are numerous challenges and interventions needed to ensure conservation and management of species and their continued availability to support food security and local livelihoods.

Keywords: Wild and non-cultivated edible plants, Kailash Sacred Landscape, Traditional knowledge, Food security

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Background

The majority of rural communities living in mountain and hill regions use wild and non-cultivated edible plant species (WNEPs) for food, medicine and other purposes [1–3]. WNEPs cover a wide range; they include wild fruit, nuts, leaves, roots, shoots and whole plants collected from forests, hedges and grassland; plants growing naturally alongside the actual crop in cultivated and fallow agricultural land; and plants established in the wild or in fields from seed that has dispersed from previously grown crops [4–9]. On occasion, plants that grow in the wild around some villages are collected as WNEPs and may be protected and managed in home gardens or agricultural fields in other villages where they count as crops.

Throughout the Himalayan region, WNEPs contribute substantially to food security, help maintain health and offer economic opportunities for millions of mountain people [10–12]. They are eaten in a myriad of ways—raw in salads and pickle, boiled in curries and soups, fried and steamed—depending on preference and taste [13, 14]. Many of these plants have cultural values, while some are considered sacred and used in religious and cultural events [11–13]. A number of studies in the Himalaya have documented WNEP species used as regular food [1, 2, 10–12] and shown that WNEPs play a significant role in fulfilling daily food requirements, especially in rural areas.

Notwithstanding the contribution to livelihoods and well-being, WNEPs have received little attention in the Himalayan region, with the exception to some extent of medicinal plants. There have been only a few studies of the diversity, use and local management practices of WNEPs [2, 11, 13, 15] and none on status and availability. Little is known about household consumption patterns or their role in household-level food and nutrition security and healthcare. Many studies have focussed simply on listing wild edible species and noting their use as food or medicine [1, 2, 9–13, 15, 16]. Furthermore, most research and development interventions under government programmes have paid little or no attention to this important sector [17–19]. Quantitative information on the presence, abundance, use and management of WNEPs is essential as a basis for developing effective conservation and management strategies that ensure that these species can continue to contribute to and, where possible, be used to improve food security.

The Kailash Sacred Landscape (KSL) is a transboundary landscape culturally linked to the region around Mount Kailash and shared by Nepal, India and the People's Republic of China. It is home to many ethnic communities and is a rich repository of WNEPs. Local people are known to rely heavily on these plant species for their livelihoods [20], but the actual availability, use, contribution to livelihoods and engagement of household members are poorly documented. The present study selected Khar Village Development Committee (VDC) in Darchula District in KSL Nepal to investigate the diversity of WNEPs, how each species is being used, the role in and implications for livelihoods and local perceptions on conservation and management differentiated by gender.

Methods

Study site and people

The study was conducted in all nine wards of Khar VDC of Darchula District in the Far Western Development Region of Nepal, located at 29.761128 to 29.817314 N latitude and 80.597531 to 80.683363 E longitude (Fig. 1). Khar VDC is a predominantly rural mid-hill area, with a total area of 26 km^2 at an elevation of 1353–3236 masl. The vegetation is sub-tropical in the lower parts and temperate at higher elevation with mostly fragmented areas of deciduous, coniferous and mixed forest and areas of cultivated land along the hill slopes (mostly rain-fed terraces) and valley bottoms (mostly irrigated). Close to half of the VDC area (51%) is covered by forest, 44% is agricultural land, 4% shrub land, 0.3% water bodies, 0.1% grassland and 0.07% settlement area [21]. The VDC is about a 3-h walk from Khalanga Bazaar, the district headquarters of Darchula. It is also connected by a rural road to the bazaar (ca. 14 km), but vehicular access is only possible during winter and spring.

In 2010, the VDC had a population of 4272 (2056 male, 2216 female) in 698 households [22]; the average household size of 7.1 is high compared to the national average of 4.9. The literacy rate is low (61% of respondents were non-literate). The dominant castes are Chhetri and Brahmin with a few households of Dalits. The major castes in the village include Manyal, Sitoli, Dobal, Mahar, Tamata, Bisht, Dadal, Bohara and Thagunna.

Research approach and methodology

Figure 2 shows the research study framework. Three broad approaches were used with multiple tools. Quantitative and qualitative primary data were collected using a range of participatory tools followed by a household survey; the results were supplemented with secondary data obtained from a literature review.

Participatory tools

A range of participatory rural appraisal tools was used to gather a wide range of information. A total of 45 key informants (18 female, 27 male) aged from 28 to 78 and representing all nine wards were interviewed individually. Key informants were selected at the village level with the help of the Api-Nampa VDC level conservation committee members, focussing on people expected to have extensive

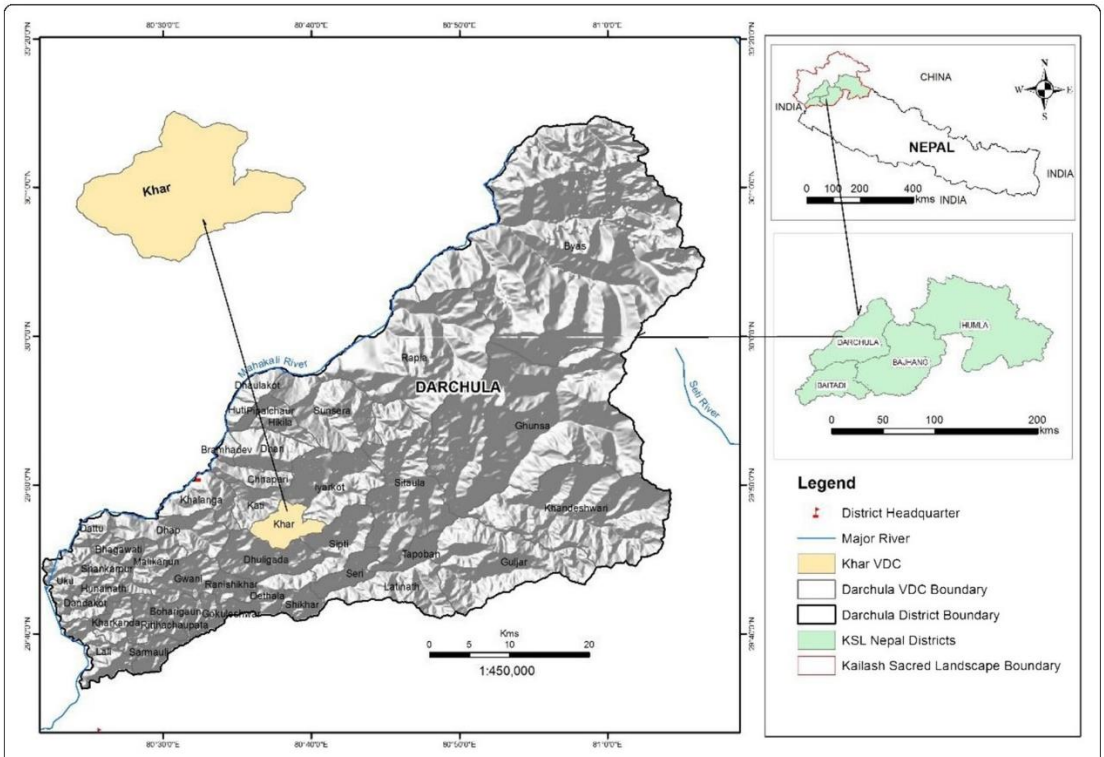

Fig. 1 The study site: Khar VDC in Darchula District in KSL Nepal

knowledge of WNEPs. Nine were specifically selected as local healers (one from each ward) who had been treating people for various health-related problems. Key informants were interviewed about their perceptions of the availability, uses and status of WNEPs and their contribution to local livelihoods.

Ten focus group discussions (one in each ward and one with representatives from the nine wards and other key institutions) were organised with 7–12 people in each group (82 participants: 40 women, 42 men). The discussions focussed on the general status and use of WNEPs in the VDC and local issues and initiatives on WNEP management.

Rapid market assessments were conducted at a local market (Dallekh Bazar) and the market at district headquarters (Khalanga Bazar) to identify the WNEPs available in different seasons, their market value and trends in use from the viewpoint of buyers and sellers.

A VDC level local crop diversity fair was organised in February 2015 to which farmers brought samples of all the WNEP species that they use that were available at the time. The aim was to make a rapid assessment of the general richness and status of non-cultivated plants available at that time. This fair provided a unique opportunity for individuals and community members to display their local plant material, as well as to share and document associated knowledge. During the fair, specimens of uncultivated plant species were collected and identified and herbarium were prepared.

WNEPs were also collected and identified in four field visits held in winter (February 2015), spring (May 2015), summer (July, 2016) and autumn (October 2016) by a multidisciplinary team consisting of a socio-economist, natural resources management expert, taxonomist and social mobiliser. Each field visit lasted for 15 days and covered all nine wards. The study team visited areas where species were found extensively in situ with the help of a social mobiliser and collected unidentified specimens for discussion with key informants. Information about species habitats was recorded, and photos were taken for future reference. Specimens were identified, and recent family and scientific names were assigned with the help of reference collections [23–27] and an expert taxonomist from the Central Department of Botany, Tribhuvan University.

Household survey

A detailed household survey with a structured questionnaire was used to obtain information about the use of

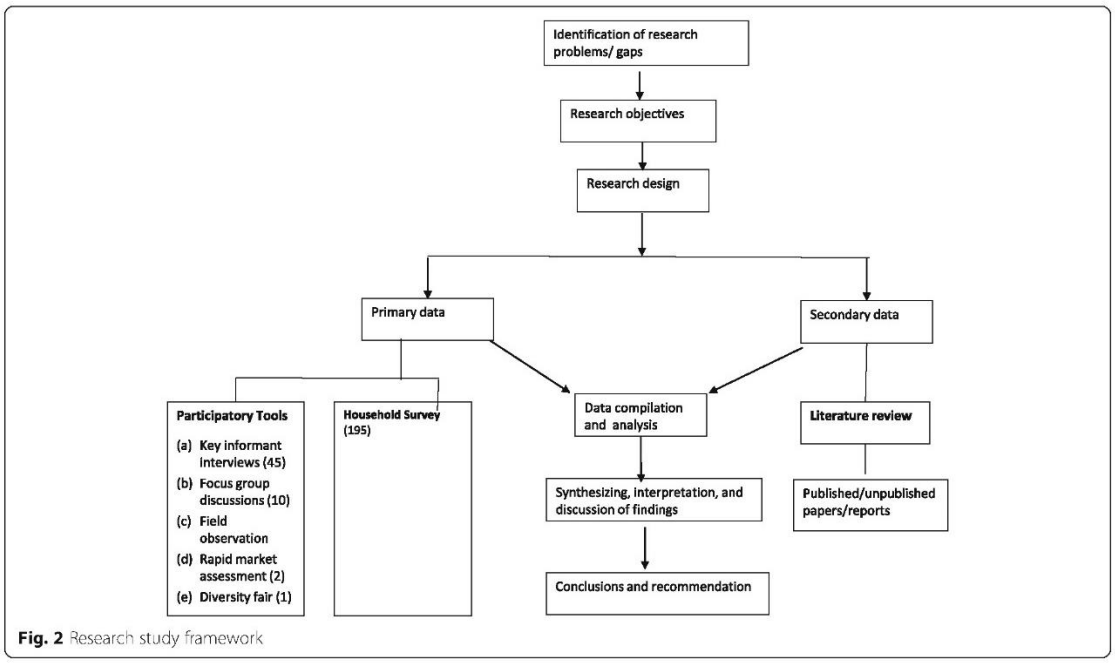

Fig. 2 Research study framework

WNEPs and any local-level management initiatives and the socio-economic and demographic features of the local population. The information gathered using the participatory tools was used in the survey design.

The sample size was determined using the following formula:

$$\text{Number of households to be interviewed} = \frac{Z^2_{1-\alpha} * N * P(1-P)}{(e^2 * N) + (Z^2_{1-\alpha} * P(1-P)}$$

where N is the total number of households ($N = 698$), Z is the level of confidence (assumed value for 90% level of confidence is 1.65), P is the estimate of the indicator to be measured (assumed value 50% in the absence of any prior information) and e is the margin of error to be attained (assumed level of precision is set at 5%).

This gave a sample size of 195 households. In order to ensure proper representation from each ward, the sample was distributed proportionally according to the number of households in each ward. Within each ward, households were selected by random sampling with the help of computer-generated random numbers.

Analytical tools

Data was analysed using descriptive analysis and frequency calculation techniques, and results are presented in figures. In addition, informant consensus factor (ICF) was calculated to determine the homogeneity of the information and degree of overall agreement in using plant species with medicinal values—the species that are used for treating health-related problems at household level. The following formula was used [28]

$$\text{ICF} = \text{Nur-Nt}/\text{Nur-1}$$

Here, Nur is the number of use reports mentioned by the informant for the given species and Nt is the number of taxa (species) used by majority of the households.

Use value (UV) was calculated for individual plant species to give quantitative measures of its relative importance to the informants objectively [29]. Use value was calculated by using the following equation: $\text{UVs} = \Sigma U/n$, where UV refers to the use value of a species, U is the number of use reports mentioned by the respondents and n is the total number of respondents interviewed.

Prior informed consent

Before the study commenced, we shared the purpose and objectives with the community and relevant stakeholders in a half-day interactive meeting held in Dallekh village in Khar VDC. Prior informed consent was taken from the household respondents as well as all participants in the participatory interviews and discussions about the documentation and dissemination of local knowledge and use of WNEP species for study purposes.

Results

Agriculture and food security

Agriculture was the major source of livelihoods for the majority of households (92%); the major crops are maize, barley, wheat, finger millet and potato. However, only 5% of households were able to meet all their annual food requirements from their own production; the remainder were only food sufficient for 10 months or less. Households adopted multiple coping strategies during the food deficit months to meet their food requirements, including seasonal migration for work to the district headquarters and various parts of India, sale of agricultural and livestock products, collection and selling of yarsagumba (*Cordyceps sinensis*) and collection of WNEPs.

Diversity of WNEP species

A total of 99 WNEPs belonging to 59 families were identified and documented (Table 1). They included 96 angiosperms, 1 gymnosperm and 2 pteridophytes, with 7 in the family Moraceae, 6 Rosaceae, 5 Urticaceae, 4 Polygonaceae and 3 each in Araceae, Dioscoreaceae, Amaranthaceae, Lamiaceae and Combretaceae. Herbs and trees were the most common life forms (Fig. 3).

Diversity of use

All households were using a range of different WNEPs for food, spice, medicinal and religious purposes. The most common uses were as food (fruit 40 species, vegetables 31 species), medicine (30 species), others (16 species) and spice (10 species). In a few cases, WNEPs formed the main meal for a short period (e.g. boiled *Dioscorea* spp.). Other uses included religious and traditional rituals, making pickles, ripening bananas, extracting cooking oil, washing and dyeing, and income generation; 35 species had multiple uses (Fig. 4, Table 1). The most commonly used parts were the fruit (45), leaves (31), and stems/shoots (17). Bark, buds, bulbs, flowers, tubers and corms, roots and seeds were also used (Table 1). Most uses (about 66%) were specific to a particular plant part, although sometimes plant parts had multiple uses (e.g. as religious offerings and as medicine). In around two thirds of the species, only one plant part was used; in the others, multiple parts were used.

A total of 30 plant species have been used for household-level healthcare (Table 1). Diseases cured through the local knowledge system in the study sites were grouped into eight major types, and ICF was calculated for those diseases and health-related problems (Table 2). These include stomach disorder (diarrhoea/dysentery), cuts and wounds, fever and headache, skin diseases/skin irritation, worms in stomach, nausea and vomiting, snake and scorpion bites and cough and cold. The values of ICF was found maximum for worms in the stomach (0.99) and minimum for skin disease treatment (0.67). Eight species were used to cure stomach disorder having maximum (178) number of use reports followed by cuts and wounds (160), and lowest use reports was found for skin disease (4) treatment (Table 2).

WNEPs used as vegetables for nutrition and food security

In terms of regular food, one of the most important contributions of WNEPs was as a vegetable (Fig. 4). All respondents reported that they regularly used WNEPs as a vegetable. The most frequently collected species were *Dioscorea bulbifera* L., *Dioscorea deltoidea* Wall. ex Griseb., *Urtica dioica* L., *Fagopyrum esculentum* Moench, *Dryopteris cochleata* (D. Don) C. Chr. and *Paeonia emodi* Royle. Almost all respondents (92%) used WNEPs to meet their daily vegetable requirements, with 75% depending exclusively on WNEPs for 1–3 months of the year and 10% for more than 3 months (Fig. 5).

The key perceptions of households on WNEPs and reasons for using them as vegetables are summarised in Fig. 6. The most common advantages of WNEPs were considered to be that they were tasty and nutritious (85%) and also freely available (68%).

Annual extraction and use

The estimated annual mean harvested weight of eight important species is shown in Fig. 7. The largest harvest was of *P. emodi*, a local seasonal vegetable locally known as *heto* found in the forest (150 kg), followed by *F. esculentum* and *D. cochleata*. Species like *D. bulbifera* (a tuber boiled as a vegetable) and *U. dioica* L. are also important as sources of income as they can be sold in the local market. A few species have a significant local economic value, and people have started collecting and marketing some high-demand species like *P. emodi*, whose leaves are used to treat diarrhoea, and *D. cochleata*, an edible fern shoot which is even popular in big cities. Some 13% of households sell these plants, earning an average of US $150 per season. However, WNEPs are not a major source of cash income for most households.

The estimation of UV or relative importance of the frequently used vegetable species in the study site revealed that although the mean annual harvest of the species like *Paeonia emodi* and *Fagopyrum esculentum* is higher than *Dryopteris cochleata* (Fig. 7), the use value of *Dryopteris cochleata* (0.98) is higher than *Paeonia emodi* (0.96) and *Fagopyrum esculentum* (0.74). The use value (UV) of most important species used as vegetables in the study site is presented in Fig. 8.

Gender roles in WNEP collection, utilisation, and management

Respondents were asked who in the household did what related to WNEP use. Overall, the roles and responsibilities

Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal

	Family	Botanical name	English name	Nepali name	Local name	Use[a]	Parts used[b]	Remarks	Specimen number
1	Acoraceae	*Acorus calamus* L.	Flag root, myrtle flag	Bojho	Bojho	M	R	Dried rhizome used to treat sore throat, coughs and colds	D142
2	Adoxaceae	*Viburnum erubescens* Wall.		Bajrang	Ganaule	F	F	Fruit eaten	D305
3	Adoxaceae	*Viburnum mullaha* Buch.-Ham.ex D. Don		Kavase	Titmelau	F	F	Fruit sour but eaten	D278
4	Amaranthaceae	*Amaranthus lividus* L.	Amaranth	Marshi	Latte	V	L, Sh	Leaves and young shoots eaten as a green vegetable	D500
5	Amaranthaceae	*Amaranthus spinosus* L.	Amaranth	Marshi	Kanya marshi/ chuwa	V	L, Sh	Young leaves and shoots eaten as a green vegetable	D283
6	Amaranthaceae	*Amaranthus viridis* L.	Amaranth	Marshi	Ghiya marshi	V, O	L, Sh, Se	Young shoots and leaves eaten as a green vegetable; seeds ground to flour and used to make chapattis; seeds fried in ghee and honey and made into round balls to be eaten (ladoo/geda)	D316
7	Amaryllidaceae	*Allium* spp.			Dhunu	S	L	Dried plant leaves used in curries	D160
8	Amaryllidaceae	*Allium wallichii* Kunth	Jimbur or Himalayan onion	Jimbu Jhar	Sekkwa/ sekuwa	S	W	Dried plant used in dal and curries	D50
9	Anacardiaceae	*Pistacia chinensis* subsp. *integerrima* (J.L. Stewart ex Brandis) Rech.f.	Insect gall in Pistacia	Kakarsingee	Kakarsingee	M	Gall	Gall used to treat snake and scorpion bites	D294
10	Apiaceae	*Angelica archangelica* L.			Ganano	S, M	R, Se	Root ground and made into soup to treat stomach pain. Seeds ground to flour and used as spice in curry	D101
11	Araceae	*Arisaema flavum* (Forssk.) Schott		Bako	Bako	V	T	Corms (tubers) boiled in ash and salt to remove toxic elements, cleaned, made into a paste and mixed with buckwheat flour to prepare curry	D196
12	Araceae	*Arisaema tortuosum* (Wall.) Schott	Whipcord cobra lily	Bako	Bako	V	T	Boiled tubers eaten as vegetable	D412
13	Araceae	*Colocasia esculenta* (L.) Schott.	Taro	Pidaalu	Pidaalu	V	R, S, L	Rhizome boiled and eaten as a vegetable; young stem and leaves used as a vegetable and in pickle	D119
14	Arecaceae	*Phoenix humilis* Royle		Thakal	Thakil/thakilo	F, O	F, S	Fruit eaten; pith from stem eaten; stem used to make thatched roofs	D284
15	Asparagaceae		Asaparagus, wild Asparagus	Kurilo	Jhijhirkani	V, M	R, Sh	Shoots and leaves eaten as a vegetable;	D140

Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal *(Continued)*

	Family	Botanical name	English name	Nepali name	Local name	Use[a]	Parts used[b]	Remarks	Specimen number
		Asparagus racemosus Willd.						roots used to treat urinary and liver problems	
16	Asteraceae	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob.	Crofton weed	Banmara	Banmara	M	L	Juice from crushed leaves used to treat wounds and cuts	
17	Asteraceae	*Ageratum conyzoides* (L.) L.	Billygoat-weed	Gandhe	Gandhe	M	L	Leaves crushed and juice used to treat cuts and wounds	D73
18	Asteraceae	*Artemisia indica* Willd.	Mug-wort, Indian worm wood fleabane	Titepati	Kuljo	R, M	L	Leaves used in death ceremonies; leaves crushed and juice used to treat skin problems (irritation)	D506
19	Berberidaceae	*Berberis aristata* DC.	Barberry/ Nepal Barberry/ common Barberry	Chutro	Chutro	F, O, M	F, Ba	Fruit eaten; bark used as a dye and to treat diarrhoea, piles and malaria	D190
20	Berberidaceae	*Berberis asiatica* Roxb. ex DC.	Barberry/ Nepal Barberry	Kirmando	Kirmada	F, O	F, Ba	Fruit eaten; bark used as a dye	D116
21	Bombacaceae	*Bombax ceiba* L.	Silk cotton tree, Simal tree	Simal	Simal	V	Fl	Flowers used in a vegetable curry	D230
22	Cannabaceae	*Cannabis sativa* L.	True hemp, Indian hemp, marijuana	Bhang	Bhango	O, M	Se, L	Roasted seeds used to make pickle or eaten raw; green leaves occasionally used to make snacks (pakauda); green leaves made into a paste and applied to the forehead to treat high fever	D402
23	Chenopodiaceae	*Chenopodium album* L.	Lamb's quarter	Bethe sag	Betu/ charchare	V	L	Leaves and young shoots eaten as a green vegetable	D229
24	Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Belleric myrobalan	Barro	Barado	F, M	Se, F	Ripe fruit eaten; seeds used to treat coughs and colds	D100
25	Combretaceae	*Terminalia chebula* Retz.	Chebulic myrobalan, yellow myrobalan	Harro	Harado	F, M	Se, F	Fruit eaten; fruit and seeds used to treat coughs and colds	D154
26	Commelinaceae	*Commelina benghalensis* L.	Day flower	Kane Sag	Kanya sag	V	L, Sh	Young leaves and shoots eaten as a green vegetable	D131
27	Convolvulaceae	*Cuscuta reflexa* Roxb.	Dodder	Aakas beli	Megh	M	W	Whole plant used to prepare medicine to treat livestock with cough and throat allergy	D300
28	Cucurbitaceae	*Coccinia grandis* (L.) Voigt	Ivy gourd, Kaval fruit	Golkakri	Golyakakadi	V	F	Fruits eaten as a vegetable	D280
29	Cucurbitaceae	*Momordica dioica* Roxb. ex Willd.		Bankarela	Barkarela	V	F	Immature fruit eaten as a green vegetable	D205
30	Dioscoreaceae	*Dioscorea bulbifera* L.	Palmate leaved yam	Githi	Githo	V	T	Tubers boiled and eaten as a vegetable	D429
31	Dioscoreaceae	*Dioscorea deltoidea* Wall. ex Griseb.	Cush-cush yam	Bhyakur	Bhyakur	V,	B, T	Bulbil and tubers boiled and eaten as a vegetable	D432
32	Dioscoreaceae			Ban tarul	Ban taud	V, R	B, T		D438

Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal *(Continued)*

	Family	Botanical name	English name	Nepali name	Local name	Use[a]	Parts used[b]	Remarks	Specimen number
		Dioscorea hamiltonii Hook.f.	Air potato, potato yam					Tubers and bulbils cooked and eaten. Boiled tubers are used during religious event first day of Nepali Month Magh (January)	
33	Dryopteridaceae	*Dryopteris cochleata* (D. Don) C. Chr.	Edible fern shoot	Niuro	Liundo	V, O	L, Sh	Young coiled fronds and shoots cooked and eaten as a vegetable; sold in urban markets (high demand)	D113
34	Elaeagnaceae	*Elaeagnus parvifolia* Wall. ex Royle	Oleaster	Kankoli	Guyaalo	F	F	Fruit eaten	D266
35	Ericaceae	*Rhododendron arboreum* Sm.	Rhododendron	Laligurans	Gurauns	M, O	Fl	Flowers eaten; nectar used to treat diarrhoea and dysentery	D218
36	Euphorbiaceae	*Phyllanthus emblica* L.	Indian gooseberry	Amala	Aaula	F, M	F	Fruit eaten raw and dried; fruit used in preparation of some Ayurvedic medicines for treating indigestion	D307
37	Fabaceae	*Albizia procera* (Roxb.) Benth.	White siris	Siris	Siris (not edible)	O	L	Leaves used to cover bananas to ripen them	D85
38	Fabaceae	*Bauhinia variegata* L.	Mountain ebony, White bauli	Koiralo	Koiral	V, M	Bu, Fl	Buds and flowers used as a vegetable and in pickle; flowers used to make soup to treat bacillary dysentery	D236
39	Fagaceae	*Castanopsis tribuloides* (Sm.) A.DC.	Chestnut	Katus	Katauj	F, R	F	Fruit eaten and offered to gods during rituals	D145
40	Fagaceae	*Quercus lanata* Sm.	Woolly-leaved oak	Baanjha	Baanjha	F	F	Fruit (lekaal) eaten	D480
41	Gentianaceae	*Swertia chirayita* (Roxb. ex Fleming) Karsten	Chiretta	Chiraita	Chiraito	M	W	Whole plant used to treat fever, diabetes, and skin diseases	D299
42	Hippocastanaceae	*Aesculus indica* (Wall. ex Cambess.) Hook.	Indian horse chestnut	Pangar	Pangar	M, O	F	Roasted fruit eaten to kill stomach worms; fruit used for washing clothes	D214
43	Juglandaceae	*Juglans regia* L.	Walnut	Okhar	Okhad	F, R	F	Fruit eaten and offered to gods during festivals	D233
44	Lamiaceae	*Mentha arvensis* L.	Mint	Pudina	Padamchal	S, M	L	Leaves used in pickle; juice from leaves used for cooling in summer	D110
45	Lamiaceae	*Mentha spicata* L.	Mint	Pudina	Padamchal	S, M	L	Leaves used as spice in pickle; leaves used as medicine to reduce 'body heat'	D248
46	Lamiaceae	*Perilla frutescens* (L.) Britton	Perilla	Silame	Bhangiro	S	Se	Seeds roasted and ground to use in pickle	D387
47	Lardizabalaceae	*Holboellia latifolia* Wall.			Ghopala	F	F	Ripe fruit eaten	D493
48	Lauraceae	*Cinnamomum glanduliferum* (Wall.) Meisn.	Nepal camphor tree	Sunghandhaakokila	Sunghandhaakokila	M, R	Ba, F	Bark and fruit used to treat coughs and colds, toothache, and swelling of muscles; leaves and fruit offered to gods during rituals	D96
49	Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	Bay leaf	Tejpaat	Tejpaat/dalchini	S	L	Dried leaves used as spice for curries to add flavour and smell	D82

Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal *(Continued)*

	Family	Botanical name	English name	Nepali name	Local name	Use[a]	Parts used[b]	Remarks	Specimen number
50	Loranthaceae	*Loranthus odoratus* Wall.		Ajeru	Anjedu	F	F	Fruit very tasty	D178
51	Moraceae	*Ficus auriculata* Lour.	Eye's apron, Moretan-bay fig	Timilo	Timlo	F	F	Fruit eaten	D352
52	Moraceae	*Ficus hispida* L.f.		Khasreto	Khasattya	F	F	Fruit eaten	D132
53	Moraceae	*Ficus lacor* Buch.-Ham		Kabhro	Kapado	V	Bu, Fl	Buds and flowers boiled and eaten as a vegetable and pickle	D100
54	Moraceae	*Ficus neriifolia* Sm.		Dudhilo	Dudilo	V, F	Sh, F	Young shoots eaten as a vegetable; fruit eaten	D328
55	Moraceae	*Ficus semicordata* Buch.-Ham. ex Sm.	Nepal fodder fig	Khaniyo	Khanniyo/ khinne	F	F	Fruit eaten	D211
56	Moraceae	*Ficus subincisa* Buch.-Ham. ex Sm.		Berlo	Belto/ beldo	F	F	Ripe fruit eaten	D48
57	Moraceae	*Morus serrata* Roxb.	Mulberry	Kimbu	Kimu	F, O	F, L	Fruit eaten, very popular among children; leaves used as fodder, preferred by goats	D333
58	Musaceae	*Musa balbisiana* Colla	Banana	Bankera	Bankela	F, R	F	Ripe fruit eaten and offered to gods during rituals	D127
59	Myricaceae	*Myrica esculenta* Buch.-Ham. ex D. Don	Box byrtle	Kafal	Kafal	F	F	Fruit tasty and popular	D318
60	Myrtaceae	*Syzygium cumini* (L.) Skeels	Black plum, Java plum, Indian black berry	Jamun	Jamno	F	F	Fruit eaten	D246
61	Myrtaceae	*Syzygium* spp.			Phalda	F	F	Fruit eaten	D329
62	Nephrolepidaceae	*Nephrolepis cordifolia* (L.) C. Presl	Sword fern	Pani amala	Rasmada	M	T	Tubers eaten to treat worms	D72
63	Oxalidaceae	*Oxalis corniculata* L.	Indian sorrel, creeping sorrel	Chari amilo	Chalmado	S	L	Leaves used in preparing pickle	D99
64	Paeoniaceae	*Paeonia emodi* Royle			Hetto	V	L, Sh	Young shoots and leaves eaten as a green vegetable, fresh or sundried, rehydrated, and cooked (in winter)	D32
65	Phytolaccaceae	*Phytolacca acinosa* Roxb.		Jarko	Jarak/jarka	V, M	L, R	Young leaves and shoots eaten as a green vegetable; root used to treat sickness after eating buckwheat leaves	D4001
66	Pinaceae	*Pinus roxburghii* Sarg.	Chir pine, Himalayan long-leaved pine	Salla	Sallo khote	M	La	Resin used to clear blood clots	D70
67	Poaceae	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro	Tufted bamboo	Bans	Bans	V	Sh	Young shoots (tama) eaten as a vegetable	D174

Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal *(Continued)*

	Family	Botanical name	English name	Nepali name	Local name	Use[a]	Parts used[b]	Remarks	Specimen number
68	Poaceae	*Drepanostachyum falcatum* (Munro) Keng f.	Himalayan Bamboo	Nigaalo	Nigaalo	V, O	S, Sh	Stem used to make mats; young shoots eaten as a vegetable	D290
69	Polygonaceae	*Fagopyrum esculentum* Moench	Buckwheat	Phapar	Phanpar	V	L, Sh	Young shoots and leaves eaten as a vegetable	D443
70	Polygonaceae	*Fagopyrum tataricum* (L.) Gaertn.	Buckwheat	Phapar	Phanpar	V	L	Young shoots and leaves eaten as a vegetable	D205
71	Polygonaceae	*Polygonum* spp.			Halaudo	S	L	Young leaves used to make pickle	D8
72	Polygonaceae	*Polygonum verticillatum* Birolli ex Colla		Nigali sag	Khinaudo	V	L	Young leaves eaten as a vegetable	D112
73	Ranunculaceae	*Aconitum heterophyllum* Wall. ex Royle	Aconite	Atis	Atis	M	W, R	Whole plant and roots used to treat high fever and abdominal pain	D260
74	Rosaceae	*Fragaria nubicola* (Lindl.ex. Hookf) Lacaita			Gande kafal	F, R, M	F, W	Fruit eaten; whole plant used in death rituals; whole plant used to treat stomach disorders	D68
75	Rosaceae	*Pyracantha crenulata* (Roxb. ex D. Don) M. Roem.	Fire horn	Ghangyaru/ kaatha gedi	Ghangyar	F	F	Ripe fruit eaten in large quantities	D108
76	Rosaceae	*Pyrus pashia* Buch.-Ham. ex D. Don.		Mayal	Mel	F	F	Fruit eaten	D239
77	Rosaceae	*Rubus ellipticus* Sm.	Golden evergreen raspberry	Ainselu	Anselu	F	F	Fruit very popular	D348
78	Rosaceae	*Rubus foliolosus* D. Don	Rasberry	Ainselu	Kalo anselu	F, R	F, L, W	Fruit eaten; leaves or whole plant used in death ceremonies	D501
79	Rosaceae	*Rubus niveus* Thunb.		Ainselu	Katrya anselu	F	F	Fruit eaten	D98
80	Rubiaceae	*Rubia manjith* Roxb. ex Fleming	Indian madder	Majitho	Majitho	M	S, L	Stem and leaves used to treat cuts and wounds	D103
81	Rutaceae	*Aegle marmelos* (L.) Correa	Bael fruit	Bel	Bel	F, R	F, L	Fruit pulp eaten; leaves used for religious purposes, especially offering to gods during rituals	D187
82	Rutaceae	*Zanthoxylum armatum* DC.	Nepal pepper, prickly ash	Timur	Timur	S, M	F	Fruit dried and used as a spice in pickles and curries; dried fruit used in various allopathic medicines like indigestion and nausea	D234
83	Sapindaceae	*Sapindus mukorossi* Gaertn.	Soap nut	Reetha	Reetha (not edible)	O	F	Fruit pulp used to wash hair	D431
84	Sapotaceae	*Diploknema butyracea* (Roxb.) H.J.Lam	Nepal butter fruit Phulwara	Chiuri	Chyuro	O, F	Fl, F, Se	Nectar from flowers and ripened fruit (bhina) eaten; seeds used to make a butter	D268

Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal *(Continued)*

	Family	Botanical name	English name	Nepali name	Local name	Use[a]	Parts used[b]	Remarks	Specimen number
								for cooking vegetables and others	
85	Sauraulaceae	*Saurauia napaulensis* DC.		Gogan	Gogan	F	F	Fruit eaten	D15
86	Saxifragaceae	*Bergenia ciliata* (Haw.) Sternb.	Rock foil	Pakhanbed	Pakhanbed/simpari phool	M	R	Rhizome used to make medicine to treat kidney stones	D134
87	Schisandraceae	*Schisandra grandiflora* (Wall.) Hook.f. & Thomson	Magnolia Vine		Haliyude	F	F	Ripe fruit eaten	D245
88	Smilacaceae	*Smilax aspera* L.	Green briers	Kukurdaino	Kukuldaino	F, V	Sh, F	Fruit eaten; young shoots eaten as a vegetable	D218
89	Smilacaceae	*Smilax ovalifolia* Roxb. ex D. Don	Green briers	Kukurdaino	Kukuldaino	F, V	Sh, F	Fruit eaten; young shoots eaten as a vegetable	D68
90	Solanaceae	*Solanum nigrum* L.		Kalokamai	Ninauni	F	F	Fruit eaten	D149
91	Trilliaceae	*Paris polyphylla* Sm.		Satuwa	Satuwa	V, M	L, R	Tender leaves eaten as a vegetable; root made into paste and applied to snake bite to control the poison	D179
92	Urticaceae	*Boehmeria rugulosa* Wedd.		Getha	Githi	O	Ba	Bark paste/powder mixed with rice flour to prepare sel roti(a form of rice doughnut); bark paste used as soda and to wash clothes	D22
93	Urticaceae	*Debregeasia s alicifolia* (D. Don) Rendle		Tusaare	Tusaaro	F	F	Fruit eaten	D55
94	Urticaceae	*Girardinia diversifolia* (Link) Friis	Himalayan Nettle	Allo Sisnu	Allo	V, O	L, Sh, S,	Young leaves and shoots eaten; fibre extracted f rom stems used to make clothes and bags	D17
95	Urticaceae	*Gonostegia hirta* (Blume ex Hassk.) Miq.			Attinno	O	R	Ground root used to prepare chapatti; ground root used for washing hair	D458
96	Urticaceae	*Urtica dioica* L.	Stinging nettle	Sisnu	Sisnu	V	L, Sh	Young leaves and shoots used as a vegetable	D16
97	Verbenaceae	*Callicarpa arborea* Roxb.	Beauty berry	Guyalo	Gwailo	F	F	Tasty fruit	D67
98	Violaceae	*Viola* L.			Juke jhaar	M	L, R	Leaves and roots used to treat worms in children	D481
99	Vitaceae	*Tetrastigma* spp.			Pudaayen	F	F	Fruit eaten	D344

[a]Use: *F* fruit, *V* vegetable, *M* medicine, *O* other, *R* religious, *S* spice
[b]Part of plant used: *W* whole plant, *B* bulb, *Ba* bark, *Bu* buds, *F* fruit, *Fl* flowers, *La* latex, *L* leaf, *O* other, *R* root/rhizome, *S* stem, *Se* seeds, *Sh* shoots, *T* tuber/corm

in activities and decision-making on collection, processing, food preparation, storage and marketing of WNEPs were shared between men and women (Table 3). Irrespective of gender, about half of the respondents (49%) stated that decisions and activities related to collection and harvesting were shared by men and women, with the remainder divided almost equally between women or men. Responsibility for processing was generally thought to be shared

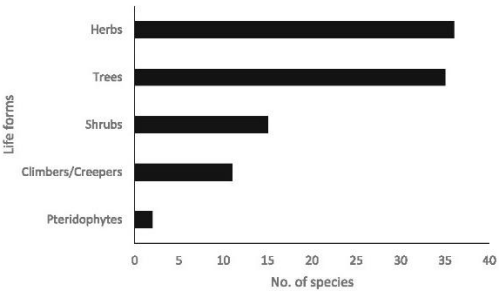

Fig. 3 Frequency of different life forms of WNEPs

equally (around 80%) as was responsibility for conservation and management. However, women had much greater responsibility for preparation and storage.

Local perceptions

Respondents were asked about the existing and potential issues of concern related to WNEPs. The primary issues identified were premature and unsustainable harvesting (147), inadequate labour resources within the family (134) and time taken for collection (120) (Fig. 9). Other issues included neglect of local food, availability of ready-made food and problems identifying whether species are edible, especially among young collectors. We discussed these issues further in the FGDs. Of the ten FGDs (82 participants), eight groups also thought that the major issues for utilisation and management were lack of human resources due to migration for seasonal work, unsustainable harvesting and changing human lifestyles and taste. We also asked about current management practices. In all ten groups, participants mentioned in situ conservation of important species by almost all people in the village, with domestication of important species as the second most important strategy. This perception was supported by the data from the household survey. The great majority of respondents (86%) reported practising in situ conservation and domestication (38%) of key species in their home gardens and agricultural fields.

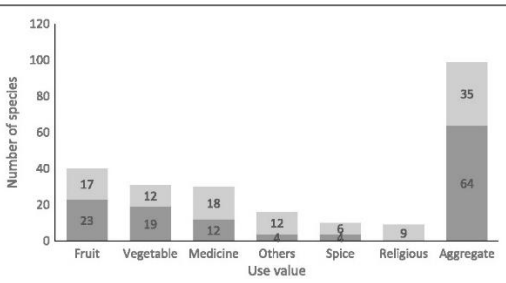

Fig. 4 Uses of WNEPs (single use, black-shaded; multiple use, grey-shaded)

Table 2 Categories of ailments and informant consensus factor (ICF)

Use categories	No. of taxa	No. of use reports	Consensus factor
Stomach disorder (diarrhoea/ dysentry)	8	178	0.96
Cuts and wounds	4	160	0.98
Fever and headache	6	125	0.96
Skin diseases/skin irritation	2	4	0.67
Worms in stomach	2	120	0.99
Nausea and vomiting	2	73	0.98
Snake and scorpion bites	2	8	0.85
Cough and cold	4	186	0.98

Discussion

Diversity of WNEPs and their use

It is estimated that at least a billion people use WNEPs in their diet [30]. Millions of people in the Himalayan region depend on WNEPs for their daily food and vegetable requirements as well as for fresh fruit and medicines [30–33]. Our study documented 99 WNEP species currently used in various forms by the local people in the Kailash Sacred Landscape area in far west Nepal. A number of studies by other authors have documented a diverse range of WNEP species and uses in different parts of the Himalayan region, but most have not assessed status and availability, household consumption patterns or local management practices. The study in Tibetan community of China documented the use of 54 species for household consumption [34]. Similar study conducted in Tibetan communities of Nepal, China and India also documented 75 wild food plants of diverse uses at household level [35]. Singh et al. [36] documented 111 WNEPs used in Bandipora district in Kashmir, while other authors identified 112 WNEPs in

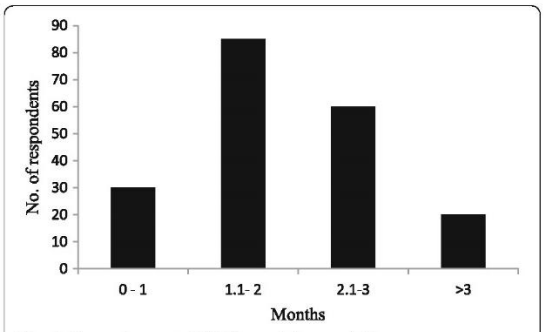

Fig. 5 Dependence on WNEPs on daily vegetable requirements ($N = 195$)

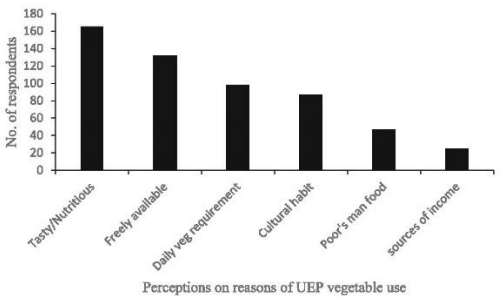

Fig. 6 Perceptions of and reasons for using WNEPs ($N = 195$)

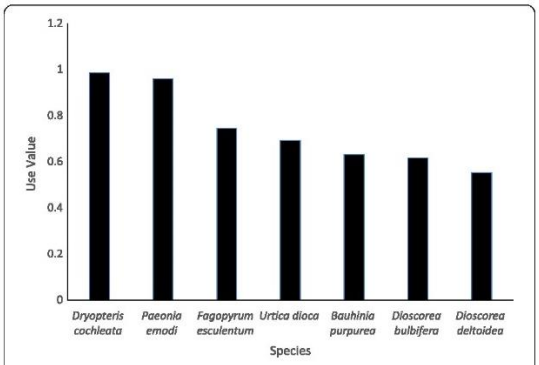

Fig. 8 Use value of frequently used vegetable species

Dhading and Kaski districts in Nepal [16] and 62 in Bhutan [37]. Khan et al. [38] conducted assessment of wild edible plants of Sewa catchment area in Northwest Himalaya of India and listed 97 plant species used by local inhabitants for various uses. More than 380 non-timber forest products (NTFPs) were identified in Meghalaya in North East India [39] and 739 in the Kangchenjunga Landscape (India, Nepal and Bhutan) [40] of which many were WNEPs, although these were not separately listed.

WNEPs contributed substantially to the food requirements of the households in the study area. People preferred to collect species with multiple use value, but they also collected large quantities of species used purely as a vegetable. *P. emodi*, *U. dioica*, *F. esculentum* and *D. cochleata* were particularly popular and constituted an important source of vegetables in household food. A large quantity of *P. emodi and F. esculentum* is harvested, but the use value of *D. cochleata* was found higher, which might be attributable to their widespread distribution and abundance of the later species across the study area making them the first choice for collection and consumption. The average annual extraction of species used as vegetables was very high; this has also been observed by others. For example, in Dhusa VDC in Dhading district, Nepal, individual households were observed to collect an average 200 kg of *D. bulbifera* per annum [13], while Chepang households in Gorkha district of Nepal consumed an average 364 kg of *D. bulbifera* and 96 kg of *U. dioica* per annum [41]. A diverse range of *Dioscorea* spp. is widely used and consumed by the local community in Himanchal and Similipal Biosphere Reserve in India [31, 42]. Together, these figures suggest that people are harvesting at least some WNEPs in large quantities, which has also been observed in studies conducted in other parts of the world [1, 2, 11, 15, 31, 32, 43–51]. Most people at the study site depended on WNEPs to fill their vegetable requirements for between 1 and 3 months or more a year. A study carried out among the Chepang people in Nepal reported that 58% of households depended on WNEPs for

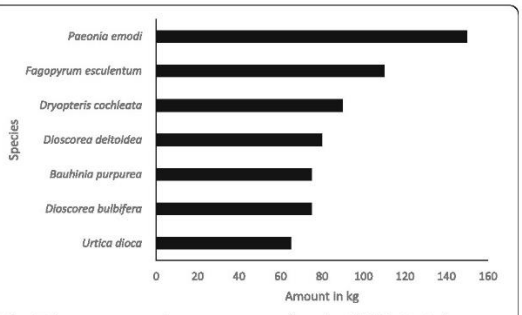

Fig. 7 Average extraction per annum of major WNEPs (in kg)

Table 3 Division of responsibility for WNEP activities and decisions among men and women

Role and responsibility	$N = 195$		
	Women	Men	Both
Activities			
Harvesting/collection	55 (28)	45 (23)	95 (49)
Processing	25 (13)	20 (10)	150 (77)
Preparation	165 (85)	10 (5)	20 (10)
Storage	135 (69)	10 (5)	50 (26)
Marketing/exchange	75 (38)	37 (19)	83 (43)
Conservation and management	20 (10)	35 (18)	140 (72)
Decision-making			
Harvesting/collection	45 (23)	55 (28)	95 (49)
Processing	25 (13)	12 (6)	158 (81)
Preparation	185 (95)	5 (3)	5 (3)
Storage	160 (82)	10 (5)	25 (13)
Marketing/exchange	45 (23)	85 (44)	65 (33)
Conservation and management	48 (25)	30 (15)	117 (60)

Note: figures in brackets are percentage of respondents

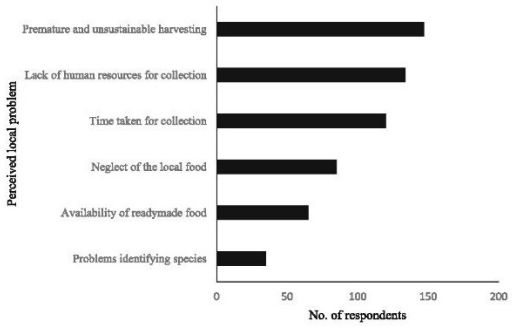

Fig. 9 Primary issues related to utilisation and management of WNEPs ($N = 195$)

vegetables for up to 5 months a year [2], and in one village in India, people ate WNEPs as vegetables for at least 50–80 days per year [47]. A study in Burkina Faso showed 20% of all food items to come from wild/non-cultivated sources [43], while non-cultivated greens are one of the major sources of vegetables in rural areas of Vietnam, eaten by almost all households [43]. Wild leafy vegetables are an important part of diet of people of Shiri in Daghestan, and 70% of them are used as snacks. They are important in maintaining social life as the dried vegetables are sent as gifts to distant relatives and people visiting them at their place [52]. So, the wild vegetables are also culturally associated with the indigenous communities.

The studies highlight the importance of WNEPs in local diets but also indicate that the current trends in harvesting of some species may not be sustainable and could affect species availability in the future [1, 2, 4, 53].

WNEPs are considered to be an important source of vitamins and minerals [32, 54–56] and to contribute to energy and micronutrients for farm families throughout the year [43, 57]. The study conducted in Naxi community of China depicted that wild edible plants play a very important role in safeguarding food and nutritional security [58]. This is also supported by other two studies conducted in India [59, 60]. However, the precise nutritional composition of most of these foods is not known [61], although one study showed, for example, that the root crop from *Dioscorea* spp. contains five times more protein and fibre than potato and sweet potato [62]. Similarly, little is known about the actual contribution of WNEPs to people's daily food requirements, and this remains poorly studied. In addition to contributing to food and nutritional security, a wide range of WNEPs contribute to health and well-being as medicinal plants [4, 10, 40, 44, 49, 63–67]. For example, most diseases in far west Nepal are treated by individuals and local healers using traditionally handed-down ethno-medicinal knowledge of plants, which have been protected and have flourished where ethnic traditions and beliefs are still strong [44, 68, 69]. The informant consensus factors for the medicinal plant use suggest that a number of plant species have been used for treating various ailments such as stomach disorder, colds and cough, wounds and cut, skin diseases, fever/headache, nausea and vomiting, worms in the stomach and snake and scorpion bites. Rural people, particularly in remote villages, have been using these plant species for generations to treat different diseases based on their indigenous knowledge. Similar treatments of various diseases were also documented in the other studies from the region [70–72]. Especially, local healers know how to prepare drugs from raw herbs through personal experience and ancestral prescription. Such drugs are regularly used and have proven to be effective, inexpensive and beneficial and with few side effects compared to allopathic drugs [2, 4, 10, 73]. The use of herbs by traditional health practitioners is based on trust gained over generations and religious connections to such practices [4]. However, the use of plants as medicines is declining [69, 74], partly because there are fewer traditional healers due to lack of knowledge transfer. The younger generation has little interest in studying traditional forms of medicine.

Although WNEPs make a significant contribution to the livelihoods of local people in the more remote mountain regions, these species are less used in the daily diets of households in other areas [2, 11, 13, 15]. WNEPs have the potential to play an important role in maintaining and improving food security in the many rural areas where food security remains a cause for concern and in supplementing nutritionally poor diets that are otherwise low in vitamins and minerals. However, changing food habits, taste, and lifestyles and availability of ready-made foods in the market are contributing to an increasing neglect of traditional foods in rural diets. Collection and use of WNEPs is considered risky and time-consuming, and young people are becoming less familiar with WNEP species and forest environments and less able to identify suitable species for harvesting. Little is known about the sustainability of harvesting practices [1, 2, 6, 9, 13, 16, 40], and reduced availability is also cited by various studies as one of the underlying causes of the declining use of WNEPs [1–3, 10–16]. The use of WNEPs is likely to decrease further, threatening the retention of knowledge about this important component of livelihoods, culture and tradition [11, 13]. At the same time, sustainable use and management of these resources remain a prime concern for the millions of mountain people whose lives still depend on them [49], as well as being essential to ensure the basis for further exploitation of their potential.

Conservation and management of WNEPs

The true status of WNEPs, their contribution to livelihoods and the interrelationship with other species in the region has yet to be studied systematically [33, 36, 44]. Recent and past studies remain inadequate as they have focussed more on compiling lists of species and less on analysing their contribution to nutrition and food security [40, 42]. Despite their important contribution to nutrition, WNEPs have also received little attention in government food and nutrition programmes in the region [2, 33, 44].

A number of studies have noted the decreasing availability of WNEPs [2, 15]. The loss of WNEPs has many causes, including habitat degradation, rapid urbanisation and over exploitation, as well as changes in food habits [75, 76]. Changes in agricultural practices towards increased monocropping, use of herbicides and pesticides and increased mechanisation and changes in forestry practices towards more managed regimes and plantation may all play a role. At the same time, some WNEP species are becoming more heavily exploited as urbanised populations become motivated to eat local products and farmers collect plants for sale in urban markets rather than personal consumption [15, 33, 44, 47, 74, 77–80]. Species with high use value are subjected to higher extraction, which may be unsustainable. Control of overexploitation and illegal harvesting will be essential to ensure sustainable management. A coordinated effort is needed from all sectors to develop and implement in situ conservation, domestication and other conservation and management strategies for long-term management of WNEP species [1–5, 13, 19, 31, 33]. Furthermore, WNEPs can be promoted through the large-scale cultivation by integrating them into agricultural systems and making markets profitable for the benefit of the people [59, 60] With the participation of local people and a wide range of other stakeholders, it will be possible to craft more holistic and culturally appropriate strategies for utilisation and management of WNEPs in the Western Himalayas [67].

Maintenance and use of WNEPs in the Kailash region, as in Nepal overall, is not just important for botanical studies or as an ecological exercise. The conservation and wise utilisation of the indigenous knowledge of useful plants can help in the improvement of living standard of poor people of Nepal. It equally holds true for several developing countries where similar ecological and socio-cultural landscapes exist [81]. These plants play a significant role in meeting the daily food requirements of thousands of people living in rural villages like Khar, and play an important part in their survival strategies [1, 2, 31, 37, 45, 82]. WNEPs are not only important in times of famine or stress [74], they are an essential part of a mineral rich normal diet for millions of people [83–85]. WNEPs are important resources, and further study is essential to provide updated inventories and information about their availability and use. Local people must be involved in conservation and management, as they are both the guardians and users of the resources and have the greatest knowledge about them. It is also important to organise local-level WNEP fairs and local food festivals to raise awareness about the importance of WNEP species, revive interest among the younger generation, and motivate communities towards proactive management of these resources. Domestication of WNEPs where possible will be needed to ensure continued availability; thus, it would be beneficial to encourage cultivation and/or domestication of plants used for food, fodder, medicine and other purposes. Technical and material support will be very much needed in the initial stages. Domestication in home gardens would be a good starting point, as they offer increased availability of water, a mostly organic-based production system, easier protection against predators and close monitoring by the household members.

Conclusions

A total of 99 WNEPs species with high diversity and multiple use values were documented in the KSL Nepal. These plants play a significant role in household-level food and nutrition as well as health security. The local livelihood system depends heavily on traditions and values that are rooted in nature. WNEP species, now often used most heavily in times of food shortage, have the potential to become important alternatives to the usual food crops cultivated by farmers. Farmers gave priority to those species that provide them with a multitude of benefits such as food and nutritional security as well as household-level healthcare but also harvested large amounts of species popular as vegetables. Species like *P. emodi*, *D bulbifera* L., *D. deltoidea*, *U dioica*, and *F. esculentum* are an important part of local peoples' livelihoods. However, there is a growing pressure on such species, which suggests that there is an urgent need for conservation and management, which requires proper research and policy advocacy. These wild and non-cultivated resources are crucial to local peoples' traditions and contribute strongly to subsistence. It is important to consider how such species can contribute to future food security. This requires an understanding of how to manage the cultural changes affecting the use of WNEPs and how to ensure sustainable availability. Integrated research and development programmes are urgently needed to address the issue.

Abbreviations

FGDs: Focus group discussions; KSL: Kailash Sacred Landscape; VDC: Village Development Committee; WNEP: Wild and non-cultivated edible plant species

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Availability of data and materials
Availability of the structured and organised version of the data is available from the first author upon request. The voucher specimens are kept at Central Department of Botany at Tribhuvan University, Nepal, and will be available upon request.

Disclaimer
The views and interpretations in this publication are those of the authors and not necessarily attributable to their organisations.

Authors' contributions
KA, SP, RCP, NC, RC and WN designed the study. KA and SP carried out the literature review and did the field study and data collection. KA, SP, RCP, NC, PC and WN analysed the data and wrote the manuscript. All authors approved the final version of the manuscript.

Ethics approval and consent to participate
A prior informed consent was taken from the farmers and local communities in the study sites. The study was conducted in Api-Nampa Conservation Area of Department of National Parks and Wildlife Conservation of Government of Nepal, and prior approval and consent was taken from the government for this study.

Consent for publication
The manuscript does not include the individuals' photographs and images, videos, reprints and personal information; hence, no need of submitting the consent for publication.

Competing interests
The authors declare that they have no competing interests.

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CONSERVATION AND MANAGEMENT PRACTICES OF TRADITIONAL CROP GENETIC DIVERSITY BY THE FARMERS: A CASE FROM KAILASH SACRED LANDSCAPE, NEPAL

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ABSTRACT

Crop genetic diversity has been an important source of subsistence livelihoods and nutrition in the remote Himalayan region for local communities. This study documents the crop diversity, their current status and farmer's knowledge and practices. Study was based on analysis of one local crop diversity fair, 18 key informant surveys, nine focus group discussions and 195 individual household surveys with set questionnaires. The community structure in the study area has female dominance (52%) with average family size of 7.1. The study documents 78 species of various crops which were used as food, vegetables, fruits, medicine, and spices. Highest varietal diversity was recorded in Maize (15), Paddy (12), wheat (11), and beans (10). However, a number of crop varieties are being lost and threatened over the time. Both anthropogenic and natural drivers of changes were reported as the major reason of such loss. Despite loss of crop varieties farmers have been maintaining a wide range of crop and varietal diversity in situ on farm by their own initiatives and experiences. Our study showed that self-saved seed contributed as the major source of planting material through which they are maintaining the crop diversity. However, a detailed study on the seed supply system is needed to support easy access to the farmers. More awareness raising program as well as empowerment of farming communities is essential for the continuation of conservation and management practices.

Key words: *Crop and varietal diversity, diversity fair, loss and threatened species, self-saved seed, Kailash Sacred Landscape*

INTRODUCTION

Agro-biodiversity has been recognized as an important factor in maintaining or enhancing agricultural sustainability and playing a significant role for the food security and livelihoods of a large number of local communities around the globe (Uprety 2000; Baldinelli 2014). Agriculture combined with agro-pastoralist communities is the basis of the livelihoods for over 80 percent of the rural population in the Hindu Kush Himalayan (HKH) region and has been recognized as a hotspot for

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crop diversity (Agnihotri and Palni, 2007). The traditional local cultivars, also known as landraces or farmer's varieties contribute significantly to sustainable food production, human nutrition and household income generation for the resource poor farmers in marginal agricultural areas and to overall climate resilience building (Baldineli, 2014; Katwal et al. 2015). Genetic diversity of traditional varieties of crops is the most economically valuable element of global agro-biodiversity and is of paramount importance for future world crop production (Rana et al. 2007; Galluzi et al. 2010). High genetic diversity of the local crops is a defense against pests, diseases and environmental changes and makes landraces more suitable than commercial varieties (Negri 2005). The HKH region has been identified as a repository for traditional knowledge widely used in natural resource use and conservation (Bist et al. 2007). However, due to socio-demographic changes such as out-migration of the younger generations to urban areas is resulting in loss of such knowledge. It is essential that such traditional knowledge and practices be conserved (Chaudhary et al. 2007; Rana et al. 2007; Chaudhary and Aryal 2009; Zomer and Oli 2011).

In the other hand, changes in agricultural land use system and climatic and non-climatic factors have caused a significant decrease in agricultural diversity (Aase et al. 2009; Chaudhary et al. 2011; Baldinelli, 2014). Furthermore, in recent years local varieties are being replaced by exotic varieties promoted by public schemes for higher production and specific robustness criteria for example pest resistant and drought resistant (Oli, 2003; Verma et.al 2010; Hyder et al. 2014) limit the option for farmers in having a balanced nutrition. On the otherhand, knowledge about climatic and non-climatic changes and their impact on food security and crop genetic resources management in the region have not been well documented (Aase et al. 2009; Singh et al. 2010; Chaudhary et al. 2011; Zoomer and Oli 2011;).

Indigenous and traditional agricultural communities act as the sole managers and custodians of local crop varieties and utilize their knowledge to maintain and manage diverse agricultural production system (Upadhyay & Subedi, 2003; Bisht et al. 2007). They have been accumulating knowledge about the agricultural practices through implementing wide range of indigenous and traditional practices based on generations of experience, informal experiments and intimate understanding of their environments (Abioye et al. 2011; Berkes et al. 2000; Usher 2000). These traditional knowledge and practices include numerous adaptations strategies at local context and also transmission of knowledge and practices to younger generations (Berkes et al 2000; Salick and Byg, 2007). However, the valuable knowledge gathered and practiced by farmers over generations is often neglected by researchers, although the information is quite essential for location specific recommendations and for developing sustainable farming systems (Abioye et al. 2011). Furthermore, lack of proper documentation of the traditional knowledge and practices, a number of crop varieties are eroding from the areas without proper knowledge of farmers about varieties and their cultivation (Sunwar et al. 2006; Regmi et al. 2009; Baral et al. 2012).

Having these contexts and background, this paper is trying to assess the richness and status of the local crop genetic resources and associated knowledge and practices of the local communities in Khar Village Development Committee (VDC) of Kailash Sacred Landscape, Nepal. We tried to document and analyze farmers' local knowledge and practices on managing crop diversity, not only in terms of 'what', 'who' and 'how', but also 'why', so that the blending of scientific and local knowledge is achieved for strengthening farmers' capacity and interest to continue growing

traditional crop varieties for the long-term security of livelihoods of the local people as well as maintain high diversity on-farm so that climate resilience is inbuilt.

OBJECTIVE

This paper aims to document the status of crop diversity and traditional management practices adopted by the local people to manage the crop diversity on farm. The specific objectives were to:

- know the current status of local crop diversity and their changes over time;
- understand and document various anthropogenic and climatic drivers of change affecting the choice and management of crop genetic resources; and
- document local knowledge/practices and adoption strategies used by the local people for management of crop diversity on farm.

MATERIALS AND METHODS

STUDY AREA

The present investigation was particularly carried out in Khar VDC of Api Nampa Conservation Area

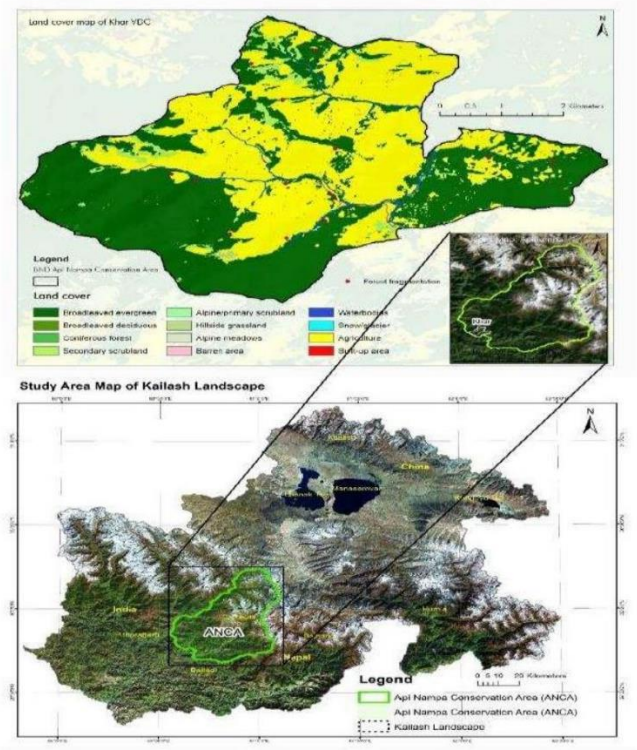

Figure 1: Study site (Land cover map of Khar VDC)

(ANCA) (Figure 1). The elevation of the VDC ranges from 1,324 to 3,242 masl with subtropical climate at lower part and temperate in the upper reaches. The area is located at about 3 hour walk from Khalanga *Bazaar*, the district headquarter of Darchula district and also connected by rural road (14 km) with Khalanga *Bazaar*. The access of the vehicle is only possible during the winter and spring seasons (not in monsoon). With an area of 25.95 km^2, Khar VDC has 698 households with population of 4,272 (CBS 2012). Nearly half of the VDC area (51.1%) is covered by forest, other land use types are agriculture (44.3%), shrub land (4.1%), water bodies (0.31%), grassland (0.11%) and settlement area (0.07%) (ICIMOD, 2013).

DATA COLLECTION

The research methodology involved both primary data collection and through literature review. For the primary data collection, sample size for household survey was determined using the following formula:

$$\text{Number of households to be audited} = \frac{Z^2_{1-X} * N * P(1-P)}{(e^2 * N) + (Z^2_{1-X} * P(1-P)}$$

Where,

N is the total number of households in the population (N=698)

Z is the level of confidence (assumed value for 90% level of confidence is 1.65);

P is the estimate of the indicator to be measured (assumed value 50% in the absence of any prior information)

e is the margin of error to be attained (assumed level of precision is set at 5%)

Under the above assumptions, a total of 195 households were selected for the detailed household survey. To have proper representation from each ward, the estimated sample size was proportionally distributed as per the number of households in nine wards of the VDC. Planned structured questionnaire for household survey was prepared and carried out in 195 households of Khar VDC. In addition, nine focus group discussions (one in each ward) were carried out and at least 18 key informants were interviewed. During the key informant's interviews, older people (more than 50 years of age) were consulted to gather traditional knowledge and practices about the local crop diversity. Farmer's recall method followed by Focus Group Discussions (FGD) was organized to see the changes of local crop diversity in last 10 years from their area. They were asked to identify the lost and threatened species along with the associated reasons. Besides, agricultural crop diversity fair was organized in Dallekh of Khar VDC in February 2016 in collaboration with District Agriculture Development Office (DADO) and Api-Nampa Conservation Area. During the fair local genetic materials were displayed, their indigenous/local knowledge were shared and documented and traditional food were also prepared from the local crops.

For data analysis, a questionnaire format was prepared in CS Pro 6.2 and then the survey data was entered into the program. Descriptive statistics like mean and frequency distribution were used to describe the household characteristics using Statistical Package for Social Sciences (SPSS, 2011) 16.0 Software.

RESULT AND DISCUSSION

SOCIO-ECONOMIC PROFILE

The farmers in the study site live under different socio-economic conditions in terms of education, family size, age group, occupation, and income source and food sufficiency level (see Table 1). The number of interviewed persons was 195 (94 male and 101 female).

The average household size of the study site is 7.1 which is higher than the district average of 5.41 and further the figure is higher than the national average i.e. 4.88 (CBS 2012). In general, the literacy rate is very low, only 39.3 percent can read and write their name and the rest 60.7 percent of the respondents were illiterate. This can be compared to the national literacy rate of 65.9% (CBS 2012).

Overall, agriculture was ranked as the most important occupation by majority of the respondents (84%). However, their self-grown food is only sufficient for 5 percent of the households. About 82 percent of the household could only live for 7-10 months on products from their own agricultural production and 13 percent of the household could live for less than 6 months from their own agricultural production. During the food deficit period households depend on multiple coping strategies such as wage labor, salaried employed, remittances, share cropping and collection of wild foods.

Table 1: Socio-economic features of the respondents.

Categories	No. of respondents (N=195)
Sex	
Male	94 (48%)
Female	101 (52%)
Age group	
15-25 years	37 (19%)
26-40 years	50 (26%)
41-55 years	74 (38%)
>56 years	34 (17%)
Average HH size	7.1
Education	
Illiterate	118 (60.7%)
Class 1-11	57 (29.1%)
Class 12-15	20 (10.2%)
Average income earned per HH	NRs 142,688
Food sufficiency level (months from self-grown food)	
Up to 6 months	25 (12.8%)
7-10 months	160 (82.1%)
>10 months	10 (5.1%)

Note: Proportions in different categories are presented within brackets.

CROP DIVERSITY IN THE STUDY SITE

Altogether 78 different species of various crops cultivated in the study site were documented through crop diversity fair organized in February 2016 in the study site. Traditionally, people grow wide range of crops for their livelihoods sustenance. The eight major crops grown by surveyed households are presented in Figure 2. Within the crops the highest diversity was recorded in Maize

having 15 different varieties followed by paddy (12) and wheat (11) as indicated in Table 2. The name of the varieties mentioned in the table are given by the farmers based on their own descriptor during diversity fair where all these varieties were displayed. Some of the varieties displayed during the fair looked similar hence further detail analysis is needed to verify by establishing experimental plots using standard descriptors. Despite high varietal diversity, majority of the households grow only a few varieties on the farm.

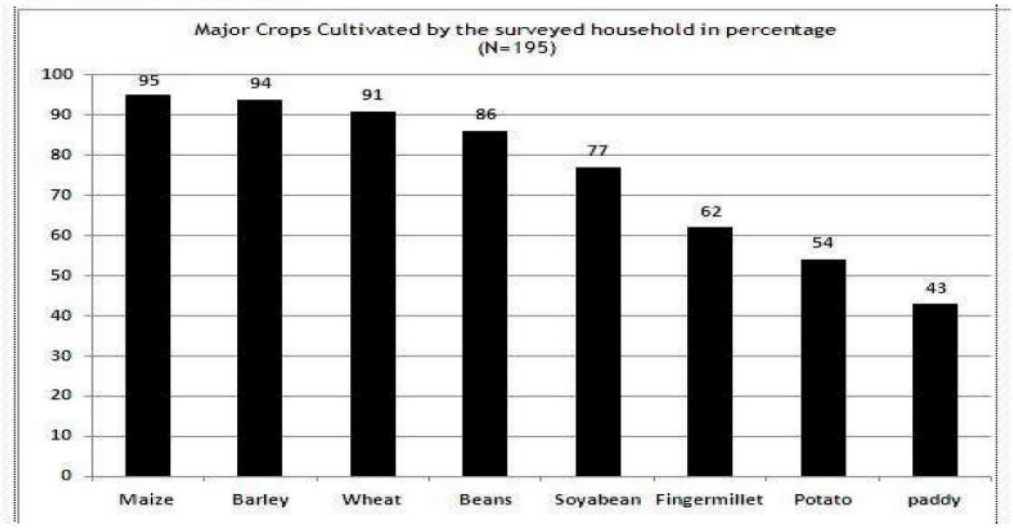

Figure 2: Major crops cultivated by majority of the household in Khar

STATUS OF CROPS AND CHANGES OVER TIME

Many of the participants in FGD recalled and reported that they used to cultivate large number of local crops species and varieties in their agriculture field in the past and are now not cultivated in the area. The reported lost and threatened species were mostly local crops and varieties of wild species. With this decline, crop varieties of various species are disappearing. A number of varieties of major crops grown in the area are disappearing (see Table 2). The cultivation of traditional crops such as finger millet, proso millet, fox tail millet, amaranths, rice bean and buckwheat has decreased in the last 10 years and it has become extremely difficult to even find the seeds of these crops. One of the older varieties of wheat (*Malaya* variety) is reported to be completely lost from the study area. Many old varieties of barley such as *jhuse jau*, *thaang jau* and *kalo jau* and maize such as *baktado*, *ragase* and *rato bilaas* are very difficult to find. The older varieties of beans such as black and white beans are also in the state of rapid decline. Two important reasons mentioned for such decline were low production potential and long crop duration which do not allow increasing cropping intensity. Similar reasons were mentioned in the study area carried out by Rana et al. (2007) and Rijal (2007). If this process continues, many such older varieties of crops will be lost forever without even being documented. This will not only reduces the local crop diversity but also increases farmer's vulnerability to climate related changes resulting on loss of traditional farming system (Bisht et al. 2007; Singh et al. 2010).

Table 2: Agricultural crop diversity of major crops grown locally (source: Diversity fair-2016)

Crop	Local name	Botanical name	Varieties	Remarks
Paddy	Dhan (12)	*Oryza sativa* L.	*Khasare, Sali, Chamade,Takmaro, Roti dhaan,Choti dhaan, Jaili dhaan,Jumli dhaan, Kirmuli dhaan,Jau dhaan, Mangali dhaan,Rato dhaan*	*Jau dhaan* and *Sali dhan* are almost eroded from Khar VDC only a couple of farmers maintain these varieties in small land area
Wheat	Gau (11)	*Triticum aestivum* L.	*Dautkhane, Bhote, Rato,Thulo, Jhuse, Geru,Moto, Haasa, Lide, Jumli Bhoto, Nangri Bhoto,*	*Jhuse, Haasa, Geru and Dautkhane* varieties have been eroding from the area
Maize	Ghoga (15)	*Zea mays* L.	*Bhabari, Rato, Murali,Temase, Pahelo, Seto,Bhate, Ragese, Airkoti,Male, Baktado, Ghar, Baure, Marudi, Bikasi*	*Baktado* variey is grown by only one farmer and *Rato, ragase* are also in the verge of disappearing from the area due to its low yield
Finger millet	Kodo (7)	*Eleusine coracana* Gaertn.	*Nang kate, Kalo, Rato,Temase, Tiuli, Mutke,Kodekauli*	All the varieties are disappearing due to its low yield and shifting towards new maize varieties introduced by DADO
Barley	Jau (5)	*Hordeum vulgare* L.	*Jhuse, Mankare, Kalo, Seto, Thang Jau*	*Jhuse, Kalo,* and *thang* are almost disappeared from the area
Beans	Sotta (10)	*Phaseolus vulgaris* L.	*Seto local, Kalo local, Rato Kirmire, Kaleji Kirmire, Asali rajma, Marma, Temase, Bote, Kalo, Batule, Ankhe Simi*	*Seto* and *Kalo* are two of the oldest varieties grown only few households (less than 10 households in Khar VDC)

FARMERS PERCEPTION ON LOSS OF CROP GENETIC RESOURCE

The multiple response on perceptions of respondents for both anthropogenic and natural drivers of changes on the loss and threatened varieties of the crops were recorded in the study area. The first important reason for loss of local crop diversity has been accelerated by the introduction of improved crops and varieties which is reported by 150 respondents out of 195 (Figure 3). About 94 percent of the respondent reported that easy availability of improved and hybrid varieties of crops is considered the leading cause of local crop diversity loss. It is followed by out and seasonal migration of the skilled human resources (110 respondents). Now, the trend changed as people migrate seasonally to India or abroad to work as wage laborers creating shortage of labor to work in agricultural fields which directly affects the crop diversity management. Other anthropogenic causes mentioned by the people are easy accessibility of road and market. Before roads were built people's livelihoods completely depended on self-grown food and mostly the traditional varieties of crops they grew in their fields. As the resources are easily available due to access to road and market people prefer buying rice from the market rather than depending on their production (Figure 3).

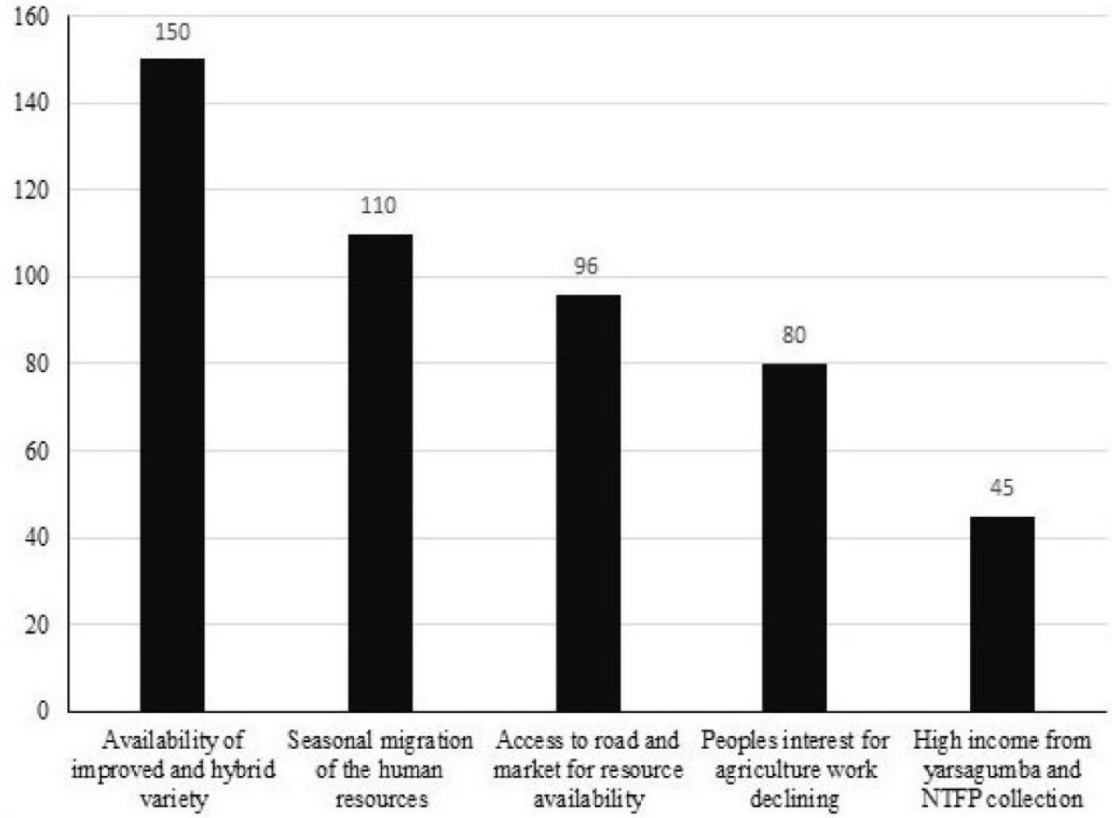

Figure 3: People's perception on anthropogenic reasons causing crop diversity management

We also conducted key informants interview with several elderly people and discuss the natural drivers of changes. A multiple and wide range of responses were recorded based on their own experiences and stories. Overwhelming (90%) of the respondent experiences that the climate is changing. Their experiences broadly range from erratic weather pattern, ecological variability, biological changes and their negative effects on local people's life. However, they are not quite sure whether these kinds of changes are because of climate only or linked to other associated reasons. We also tested several theories by asking the local people about their perceptions on changes that they are experiencing in their lifetime. To do this, at first we organized a FGD and asked them to share their various climate change related practical experiences. We listed them and prepared a major areas of changes that the local people who are experiencing in their locality and later included them in the household survey questionnaire where mixed response were recorded (see Table 3). We only presented responses on climate change related experiences which was mentioned by more than 50 percent respondents. In column 3, where respondents are not experienced the changes and in the last column the respondent didn't have any idea about such

changes. Studies by Chaudhary and Aryal (2009) and Uprety and Ghale (2002) also supported our current study findings.

Table 3: People's experiences on natural drivers of change related happenings

Local people perception on various climate change related issues	Yes	No	No Idea
Experiencing long summer (more hotter days)	105	29	61
Less snowfall	130	20	45
Less rainfall during winter	110	40	45
Drying up the water sources	150	15	30
Longer duration of drought	160	10	25
Early flowering of rhododendron	120	25	50
Never seen weeds present in agriculture field	160	10	25
Insect pest attack on local varieties	110	30	55
New species adopted well	122	50	23

LOCAL MANAGEMENT PRACTICES AND ADAPTATION STRATEGIES

Seed management practice

The present study revealed that local seed sources are important for maintaining and managing crop diversity in their farm. A multiple responses on managing the seeds for next season have been recorded during the survey. Self-saved seed (reported by 98.5% HHs) are the first source of planting materials and has the highest contribution to all of the major farm components; cereals, pulses, vegetables, fruits, and spices and sharing between and among the neighbors contributed the second most important. Interestingly, their relatives play significant role in management of crop diversity by contributing third place as reported by 55 percent of the respondents (see Figure 4). Self-saved seeds are the primary source of seed management in other parts of Nepal where community people stored seeds for the next cultivation (Rijal et al. 1998; Poudel et al. 2015). But such a study is lacking focusing on local crop species particularly in far-western hilly districts and Kailash Sacred Landscape area. The proper management of traditional varieties depends on the continued functioning of informal seed exchange networks as it accounts for large proportion of seed exchange in various parts particularly in rural areas (Hodgkin et al. 2006).Therefore, local seed management through informal seed system needs to be strengthened to manage crop diversity in farmer's field.

In the other hand, many local crop varieties are lost and many more are threatened in the farmer's field. The present study reported that a number of crops like Marshe (locally called chuwa) (*Amaranthus* L.), finger millet (*Eleusine coracana* L.), proso millet (*Panicum miliaceum* L.), and foxtail millet (*Setaria italica* (L.) Beauvois) are already in threatened condition in the study area. Therefore, such threatened crop species could be placed for ex-situ conservation where the formal institution could further improve the crop quality and resend them back to the community.

Furthermore, product diversification on these crops can enhance the conservation of these crop varieties on long run. Therefore, policy makers, researchers and other relevant organizations should initiate measures towards ex-situ conservation for threatened local crop varieties.

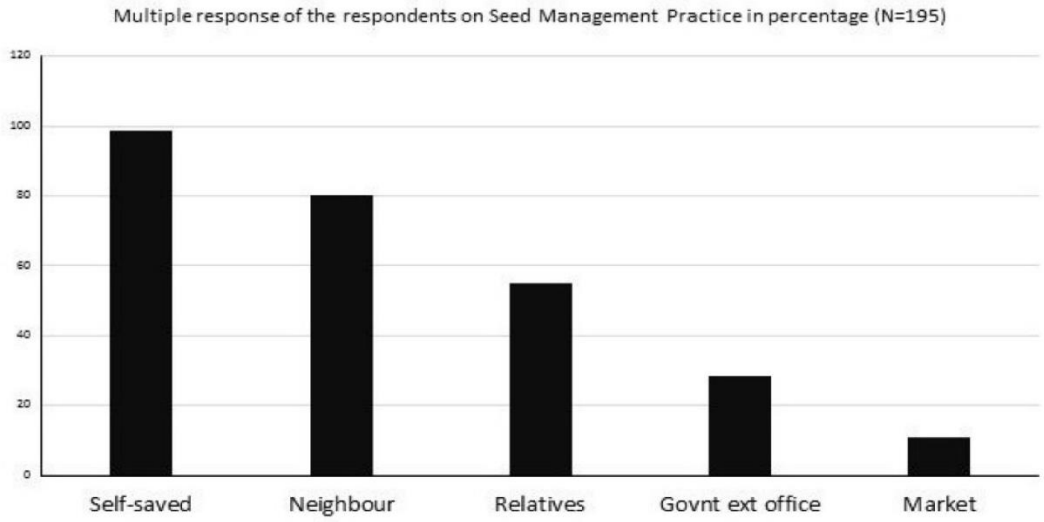

Figure 4: People's response on seed management practice

Women's role on seed selection and management

Once we knew majority of the households keep their own grown seed for the next cultivation, we asked the respondents who manages the seeds most in their household. About 82 percent of the respondents mentioned that the management of local crop diversity is one of the key responsibilities of women because they are good in seed selection, seed storage and seed supply/exchange. Since women are the ones who do the actual seed selection, they select according to their preference and household needs. In this regard we asked women to exchange their views and information regarding seed management practice. They have the information on how seed is selected and stored, and what varieties and seed qualities others have in the village. In this way, they serve as the manager because they know who has what seeds and their quality and are the member of informal seed network at village. Farmer's seed networks play an essential role to help ensure access to varieties at risk and enable and incentivize on-farm conservation of crops diversity. They create the linkage between farmers and provide channels for mutual assistance (Sperling and Mcguire 2010). Research shows that the communities with weak social networks tend to be more vulnerable to adverse conditions because of constrained access to locally adapted seeds compared to those communities with strong social seed networks (Poudel et al. 2005). So, this seed networks needs to be studied well and their importance in conservation of local crop diversity should be valued. Informal/social seed systems almost entirely provide the supply of seeds of traditional varieties (Poudel et al. 2015).

Farmer's initiatives and local adaptation strategies to manage crop diversity

Our current study indicates that farmers have initiated various local level adaptation practices to minimize the impacts of both climatic and non-climatic changes. The findings suggest that about 87 percent of the surveyed households reported that they practice intercropping i.e. planting two or more crops together such as growing maize and beans together. Interestingly, about 75 percent of

the respondents mentioned that they carefully do the right crop and seed selection to avoid adverse conditions (Table 4). For instance, local people in Khar cultivate *Dautkhane* (local wheat variety having drought resistant) when they thought this year dry period likely to be longer. Other on farm adaptation practices (see Table 4) are changes in planting time and location, soil management, diversifying livelihoods options like depends more on off-farm work. Adopting off-farm works such as mat making, wage labor helped to earn additional income for the family to cope with such changes.

Similar study carried out by Ajani et al. (2013); Unruh (2004); Bellon (2008) also shows that diversification of crop varieties is one of the potential adaptation options to reduce vulnerability to climatic and non-climatic variability and changes. It is also common to other parts of Nepal where farmers increase the crop diversity to reduce such adverse effects (Poudel et al. 2015; Rana et al. 2007). Policy incentives to cultivate the new modern variety sometimes forced farmers to grow only a single variety which is also contributing in reducing crop diversity on farmer's field (Di Falco and Perrings 2005). In these contexts, it is better to encourage farmers to use more local crop varieties to grow diverse crops in their farm rather than providing incentives and reward to those farmers who grow only one or two crops in commercial scale.

Looking at the various strategies and practices that the farmers are practicing indicates that farmers in the study sites are very cautious about the changes and are constantly looking for the ways to adapt such changes. However, the study also documented that they have limited access of information and materials of the crop varieties grown widely. Furthermore, the scientific information about the weather and climate forecasting are rarely available. Therefore, there is a need of balanced approach where farmer's local knowledge and practices as well as scientific knowledge and practices blend together for the best output.

Table 4: Local level initiatives adopted by farmers to minimize the impacts of changes (anthropogenic and climatic)

Local level initiatives adopted to minimize impacts of anthropogenic and climate changes	Yes	No
Planted different crops together	86.8*	13.2
Changes in cropping systems	34.1	65.9
Changed planting locations of crops	67.6*	32.4
Changed planting time	50	50
Kept more livestock, instead of depending on crops	60.4*	39.6
Planted trees	52.2*	47.8
Done more water harvesting	6.6	93.4
Done more off-farm work, instead of farming	73.6*	26.4
Soil management	69.8*	30.2

Note: * represents the percentage above 50.

CONCLUSION

The present study focuses on the local crop diversity and its management by the farmers in Kailash Sacred Landscape area of far-western Nepal. The crop diversity in farmer's field is high with higher varietal diversity in major crops like maize, paddy, wheat, finger millet and barley. These diversity could be considered as potential units for maintaining species as well as varietal diversity and conserving the important plant genetic resources for food, nutritional as well as cultural security. However, a number of varieties as well as the species are being lost and threatened due to anthropogenic and climate drivers of change. Despite genetic erosion happening, local people are initiating a number of adaptation strategies and practices to minimize the loss. Self-conserved seed contributed as the major source of planting material followed by exchange of seeds and information with neighbors.

Awareness raising among and between the farmers are necessary. Local level crop diversity fair and other cultural fair enhance farmers' understanding about the status as well as the importance of their own varieties maintained by them. It also provides information about the seed source within the community. So, such events should be organized in the accessible areas where farmers can participate and benefit from cross-exchange.

Strengthening the local seed supply system of the local crop varieties is very important for the on-farm management of crop diversity in the village. It is also important to constantly monitor the changes of the crop varietal diversity. This is important particularly to those threatened crop species with its associated reasons. Informal as well as the formal network should be established between community people and ex-situ conservation. The species that are threatened could be placed in a national gene bank under the National Agriculture Research Council.

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Food from farm and forest, a case study from Kailash Sacred Landscape

Kamal Prasad Aryal, Ram Prasad Chaudhary and Sushmita Poudel

People living in the Kailash Sacred Landscape in Far Western Nepal depend significantly on crop diversity, both cultivated and wild, for food, nutrition and income. Nearly 85 percent of households also rely exclusively on wild and non-cultivated edible plants for one or more months of the year. Conservation of this unique agroecological system is crucial for the future of this food-insecure region.

The Kailash Sacred Landscape is a transboundary area shared by Nepal, India and the People's Republic of China. It is home to several ethnic and linguistic groups and is rich in biodiversity, particularly agricultural crop and wild genetic diversity. However, documentation is poor regarding these resources' availability, use, contribution to livelihoods and household food security, and the engagement of household members in conserving and managing diversity.

Many districts in the mid-hills and mountains of Far Western Nepal are in food deficit and score the lowest on the Human Development Index for regions within Nepal. In a context characterized by high poverty rates and chronic food and livelihood insecurity, there is a high level of outmigration, mostly of men.

A study undertaken by ICIMOD in Khar Village Development Committee, Darchula district, investigated the diversity of cultivated and wild crops, their use, their role in and implications for livelihoods, and local perceptions on conservation and management differentiated by gender.

Women at a stall during the crop diversity fair in Khar
©ICIMOD/Pradyumna Rana

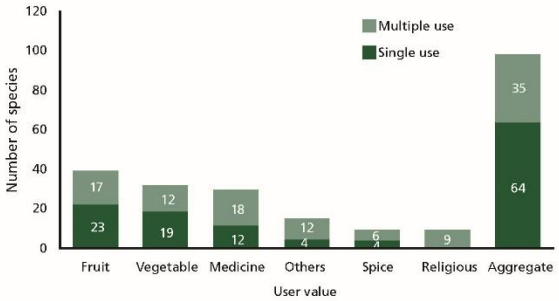

Figure 8: Use of wild and non-cultivated edible plants
Source: Case study authors' own elaboration, 2020.

The study documented 88 crops (vegetables, spices, fruits, beans and pulses, cereals and pseudo cereals) and 235 varieties from 37 botanical families. The highest varietal diversity within major crops was recorded in maize, followed by paddy, wheat and beans. However, only 5 percent of households were able to meet their annual food requirement from their own production; the remainder were only food self-sufficient for 10 months or less. Households adopted multiple coping strategies during the food deficit months, including seasonal migration for work to the district headquarters and to parts of India, sale of agricultural and livestock products, collection and sale of *yartsa gunbu*, the caterpillar fungus (*Ophiocordyceps sinensis*), and collection of wild and non-cultivated edible plants (WNEPs). Besides cultivated crops, the study recorded 101 WNEPs belonging to 60 botanical families. Importantly, nearly 85 percent of households depend exclusively on WNEPs for at least one month of the year.

However, there is erosion and loss of this crop and wild diversity due to the introduction of hybrids, outmigration, the easy availability of other foods, and the seasonal movement of entire villages in search of *yartsa gunbu*.

Wild edibles, crucial during times of food shortage, have the potential to become important alternatives to the usual vegetable crops cultivated by farmers. The study also showed that farmers prioritize those species that provide multiple benefits, such as food and nutrition security, as well as household-level health care. It is

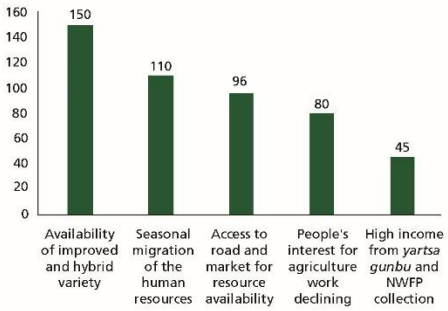

Figure 9: Reasons for the decline of traditional crops
Source: Case study authors' own elaboration, 2020.

Discussing rice variety traits with a farmer in Khar
©ICIMOD/Pradyumna Rana

important that government interventions are designed to conserve this diversity. That could mean developing conservation and restoration plans with an explicit focus on species crucial to household nutrition and health. Domestication in home gardens could be a good starting point for some species, as they offer increased availability of water, a mostly organic-based production system, easier protection against predators and close monitoring by household members.

Changing food habits, taste and lifestyles and the availability of ready-made foods in the local market are contributing to the growing neglect of traditional foods in rural diets. Integrated research and development, including product diversification and marketing of these crops, is needed to promote the conservation of diversity and ecosystems, and secure better returns for producers.

Local people must be involved in the conservation and management of crop diversity, as they are both the guardians and users of the resources and have the greatest knowledge of them. The study highlighted the role of women as seed keepers and the importance of conserving this diversity. It is essential that government and civil society interventions aimed at improving the food security of the Far Western Region place women and their concerns at the centre of research and extension.

When I was growing up, we used to cultivate a diversity of traditional crops like finger millet, amaranth, foxtail millet, proso millet, barley and buckwheat. Everyone loved finger millet, buckwheat and maize bread back then. Our own production was sufficient for our family, and we didn't depend upon the market for our food.

People have stopped planting traditional local varieties such as millets, amaranth and barley. It is even hard to find the seeds of these varieties now. Eating rice is considered modern, while eating millet is considered a sign of backwardness. Programmes such as these will help us conserve traditional seeds. Perhaps my grandchildren will be able to utilize these crops in the future.

Jaymati Badal,
77, a resident of Khar, Darchula, belongs to a women's group that collected seeds, fruits and other plants

study was mainly concentrated in and around the vulture restaurant. Altogether 154 individuals of 5 species of vultures were recorded in the study area. White rumped vultures were the most abundant (72) followed by Himalayan griffon vulture (68), Egyptian vulture (13), Red headed vulture (3) and slender billed vulture (3). As much as 22 nests were recorded nearby the vulture restaurant. Among these nests, 21 nests were belonged to white rumped vulture and one nest was belonged to Egyptian vulture. However, there was no record of nests of vultures from other parts of the study area. These vultures highly preferred the riverine mixed and *Bombax ceiba* forest. The study further revealed that there was a great role of vulture restaurant in providing the safe diclofenac free carcass for vultures in regular basis. Likewise, local people and conservation experts working in the area said that the numbers and species diversity of vultures have been increased after the establishment of the restaurant.

O-WB-2-455

Crop Diversity Maintained in farmers field: Case from Api-Nampa conservation area of far western Nepal

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This Paper examines the crop species diversity and their status in farmers' field of Api-Nampa Conservation Area of Kailash Sacred Landscape area of Far-western region of Nepal. Diversity fair of local crop species, semi-structured interviews, direct observations and Focus Group Discussions were employed to collect data. Overall crop species diversity is measured from the species inventories. A total of 190 different crop species were recorded through diversity fair however; the varietal diversity for *Dolichos lablab* was reported highest among other species. This study suggests diversity are purposively maintained by the local people for diverse product harvesting and are the major contributor for household level food and nutritional security. Farmers reported that 4 crop species have been lost for last 10 years and 5 species are in the verge of extinction from the area. Land use changes, out-migration, introduction of new varieties, and poor agricultural production system were the major causes associated to this trend. Despite of species erosion, self-saved seed and informal seed supply system among the villagers helped to maintain the crop species diversity on farm.

O-WB-2-459

Population Status, Occupancy and Distribution Modelling of Cheer Pheasant (*Catreus wallichii*) in Dhorpatan Hunting Reserve, Nepal

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The Cheer pheasant (*Catreus wallichii*) is a globally threatened species listed as vulnerable in Word Conservation Union (IUCN) Red list and legally protected by the Government of Nepal. The conservation of this species is of great importance worldwide and regular monitoring of its status and distribution are necessary. This study was done to assess the population status, estimate occupancy patterns in Dhorpatan Hunting Reserve, as well as to identify potentially suitable habitat of Cheer in Nepal. The study was conducted during the breeding season i.e. May and October, 2013. Dawn call count method was used to obtain the population status and detection and the non-detection survey was done to estimate the occupancy of Cheer. The occupancy data was analyzed in the program PRESENCE. Habitat suitability was predicted throughout Nepal using a MaxEnt modeling approach, combining presence-only data. Population data revealed that Dhorpatan valley still supports the significant population of

Nepal Academy of Science and Technology

CERTIFICATE

Awarded to

Kamal Prasad Aryal.

for active participation/paper presentation/poster presentation

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KUNMING INSTITUTE OF BOTANY
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To

Kamal Prasad Aryal
ICIMOD, Kathmandu, Nepal
Date: 22 September, 2018

Subject: Appreciation letter for your contribution in international workshop on plant diversity and conservation

Dear Mr. Aryal,

On behalf of the organizing committee of the "International workshop on plant diversity and conservation of the belt and road countries" which was held during 9-22 September 2018 in Kunming, Yunnan ,China, we would like to thank you for your active participation and presentation on your research experiences from Kailash Sacred Landscape, Nepal on crop diversity management. Sharing your rich knowledge and experiences on agrobiodiversity management from the region helped all of us to gain deeper understanding about the topics.

Your participation to our invitation was a great opportunity for us for achieving the workshop results

Thank you for your invaluable contribution and looking forward to welcoming you again

With regards

Yang Xf.

Prof. Yang Xuefei
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