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Full Length Research Paper

Conservation status assessment of native vascular flora of Kalam Valley, Swat District, Northern Pakistan

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In the present study, conservation status of important vascular flora found in Kalam valley was assessed. Kalam Valley represents the extreme northern part of Swat District in KPK Province of Pakistan. The valley contains some of the precious medicinal plants. 245 plant species which were assessed for conservation studies revealed that 10.20% (25 species) were found to be endangered, 28.16% (69 species) appeared to be vulnerable. Similarly, 50.6% (124 species) were rare, 8.16% (20 species) were infrequent and 2.9% (7 species) were recognized as dominant. It was concluded that Kalam Valley inhabits most important plants majority of which are used in medicines; but due to anthropogenic activities including unplanned tourism, deforestation, uprooting of medicinal plants and over grazing, majority of these plant species are rapidly heading towards regional extinction in the near future. To maintain the biodiversity of the study area, some *in-situ* and *ex-situ* conservation measures in the form of protected areas, sustainable grazing, supplying alternative energy sources to the native population, seeds preservation and growing precious medicinal plant species in nurseries established under the supervision of forest department are urgently needed.

Key words: Preserving, vascular flora, regional extinction.

INTRODUCTION

Plant conservation means controlling plants in all available habitats, and their resources and collecting relevant data on social, ecological and economic aspects useful for developing an effective policy relating to plant management (Pereira et al., 2013). The support of local population is always considered as imperative for any conservation strategy of plant species because local people are linked to plant species through various means (Pimm et al., 2014). As evident from the studies of several researchers that supply of ecosystem services is

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directly dependent on maintaining diversity. However, in spite of many international efforts to reduce biodiversity losses, it seems there is no reduction in loss to biodiversity (Butchart et al., 2010). Although the concept of protected areas in different parts of the world aims to reduce losses to biodiversity, methods like these are limited to low coverage of species and not sufficient to protect biodiversity at optimum level (Pimm et al., 2014); for instance, Selig et al. (2014) recently revealed that many of the areas where conservation measures are deemed necessary are still outside the human conservation umbrella especially in the African and South American continents. Overall, overexploitation, habitat degradation, attack of invasive species and pollution are the major threats which reduce biodiversity and the combined effect of these factors will favor decline in biodiversity towards some tapering point (Barnosky et al., 2012). Given the importance of biodiversity in global ecosystem, the understanding of threats to biodiversity is more imperative today than ever before (Berteaux et al., 2010). Due to highly diverse geographic, climatic and topographic conditions, the land of Pakistan has rich floral diversity consisting of 6,000 species of vascular plants (Ali, 2008); of these, the number of pteridophytes is 128 species, gymnosperms are 23 species, monocots are 1140 species whereas dicots are 4492 species. The total area of Pakistan under forest is 4% in which 5% are protected forests. Pakistan has a variety of forests which include tropical dry deciduous forests, tropical thorn forests, sub-tropical evergreen broad leaved forests, sub-tropical thorn forests, littoral swamp forests, Himalayan moist temperate forests, Himalayan dry temperate forests, sub alpine belt of forest and alpine peaks. Out of these the coniferous forests form 4% of the total forest vegetation and as significant source of timber and fuelwood for the native population. The manmade forests found in Pakistan include farmland trees, irrigated plantation, linear plantation and roadside plantation. 90% of the total wood used in Pakistan for fuel wood purposes come from these forests (Ilyas, 2006). Plant conservation studies in Pakistan have got much attention during the past few decades, but so far, only marginal piece of land in Pakistan has been evaluated according to IUCN criteria for conservation purposes. Some of the most relevant studies focusing on plant conservation include Ali and Alam (2006) who studied native endemic plant found in Gilgit Baltistan for conservation purposes and revealed that 3 important species including *Astragalus gilgitensis* Ali*, Asperula oppositifolia* Regel and Schmalh. and *Astragalus clarkeanus* Ali are critically endangered; similarly, *Rhodiola saxifragoides* (Fröd.) H. Ohba and *Aconitum violaceum* Jacquem. ex Stapf were found to be vulnerable according to IUCN category and criteria 2001. Some other studies based on plant conservation in the vicinity of the present study area include Shabbir and Bajwa (2007), Haq (2011), Hazrat and Wahab (2011), Shabeer and Jabeen (2012), Khan et al. (2013), Ahmad and Habib (2014), Qureshi et al. (2014), Hamayun et al. (2006), Ali et al. (2011), Sher et al. (2012) and Ullah and Rashid (2014). So far, no research study related to conservation is available on the virgin Kalam Valley which is the focus of the present research work.

The present study was conducted in Kalam Valley which includes prominent villages like Proper Kalam village, Ashoran, Boyon, Jalbanr, Matiltan, Gorkin, Shahu, Ushu and stretching up to the northern parts of Paloga. Kalam is located at 100 km north of Mingora city and is one of the major spots for tourists especially during warmer season. At Kalam, Ushu River and Gabral Swat River join together which give rise to River Swat. On the west of Kalam Valley lies Gabral which is bordered by Upper Dir District whereas the areas north of Kalam Village up to Paloga represent catchment areas of Ushu River which collectively constitute Kalam Valley bordered by Mankial and Behrain on the South, Indus Kohistan on the west and Chitral and Ghizar districts on the north. Geographically, the study area is characterized by 35° 22 to 35° 53 North latitudes. The longitudinal range of the study area is 72° 28 to 72° 49 East as illustrated from the area map (Figures 1, 2, 3, 4 and 5) (Shah, 1977; Ahmad, 1969).

Due to differences in geographic, climatic and topographic factors, Pakistan is a land of rich floral diversity stretching up to a total of 6000 plant species. According to a survey conducted by IUCN 2009, 19 taxa from flora of Pakistan have been recorded in the red data list. According to this report, *Asparagus gharoensis* Blatt. has become extinct, and *Scaevola plumieri* (L.) Vahl and *Scaevola taccada* (Gaertn.) Roxb. have been categorized as regionally extinct; *Allium gilgiticum* F.T.Wang & Tang, *Arabidopsis brevicaulis* (Jafri) Jafri, *Elymus russellii* (Melderis) Cope, *Christolea mirabilis* (Pamp.) Jafri, *Plantago baltistanica* H.Hartmann, *Saxifraga duthiei* Gand and *Consolida schlagintweitii* (Huth) Munz are presumably extinct. *Androsace russellii* Y.J.Nasir, *A. oppositifolia* Reg. & Schmalh. subsp. *baltistanica* Nazim., *Haplophyllum gilesii* (Hemsl.) C.C.Towns, *A. clarkeanus* Ali, *Tanacetum baltistanicum* Podlech and *Berberis pseudumbellata* Parker subsp. *gilgitica* Jafri come under the category of critically endangered, similarly *A. violaceum* Jacquem. ex Stapf and *Rhodiola saxifragoides* (Fröd.) H. Ohba have been recorded as vulnerable (Alam and Ali, 2010). But, these data appear to be deficient and underestimated. According to another report based on the 19 taxa from Pakistan included in the IUCN Red List, 2 species of plant are counted as vulnerable, 13 species are least concern (lower risks), 1 species comes under the category of near threatened and 3 species fall in data deficient category (IUCN, 2009). Contrary to this data (IUCN 2009), the findings of Ali and Qaiser (2010) reveal that a total of 21 species of flowering plants come under the threatened category in Pakistan. For accurate determination of the conservation status of plant species, it is imperative to have a solid

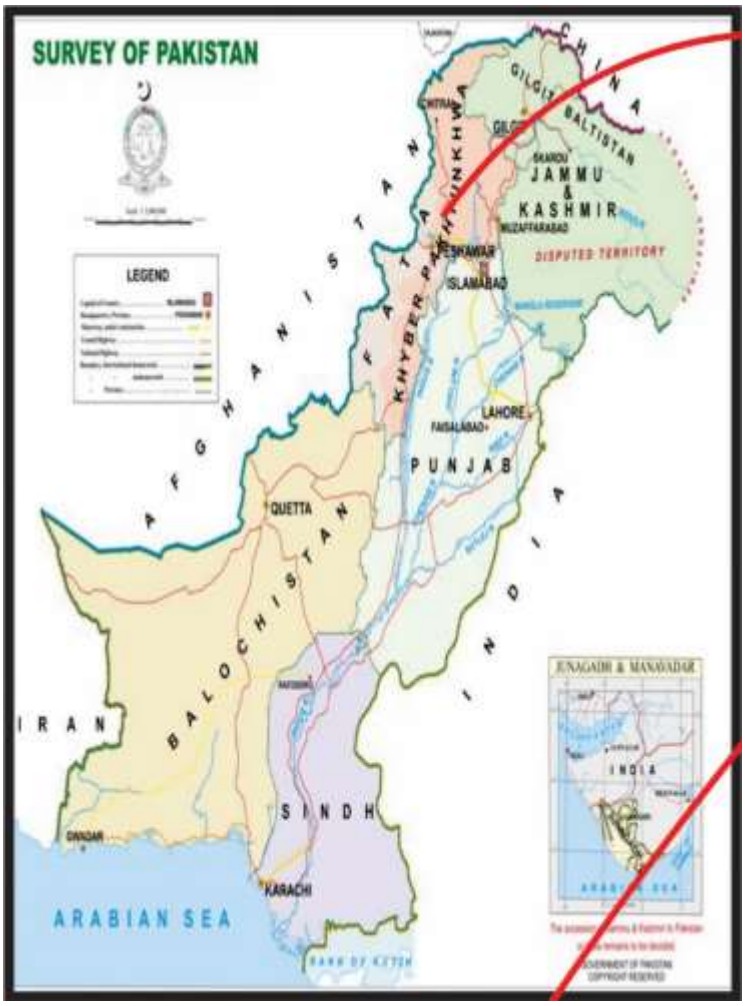

Figure 1. Map of Pakistan.
Source: Oxford School atlas for Pakistan (Ahmad 1969).

data on fluctuations in the population size, area of occupation and the extinct of occurrence of a species over long period of time. Unfortunately, such studies have not been compiled in Pakistan so far; resultantly, data on conservation status of plants in Pakistan is still incomplete (Alam and Ali, 2009).

According to biodiversity action plan of Government of Pakistan (1997), the scrub, planted trees, forests and farmlands constitute up to 4.2 million hectares (4.8%) of the total land of Pakistan. The coniferous forests growing in Pakistan forms a canopy cover of less than 50%. High coverage forests occupy 400,000 ha of the total land (GoP and IUCN, 2000). The reduction rate of woody biomass in Pakistan per year is 4 to 6% which is due to enormously increasing population associated with no alternative source of energy, hence there is a growing fear that the woody biomass may not last longer than 10 years. The most serious threat to conservation of plants is loss of habitat due to huge deforestation which is giving birth to some devastating factors including climate change, soil erosion and emergence of alien and invasive species in majority of the degraded habitats which make conditions unfavorable for the growth of indigenous plants. It has been seen that the population living in the vicinity of big plantations is suffering from abject poverty with no any alternative energy source other than wood which results in huge and unplanned cutting of forests; therefore, no effective conservation strategy can be applied in such spots especially colder parts of the world. Furthermore, the population found in these areas is heavily dependent on agriculture so the logical end is clearing land (terracing) for growing crops.

MATERIALS AND METHODS

The present research project was held for 3 years (April 2012 to October 2014). The whole area of Kalam Valley is 1200 km^2 comprising prominent villages of Kalam old village, Jalbanr,

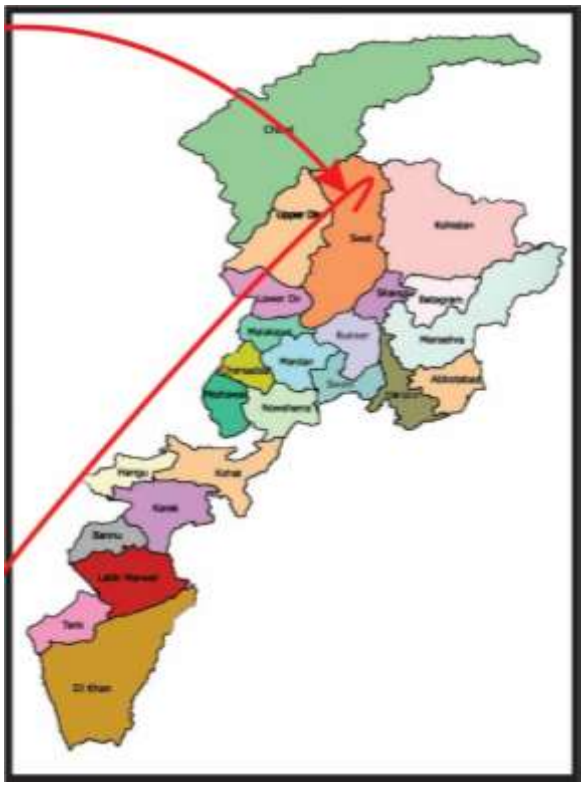

Figure 2. Map of Khyber Pakhtunkhwa.
Source: Oxford School atlas for Pakistan (Ahmad 1969).

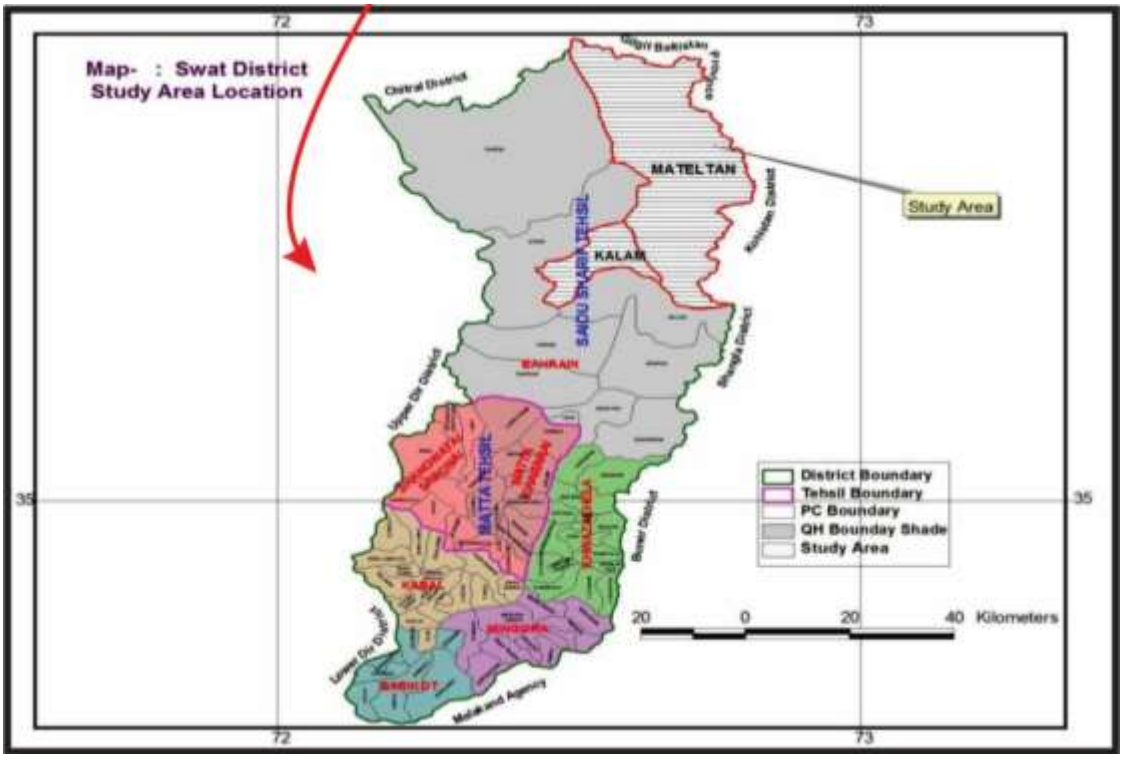

Figure 3. Map of district Swat with study area demarcated.
Source: Oxford School atlas for Pakistan (Ahmad 1969).

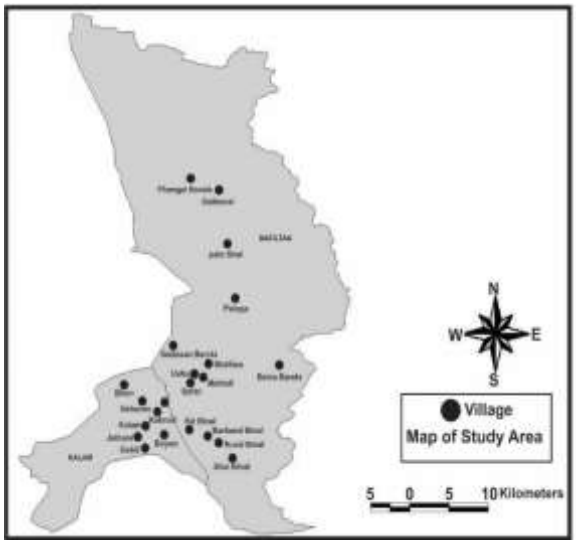

Figure 4. Prominent localities of the study area.
Source: Pakistan Geological Survey (Shah 1977).

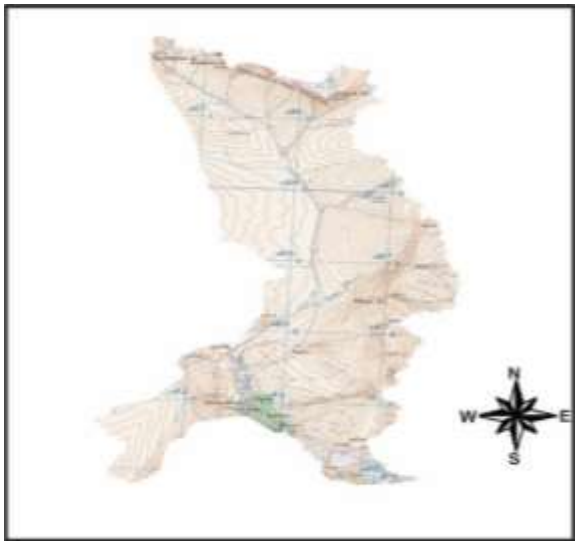

Figure 5. Contour map of the study area demarcating altitudinal belts along geographic coordinates.
Source: Pakistan Geological Survey (Shah 1977).

Ashuran, Qaroonji, Boyon, Kargilo, Gorkin, Ushu, Paleer, Paloga, Matiltan, Mahodand up to Denshai in the north. The whole study area was divided into 7 transact lines with Ushu River as baseline; distance between transacts was 8 km from south to north (which formed a total of 14 transacts, 7 transacts each on the east and west sides of the baseline) (Figure 6). Each transact line was divided into study stations mainly on the basis of altitude with a difference of 300 m elevation gradient. Vegetation sampling based on calculation of density, frequency, cover, basal area and dominance of species was done through quadrat method. All the study sites were frequently visited for exploration of important ethnobotanical plants, especially precious medicinal plants. Plant specimens were collected from all habitats in all the study sites and field data comprising habit, lifeform, morphological status, frequency of occurrence, geographical coordinates and ethnobotanical value were recorded on the spot. The collected plant specimens were dried, preserved and correctly identified from Flora of Pakistan (Stewart, 1972; Nasir and Ali, 1971-1995; Ali and Qaiser, 1995-2012). The voucher specimens were deposited in the Herbarium Botany Department, Hazara University Mansehra. A complete know how about the growth, availability, occurrence, behavior, mode of collection, part used and distribution pattern of these important plant species was obtained by using methods of observation, distribution of questionnaires and interviews with knowledgeable persons including key informants and household dwellers. A total of 196 questionnaires containing data about availability of plant

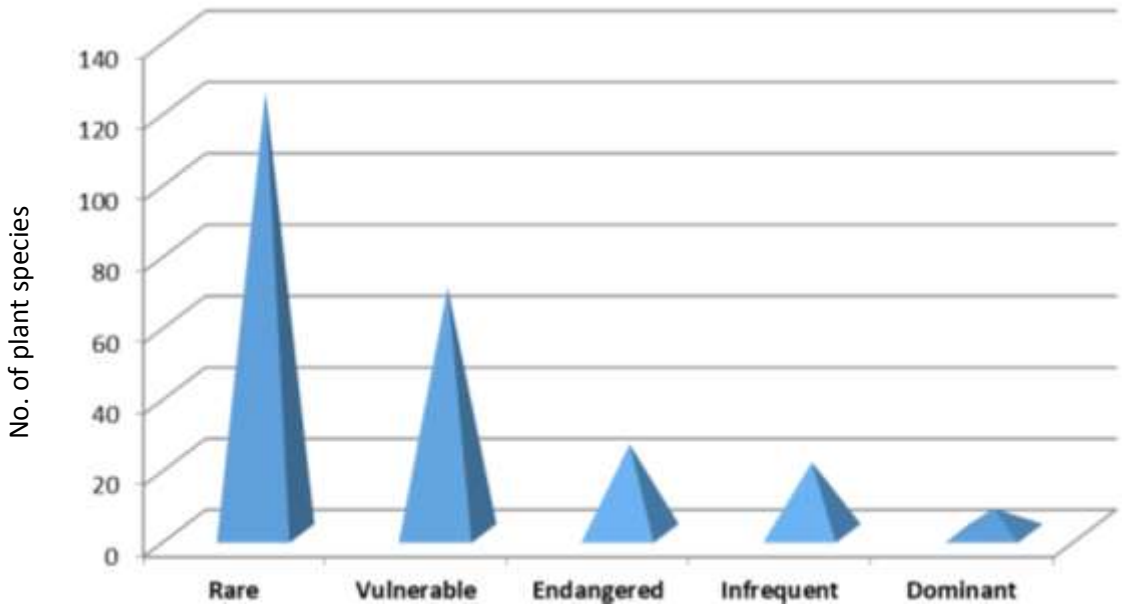

Figure 6. Conservation status of medicinally important plants.

Table 1. Mean of Preference ranking value according to Martin (1995) of the presumed scarce plant species in the study area. Key informants (coded A to J).

List of plant species	A	B	C	D	E	F	G	H	I	J	Total score	Ranking
Viola biflora L.	5	4	6	6	5	5	6	6	5	5	53	1st
Skimmia laureola Franch.	6	5	5	4	6	4	5	4	6	6	51	2nd
Rheum australe D. Don	4	6	4	5	4	3	3	3	4	1	37	3rd
Trillium govanianum Wall. ex D.Don	1	1	3	3	1	6	2	5	3	2	27	4th
Viola canescens f. *glabrescens* W. Becker	3	3	2	2	2	2	1	2	2	4	23	5th
Hyoscyamus niger L.	2	2	1	1	3	1	4	1	1	3	19	6th

species, mode of harvest, part used, fuelwood consumption, grazing pressure and market value of different plant species were served among the local masses familiar with these plants. Out of these, 184 questionnaires were returned wherein 9 were incomplete and 175 contained complete information. For accurate measurement of different parameters related to plant conservation, reference ranking technique used by Martin (1995) was used as an additional technique so that the data on availability of plant specimens are ascertained.

Martin reference technique is a statistical method in which single plant specimen is given to 10 different informants and then they are asked to give marks 0 to 10 depending upon the availability of plant species. The plant species considered to be the rarest is given the highest marks; availability status is then calculated by summation of marks given by all informants relating to a particular plant species (Table 1). For easy application under local conditions, the 9 categories used by IUCN were reduced into 5 categories, that is, endangered, rare, vulnerable, infrequent and dominant. The conservation status of commercially most important species was determined by using IUCN criteria 2001 version 3.1 (with minor modifications to apply on local basis) (Table 2). After calculating the total score in respect of each plant species, the plant species were categorized as endangered, rare, vulnerable, infrequent and lastly dominant species.

RESULTS AND DISCUSSION

The present study assessed the conservation status of a total of 245 important species of plants. The IUCN (2001) criteria and category scheme was reduced to 5 categories (Table 3) so that the scheme may be effectively applied according to local conditions. As per the enumerated results, 50.61% (124 species) were classified as rare species, 28.16% (69 species) as vulnerable species, 10.20% (25 species) were declared as endangered plant species, 8.16% (20 species) were counted as infrequent and 2.86% (7 species) appeared to be dominant species (Figure 7). According to Stewart (1967), the vascular flora of district swat contains 1550 species. Shinwari et al. (2003) made an estimation of flora of Swat; according to him, 6.3% of the flora is threatened, 1.6% comprise rare species. The same author further revealed that there is high anthropogenic pressure in Swat District as compared to the adjoining districts of Chitral and Buner. The same study further

Table 2. Conservation Status Assessment of Plant Species using IUCN (2001) categories and criteria version 3.1.

Division/Family/Species	Availability class	Collection status	Part used	Growth behavior	Total score	Conservation status
1. Availability	**2. Collection**					
0 = Uncommon or very rare	0 = More than 1000 kg/yr					
1 = Less common or rare	1 = Consumed from 500-1000 KG/year					
2 = Occasional	2 = Consumed from 300-500 KG/year					
3 = Abundant	3 = Consumed from 100-200 KG/year					
4 = Very abundant	4 = Consumed less than 100 KG/year					
3. Growth	**4. Part used**					
0 = Regrowth in more than 3 years	0 = Root/Whole plant					
1 = Regrowth within 3 years	1 = Bark					
2 = Regrowth within 2 years	2 = Seeds, Fruits					
3 = Regrowth within 1 year	3 = Flowers					
4 = Regrowth in a season	4 = Leaves/Gum/Latex					
5. Total score						
The total score is obtained by summation of ranks given to a plant species in all the four categories comprising availability, collection, re-growth and part used which indicates the conservation status as given below:						
1. 0 - 4 Endangered						
2. 5 - 8 Vulnerable						
3. 9 - 12 Rare						
4. 13 - 14 Infrequent						
5. 15 - 16 Dominant						

disclosed that there are 12 endemic plant species to Pakistan including 4 species which are endemic to Swat District. These data reflect that 0.1% of the flora of Swat is endemic exclusively to Pakistan. 80% of the total endemic plant species of Pakistan are confined to the north western hilly belt. According to Myers et al. (2000), nearly 88% of the natural vegetation has been lost from the global 25 hotspots having rich species diversity. The findings of Singh and Khurana (2002) identified that the present rate of species extinction is 1000 to 10,000 times more than the prehistoric ages. The study conducted by Burns et al. (2009) in Alaska culminated with result that nearly 8 species found in Alaska are critically endangered at global level. In another research endeavor, Turis et al. (2014) analyzed the flora of main land Slovakia which revealed 46 species as regionally extinct, 461 plant species in threatened category, 141 plant species in endangered category, 209 plant species nearly threatened, 103 plant species in least concern category and 6 plant species were identified to be data deficient. Ali and Alam (2006) explored Gilgit areas of northern Pakistan and identified *A. clarkeanus* Ali, *A. oppositifolia* Reg. & Schmalh. subsp. *baltistanica* Nazim. and *A. gilgitensis* Ali to be critically endangered; similarly, *A. violaceum* Jacquem. *ex* Stapf *var. weileri* (Gilli) H. Riedl and *Rhodiola saxifragoides* (Fröd.) H. Ohba were identified as vulnerable species in the light of IUCN category and criteria (2001). In close association to the present study, Haq (2011) enumerated 37 plant species in the threatened category during his exploration of Nandiar Khwar District Batagram. In another study, Shah and Hussain (2012) assessed 107

Table 3. Conservation status of commercially important indigenous plants of Kalam valley.

S/N	Plant species	Family	Life form	Availability	Collection	Growth	Part Used	Total Score	Calculated Conservation Status
1	*Abies pindrow* (Royle ex D.Don) Royle	Pinaceae	P	1	0	0	1	2	EN
2	*Achillea millefolium* L.	Asteraceae	P	3	4	2	0	9	R
3	*Achyranthes aspera* L.	Amaranthaceae	P	3	2	2	0	7	VU
4	*Aconitum heterophyllum* Wall. ex Royle	Ranunculaceae	P	1	0	3	0	4	EN
5	*Actaea spicata* L.	Ranunculaceae	P	1	4	3	0	8	VU
6	*Adiantum capillus-veneris* L.	Pteridaceae	P	3	3	3	0	9	R
7	*Aegopodium alpestre* Ledeb.	Apiaceae	P	2	4	4	4	14	IF
8	*Aegopodium burttii* Nasir	Apiaceae	A	2	4	3	0	9	R
9	*Aegopodium podagraria* L.	Apiaceae	P	2	4	3	0	9	R
10	*Ailanthus altissima* (Mill.) Swingle	Simaroubaceae	P	4	4	1	1	10	R
11	*Ajuga bracteosa* Wall.ex Benth.	Lamiaceae	P	2	1	4	0	7	VU
12	*Ajuga parviflora* Benth.	Juglandaceae	A	1	2	4	0	7	VU
13	*Alliaria petiolata* (M.Bieb.) Cavara and Grande	Brassicaceae	B	3	4	3	0	10	R
14	*Allium humile* Kunth.	Amaryllidaceae	B	1	2	3	0	6	VU
15	*Allium stracheyi* Baker	Amaryllidaceae	P	2	4	3	0	9	R
16	*Allium griffithianum* Boiss.	Amaryllidaceae	B	2	4	3	0	9	R
17	*Amaranthus caudatus* L.	Amaranthaceae	A	3	3	3	0	9	R
18	*Amaranthus viridis* L.	Amaranthaceae	A	3	3	3	0	9	R
19	*Anagallis arvensis* L.	Primulaceae	A	1	4	3	0	8	VU
20	*Anaphalis triplinervis* (Sims) Sims ex C.B.Clarke	Asteraceae	P	3	4	3	1	11	R
21	*Anthriscus nemorosa* (M. Bieb.) Spreng.	Apiaceae	P	2	4	3	1	10	R
22	*Artemisia persica* Boiss.	Asteraceae	P	3	2	3	4	12	R
23	*Artemisia vulgaris* L.	Asteraceae	P	2	2	3	3	10	R
24	*Artemisia indica* Willd.	Asteraceae	P	3	2	3	3	11	R
25	*Artemisia scoparia* Waldst. and Kitam.	Asteraceae	P	3	2	2	0	7	VU
26	*Atropa acuminata* Royle ex Lindl.	Solanaceae	P	1	1	2	0	4	EN
27	*Berberis calliobotrys* Bien. ex Koehne	Berberidaceae	P	3	3	2	2	10	R
28	*Berberis orthobotrys* Bien.ex Aitch.	Berberidaceae	P	2	3	2	2	9	R
29	*Berberis pseudumbellata* Parker.	Berberidaceae	P	2	3	1	2	8	VU
30	*Berberis vulgaris* L.	Berberidaceae	P	3	1	2	1	7	VU
31	*Berberis jaeschkeana* C.K.Schneid.	Berberidaceae	P	2	3	3	2	10	R
32	*Berberis lycium* Royle	Berberidaceae	P	3	0	2	0	5	VU
33	*Bergenia ciliata* (Haw.) Sternb.	Saxifragaceae	P	2	1	3	1	7	VU
34	*Bergenia stracheyi* (Hook.f. and Thomson) Engl.	Saxifragaceae	P	2	2	3	4	11	R
35	*Betula utilis* D.Don	Betulaceae	P	2	3	1	1	7	VU
36	*Bistorta amplexicaulis* (D. Don.) Green	Polygonaceae	P	2	1	3	4	10	R
37	*Brassica nigra* (L.) K. Koch	Brassicaceae	A	2	3	3	0	8	VU
38	*Buddleja crispa* Benth.	Scrophulariaceae	P	2	4	2	0	8	VU

Table 3. Contd.

39	*Buglossoides arvensis* (L.) I.M.Johnst.	Boraginaceae	A			2							4				3		0					9	R
40	*Bunium persicum* (Boiss.)Fedtsch.	Apiaceae	P			2			0								3				2			7	VU
41	*Bupleurum falcatum* L.	Apiaceae	P				3						4				3		0					10	R
42	*Bupleurum gilesii* H.Wolff	Apiaceae	P			2							4				3		0					9	R
43	*Buxus sempervirens* L.	Buxaceae	P		1						2				1					1				5	VU
44	*Caesalpinia decapetala* (Roth) Alston	Fabaceae	P				3						4			2				1				10	R
45	*Calendula arvensis* M.Bieb.	Asteraceae	A				3						4					4				3		14	IF
46	*Caltha alba* Camb.	Ranunculaceae	P			2					2						3		0					7	VU
47	*Campanula tenuissima* Dunn	Campanulaceae	P			2							4				3			1				10	R
48	*Cannabis sativa* L.	Cannabaceae	A				3					3					3		0					9	R
49	*Capsella bursa-pastoris* (L.) Medic.	Brassicaceae	A					4					4				3				2			13	IF
50	*Cedrus deodara* (Roxb. ex D. Don) G. Don	Pinaceae	P				3			1					1					1				6	VU
51	*Celosia argentea* L.	Amaranthaceae	A			2						3						4					4	13	IF
52	*Ceterach officinarum* Willd.	Aspleniaceae	P				3						4				3		0					10	R
53	*Chaerophyllum reflexum* Aitch.	Apiaceae	A				3						4					4			2			13	IF
54	*Chenopodium album* L.	Amaranthaceae	A			2						3						4	0					9	R
55	*Chenopodium foliosum* Asch.	Amaranthaceae	A				3					3						4				3		13	IF
56	*Cichorium intybus* L.	Asteraceae	P			2					2						3		0					7	VU
57	*Clematis grata* Wall.	Ranunculaceae	P			2							4					4		2				12	R
58	*Colchicum luteum* Baker	Colchicaceae	P	0					0								3			1				4	EN
59	*Convolvulus arvensis* L.	Convolvulaceae	P					4		1							3		0					8	VU
60	*Coriandrum sativum* L.	Apiaceae	A				3			1							3					3		10	R
61	*Corydalis govaniana* Wall.	Papaveraceae	P		1					1							3					3		8	VU
62	*Crataegus songarica* K. Koch	Rosaceae	P		1						2				1					1				5	VU
63	*Cuscuta reflexa* Roxb.	Convolvulaceae	P				3					3					3		0					9	R
64	*Cyperus rotundus* L.	Cyperaceae	P					4				3					3			1				11	R
65	*Cypripedium cordigerum* D.Don	Orchidaceae	P		1							3					3		0					7	VU
66	*Dactylorhiza hatagirea* (D.Don.) Soo.	Orchidaceae	P		1					1							3			1				6	VU
67	*Daphne mucronata* Royle	Thymelaeaceae	P			2					2						3					3		10	R
68	*Daphne papyracea* Wall. ex G. Don	Thymelaeaceae	P		1								4			2						3		10	R
69	*Datura stramonium* L.	Solanaceae	A			2					2						3				2			9	R
70	*Debregeasia saeneb* (Forssk.) Hepper and J.R.I.Wood	Urticaceae	P			2						3					3					3		11	R
71	*Delphinium denudatum* Wall. ex Hook. F. and Thomson	Ranunculaceae	P	0								3						4					4	11	R
72	*Descurainia sophia* (L.) Webb. ex Prantl	Brassicaceae	A					4			2						3					3		12	R
73	*Dicliptera bupleuroides* Nees.	Acanthaceae	P				3						4					4					4	15	DOM
74	*Dioscorea deltoidea* Wall. ex Griseb.	Dioscoreaceae	P			2				1							3			1				7	VU
75	*Diospyros lotus* L.	Ebenaceae	P			2				1						2					2			7	VU
76	*Dryopteris filix-mas* (L.) Schott	Dryopteridaceae	P			2					2						3		0					7	VU
77	*Dryopteris juxtaposita* Christ	Dryopteridaceae	P				3					3					3		0					9	R

Table 3. Contd.

78	*Duchesnea indica* (Jacks.) Focke	Rosaceae	P	2	4	3	2	11	R
79	*Dysphania botrys* (L.) Mosyakin and Clemants	Amaranthaceae	A	3	2	3	1	9	R
80	*Elaeagnus parvifolia* Wall. ex Royle	Elaeagnaceae	P	1	4	2	2	9	R
81	*Ephedra gerardiana* Wall.ex Stapf.	Ephedraceae	P	3	0	2	1	6	VU
82	*Epilobium hirsutum* L.	Onagraceae	P	2	4	3	0	9	R
83	*Epilobium laxum* Royle	Onagraceae	P	2	4	3	0	9	R
84	*Epilobium angustifolium* L.	Onagraceae	P	3	4	3	0	10	R
85	*Equisetum ramosissimum* subsp. *debile* (Roxb. ex Vaucher) Hauke	Equisetaceae	P	2	4	3	1	10	R
86	*Erigeron bonariensis* L.	Asteraceae	A	3	4	3	0	10	R
87	*Erigeron canadensis* L.	Asteraceae	A	3	4	4	4	15	DOM
88	*Euphorbia heterophylla* L.	Euphorbiaceae	A	3	4	3	0	10	R
89	*Euphorbia wallichii* Hook.f.	Euphorbiaceae	P	2	3	3	4	12	R
90	*Euphrasia himalayica* Wettst.	Orobanchaceae	A	2	3	3	3	11	R
91	*Ficus carica* L.	Moraceae	P	2	3	0	3	8	VU
92	*Foeniculum vulgare* Mill.	Apiaceae	B	3	1	3	2	9	R
93	*Fragaria vesca* L.	Rosaceae	P	2	4	3	2	11	R
94	*Fumaria indica* (Hausskn.) Pugsley	Papaveraceae	A	3	2	4	4	13	IF
95	*Galium aparine* L.	Rubiaceae	A	3	4	3	0	10	R
96	*Galium elegans* Wall. ex Roxb.	Rubiaceae	P	2	4	3	0	9	R
97	*Gentiana cachemirica* Decne.	Gentianaceae	P	1	2	3	3	9	R
98	*Gentianodes eumarginata* Omer	Gentianaceae	A	1	4	3	3	11	R
99	*Gentianopsis paludosa* (Hook.f.) Ma	Gentianaceae	A	1	4	3	3	11	R
100	*Geranium nepalense* Sweet.	Geraniaceae	P	1	0	2	0	3	EN
101	*Geranium pusillum* L.	Geraniaceae	A	1	4	4	4	13	IF
102	*Geranium wallichianum* (D. Don.)Ex Sweet.	Geraniaceae	P	2	1	4	0	7	VU
103	*Geranium collinum* Stephan ex Willd.	Geraniaceae	P	2	4	3	0	9	R
104	*Geranium sylvaticum* L.	Geraniaceae	P	2	4	4	4	14	IF
105	*Hyoscyamus niger* L.	Solanaceae	A	1	0	3	2	6	VU
106	*Hypericum oblongifolium* Choisy	Hypericaceae	P	3	4	3	0	10	R
107	*Hypericum perforatum* L.	Hypericaceae	P	2	2	3	3	10	R
108	*Impatiens brachycentra* Kar. and Kir.	Balsaminaceae	A	4	4	4	4	16	DOM
109	*Impatiens thomsonii* Hook. f.	Balsaminaceae	A	4	4	4	4	16	DOM
110	*Indigofera heterantha* Brandis	Fabaceae	P	3	1	3	1	8	VU
111	*Indigofera atropurpurea* Hornem.	Fabaceae	P	2	3	3	1	9	R
112	*Indigofera heterantha* var. *gerardiana* (Graham ex Baker in Hook. f.) Ali	Fabaceae	P	4	3	2	0	9	R
113	*Indigofera tinctoria* L.	Fabaceae	P	2	2	3	1	8	VU
114	*Iris florentina* L.	Iridaceae	P	3	4	2	0	9	R
115	*Iris germanica* L.	Iridaceae	P	3	4	2	0	9	R
116	*Iris hookeriana* Foster	Iridaceae	P	3	4	2	0	9	R

Table 3. Contd.

117	*Isodon rugosus* (Wall. ex Benth.) Codd	Lamiaceae	P	2	3	2	0	7	VU
118	*Jasminum humile* L.	Oleaceae	P	3	4	2	0	9	R
119	*Jasminum officinale* L.	Oleaceae	P	3	4	2	0	9	R
120	*Juglans regia* L.	Juglandaceae	P	1	0	0	1	2	EN
121	*Juniperus communis* L.	Cupressaceae	P	3	3	1	1	8	VU
122	*Justicia adhatoda* L.	Acanthaceae	P	4	4	2	0	10	R
123	*Lactuca dissecta* D. Don	Asteraceae	A	3	2	4	4	13	IF
124	*Lathyrus laevigatus* (Waldst. and Kit.) Gren.	Euphorbiaceae	P	2	4	3	2	11	R
125	*Lonicera asperifolia* Hook. f. and Thomson	Caprifoliaceae	P	2	2	3	2	9	R
126	*Lonicera myrtillus* Hook. f. and Thomson	Caprifoliaceae	P	2	2	3	2	9	R
127	*Malus pumila* Mill.	Rosaceae	P	2	3	3	2	10	R
128	*Malva neglecta* Wallr.	Malvaceae	A	3	2	4	4	13	IF
129	*Malva sylvestris* L.	Malvaceae	P	2	3	4	4	13	IF
130	*Malva parviflora* L.	Malvaceae	A	3	3	4	4	14	IF
131	*Mentha longifolia* (L.) L.	Lamiaceae	P	3	2	3	0	8	VU
132	*Mentha aquatica* L.	Lamiaceae	P	3	4	3	1	11	R
133	*Micromeria biflora* (Buch.-Ham. ex D.Don) Benth.	Lamiaceae	P	2	4	3	0	9	R
134	*Morus alba* L.	Moraceae	P	2	0	1	2	5	VU
135	*Morus nigra* L.	Moraceae	P	2	0	1	2	5	VU
136	*Myrsine africana* L.	Primulaceae	P	3	4	3	2	12	R
137	*Nasturtium officinale* R.Br.	Brassicaceae	P	4	2	3	0	9	R
138	*Nepeta laevigata* (D. Don) Hand.-Mazz.	Lamiaceae	P	3	4	3	0	10	R
139	*Nepeta clarkei* Hook.f.	Lamiaceae	P	2	4	3	0	9	R
140	*Nepeta podostachys* Benth.	Lamiaceae	P	4	4	2	0	10	R
141	*Nepeta praetervisa* Rech.f.	Lamiaceae	P	1	4	2	0	7	VU
142	*Nepeta prattii* H.Lév.	Lamiaceae	P	3	4	3	0	10	R
143	*Nepeta raphanorhiza* Benth.	Lamiaceae	P	1	4	3	0	8	VU
144	*Oenothera rosea* L'Hér. ex Aiton	Onagraceae	P	2	4	3	0	9	R
145	*Olea ferruginea* Wall. ex Aitch.	Oleaceae	P	2	0	0	1	3	EN
146	*Onosma hispida* Wall. ex G. Don	Boraginaceae	P	3	3	3	0	9	R
147	*Origanum vulgare* L.	Lamiaceae	P	2	2	2	0	6	VU
148	*Otostegia limbata* (Benth.) Boiss.	Lamiaceae	P	2	4	4	4	14	IF
149	*Oxalis corniculata* L.	Oxalidaceae	A	2	3	4	4	13	IF
150	*Paeonia emodi* Royle	Paeoniaceae	P	0	1	0	0	1	EN
151	*Papaver dubium* L.	Papaveraceae	A	2	3	3	2	10	R
152	*Papaver hybridum* L.	Papaveraceae	A	2	3	3	2	10	R
153	*Papaver pavoninum* C.A. Mey.	Papaveraceae	A	2	3	3	2	10	R
154	*Papaver rhoeas* L.	Papaveraceae	A	2	3	3	2	10	R
155	*Papaver somniferum* L.	Papaveraceae	A	2	3	3	2	10	R
156	*Phytolacca acinosa* Roxb.	Phytolaccaceae	P	2	2	4	4	12	R
157	*Picea smithiana* (Wall.) Boiss.	Pinaceae	P	1	0	0	1	2	EN

Table 3. Contd.

158	*Pimpinella diversifolia* DC.	Apiaceae	P			2						4			1				0				7	VU
159	*Pinus wallichiana* A.B. Jacks.	Pinaceae	P		1				0					0						1				2	EN
160	*Pinus roxburghii* Sarg.	Pinaceae	P			2			0					0						1				3	EN
161	*Plantago lanceolata* L.	Plantaginaceae	P		1					1								3				2				7	VU
162	*Plantago major* L.	Plantaginaceae	P		1						2							3				2				8	VU
163	*Plantago ovata* Forssk.	Plantaginaceae	A			2					2							3				2				9	R
164	*Platanus orientalis* L.	Platanaceae	P	0					0					0							1					1	EN
165	*Pleurospermum stylosum* C.B. Clarke	Apiaceae	A			2					2							3		0						7	VU
166	*Polygonatum verticillatum* (L.) All.	Asparagaceae	P				3		0								2				1					6	VU
167	*Polygonum hydropiper* L.	Polygonaceae	A				3						4					3		0						10	R
168	*Potentilla nepalensis* Hook.	Rosaceae	P			2							4					3				2				11	R
169	*Primula denticulata* Sm.	Primulaceae	P			2				1								3			1					7	VU
170	*Primula rosea* Royle	Primulaceae	P				3						4				2				1					10	R
171	*Primula schlagintweitiana* Pax	Primulaceae	A			2							4				2				1					9	R
172	*Prunella vulgaris* L.	Lamiaceae	P				3					3			1					0						7	VU
173	*Prunus cornuta* (Wall.ex Royle) Steud.	Rosaceae	P		1						2							3				2				8	VU
174	*Prunus domestica* L.	Rosaceae	P			2				1					1							2				6	VU
175	*Punica protopunica* Balf. f.	Lythraceae	P			2				1					1							2				6	VU
176	*Pyrus communis* L.	Rosaceae	P			2					2				1						1					6	VU
177	*Quercus semecarpifolia* Sm.	Fagaceae	P			2			0					0						0						2	EN
178	*Quercus baloot* Griff.	Fagaceae	P			2			0					0							1					3	EN
179	*Quercus dilatata* A.Kern.	Fagaceae	P		1				0					0								2				3	EN
180	*Quercus incana* Bartram	Fagaceae	P				3			1				0							1					5	VU
181	*Ranunculus muricatus* L.	Ranunculaceae	A		1							3			1					0						5	VU
182	*Rheum australe* D. Don	Polygonaceae	P		1				0						1					0						2	EN
183	*Rhodiola wallichiana* (Hook.) S.H.Fu.	Crassulaceae	P			2						3			1					0						6	VU
184	*Ribesalpestre* Wall. ex Decne	Grossulariaceae	P			2							4					3				2				11	R
185	*Ribes orientale* Desf.	Grossulariaceae	P			2							4					3				2				11	R
186	*Robinia pseudoacacia* L.	Fabaceae	P			2			0									3		0						5	VU
187	*Rubus fruticosus* L.	Rosaceae	P				3				2						2					2				9	R
188	*Rubus ellipticus* Sm.	Rosaceae	P		1					1							2					2				6	VU
189	*Rubus sanctus* Schreb.	Rosaceae	P		1					1							2				1					5	VU
190	*Rubus ulmifolius* Schott	Rosaceae	P			2						3					2					2				9	R
191	*Rumex alpinus* L.	Polygonaceae	P		1								4						4					4		13	IF
192	*Rumex dentatus* L.	Polygonaceae	A				3						4						4					4		15	DOM
193	*Rumex hastatus* D. Don	Polygonaceae	P				3						4				2				1					10	R
194	*Rumex nepalensis* Spreng.	Polygonaceae	P			2							4					3		0						9	R
195	*Salix pycnostachya* Anderson.	Salicaceae	P		1				0					0							1					2	EN
196	*Salix tetrasperma* Roxb.	Salicaceae	P			2			0						1						1					4	EN
197	*Salvia cana* Wall. ex Benth.	Lamiaceae	P				3						4						4					4		15	DOM
198	*Salvia moorcroftiana* Wall. ex Benth.	Lamiaceae	P				3				2								4					4		13	IF

Table 3. Contd.

199	*Sambucus wightiana* Wall.ex wight. and Arn.	Adoxaceae	P			2					2						3				2					9	R
200	*Saussurea albescens* Hook. f and Thomson	Asteraceae	P		1							3						4					3			11	R
201	*Saussurea costus* (Falc.) Lipsch.	Asteraceae	P	0					0								3			0						3	EN
202	*Scandix pecten-veneris* L.	Apiaceae	A			2							4				3								4	13	IF
203	*Scilla griffithii* Hochr.	Asparagaceae	B			2							4				3				1					10	R
204	*Sedum ewersii* Ledeb.	Crassulaceae	P			2							4				3					2				11	R
205	*Sedum roseum* (L.) Scop.	Crassulaceae	P			2							4				3				1					10	R
206	*Sedum hispanicum* L.	Crassulaceae	B			2							4					4							4	14	IF
207	*Seseli libanotis* (L.)W.D.J.Koch	Apiaceae	P			2							4				3			0						9	R
208	*Silene conoidea* L.	Caryophyllaceae	A				3						4				3					2				12	R
209	*Silene gonosperma* (Rupr.) Bocquet	Caryophyllaceae	P			2							4				3					2				11	R
210	*Silybum marianum* (L.) Gaertn.	Asteraceae	B			2						3					3					2				10	R
211	*Sinopodophyllum hexandrum* (Royle) T.S. Ying	Berberidaceae	P			2			0					1							1					4	EN
212	*Sisymbrium irio* L.	Brassicaceae	A				3				2						3					2				10	R
213	*Skimmia laureola* Franch.	Rutaceae	P		1				0					1							1					3	EN
214	*Solanum nigrum* L.	Solanaceae	A			2							4				3					2				11	R
215	*Solanum pseudocapsicum* L.	Solanaceae	P		1								4		1					0						6	VU
216	*Solanum surattense* Burm. f.	Solanaceae	A		1							3					3			0						7	VU
217	*Solena amplexicaulis* (Lam.) Gandhi	Cucurbitaceae	P			2							4				3					2				11	R
218	*Solidago virgaurea* L.	Asteraceae	P				3						4				3			0						10	R
219	*Sonchus oleraceus* (L.) L.	Asteraceae	A				3						4					4							4	15	DOM
220	*Stellaria decumbens* Edgew	Caryophyllaceae	P				3						4					4	0							11	R
221	*Stellaria media* (L.) Vill.	Caryophyllaceae	A				3						4					4	0							11	R
222	*Swertia ciliata* (D. Don ex G. Don) B.L. Burtt	Gentianaceae	A		1								4				3			0						8	VU
223	*Swertia cordata* (Wall. ex G. Don) C.B. Clarke	Gentianaceae	A		1						2						3			0						6	VU
224	*Swertia petiolata* D. Don	Gentianaceae	P			2							4				3			0						9	R
225	*Taraxacum officinale* F.H. Wigg.	Asteraceae	P				3				2						3					2				10	R
226	*Taxus fuana* Nan Li and R.R.Mill	Taxaceae	P		1				0						0						1					2	EN
227	*Thymus linearis* Benth.	Lamiaceae	P			2			0								3			0						5	VU
228	*Torilis japonica* (Houtt.) DC.	Apiaceae	A			2							4				3			0						9	R
229	*Torilis leptophylla* (L.) Rchb.f.	Apiaceae	A			2							4				3				1					10	R
230	*Trachyspermum ammi* (L.) Sprague	Apiaceae	A				3			1							3					2				9	R
231	*Trigonella foenum-graecum* L.	Fabaceae	A				3					3					3					2				11	R
232	*Trillium govanianum* Wall. ex D.Don	Melanthiaceae	P		1				0								3			0						4	EN
233	*Tulipa clusiana* DC.	Liliaceae	P				3					3				2					1					9	R
234	*Valeriana pyrolifolia* Decne.	Caprifoliaceae	P					4		1						2				0						7	VU
235	*Valeriana jatamansi* Jones	Caprifoliaceae	P	0					0								3			0						3	EN
236	*Verbascum thapsus* L.	Scrophulariaceae	B			2					2							4					3			11	R
237	*Viburnum cotinifolium* D. Don	Adoxaceae	P			2							4				3					2				11	R
238	*Viburnum grandiflorum* Wall.ex DC.	Adoxaceae	P					4					4				3					2				13	IF
239	*Viola biflora* L.	Violaceae	P		1				0								3							3		7	VU

Table 3. Contd.

240	*Viola canescens* Wall.	Violaceae	P		2		1					3		0			6	VU
241	*Viola tricolor* L.	Violaceae	A		2			2					4	0			8	VU
242	*Viola alba* Besser	Violaceae	P		2			2				3				3	10	R
243	*Viscum album* L.	Santalaceae	P		2				4		2			0			8	VU
244	*Withania somnifera* (L.) Dunal	Solanaceae	P	1				3		1					1		6	VU
245	*Zanthoxylum armatum* DC.	Rutaceae	P	1			1			0					1		3	EN

i. Dominant = DOM, ii. Endangered = EN, iii. Infrequent = IF, iv. Rare = R, v. Vulnerable = V.

plant species growing in Chakesar Valley by applying IUCN (1994 – 2001) criteria and showed that among the total species, 37% were endangered, 25% vulnerable, 28% rare whereas 9% of the plant species appeared to be infrequent.

According to the present study, the population of few species including *Trillium govanianum* Wall. ex D.Don*, Aconitum heterophyllum* Wall. ex Royle*, Saussurea costus* (Falc.) Lipsch.*, Sinopodophyllum hexandrum* (Royle) T.S. Ying and *Colchicum luteum* Baker has been tremendously decreased. Similar study was conducted by Ahmad and Habib (2014) in Dawarian village of Azad Jammu and Kashmir which identified that *Ajuga bracteosa* Wall.ex Benth.*, A. heterophyllum* Wall. ex Royle*, Bistorta amplexicaulis* (D. Don.) Green*, S. costus* (Falc.) Lipsch. and *Berberis lycium* Royle are standing on the verge of extinction. Contrary to the present study, the findings of Hamayun et al. (2006) from his studies of Utror and Gabral valley northern Pakistan identified that 49% species of the identified list fell in the threatened category. This difference of data between both studies conducted in closely adjoining areas is partly due to the difference of methodology used in research work and partly due to difference in the set of environmental conditions. In contrast to Hamayun et al. (2006), the present study used most authentic and globally recognized tool of information gathering in the form of IUCN category and criterion (2001). The list of threatened flora (endangered + vulnerable) explored in Kalam Valley identified that of the total 245 species, 38.36% (94 species) were threatened. Most threaten species, that is, 8 were of family Lamiaceae followed by 6 species of Rosaceae; 5 species each of Solanaceae, Berberidaceae and Pinaceae; 4 species each of Ranunculaceae and Fagaceae; 3 species each of Asteraceae, Apiaceae, Moraceae, Fabaceae and Violaceae; 2 species each of Caprifoliaceae, Geraniaceae, Gentianaceae, Juglandaceae, Plantaginaceae, Orchidaceae, Salicaceae and Primulaceae, whereas the rest of the families had only 1 species falling in threatened category (Table 4). In close conformity to the present findings, Hazrat and Wahab (2011) identified 84 threatened species and 13 infrequent species from their study of the hilly tracts in KPK. In a recent study conducted by Ullah and Rashid (2014), the conservation status of a total of 45 most important medicinal plants in Mankial valley northern Pakistan was evaluated; the findings enumerated the vulnerable species to be 28.88%, endangered species, 46.66% and critically endangered, 24.66% assessed by IUCN standards. The results of the present findings were compared with the data containing conservation status of plant species assessed according to IUCN (2003) applied on global scale which revealed that some of the species including *Bergenia ciliata* (Haw.) Sternb.*, Aconitum heterophyllum* Wall. ex Royle*, Paeonia emodi* Royle*, C. luteum* Baker*, Skimmia laureola* Franch.*, Taxus fuana* Nan Li and R. R. Mill and *S. hexandrum* (Royle) T.S. Ying had nearly the same conservation score; whereas the conservation status of plants including *Allium humile* Kunth.*, Abies pindrow* (Royle ex D.Don) Royle*, Pinus wallichiana* A. B. Jacks.*, Picea smithiana* (Wall.) Boiss.*, Thymus linearis* Benth.*, Plantago lanceolata* L.*, Quercus incana* Bartram and *Polygonatum verticillatum* (L.) determined by the present study was different from that of the Global record identified according to IUCN (2003). This difference is due to the range of area used for investigation of plant species as well as difference in the set of environmental conditions. Furthermore, some of the species which include *A. bracteosa* Wall.ex Benth.*, Achyranthes aspera* L.*, Bunium persicum* (Boiss.) Fedtsch.*, B. lyceum* Royle*, Jasminum humile* L.*, Datura stramonium* L.*, S. costus* (Falc.) Lipsch.*, Juglans regia* L.*, T. govanianum* Wall. ex D.Don*, Trachyspermum ammi* (L.) Sprague*, Viola biflora* L. and *Valeriana jatamansi* Jones were assessed during the present study for conservation purposes which were found to be data deficient according to IUCN (2003). This means that these findings will supply

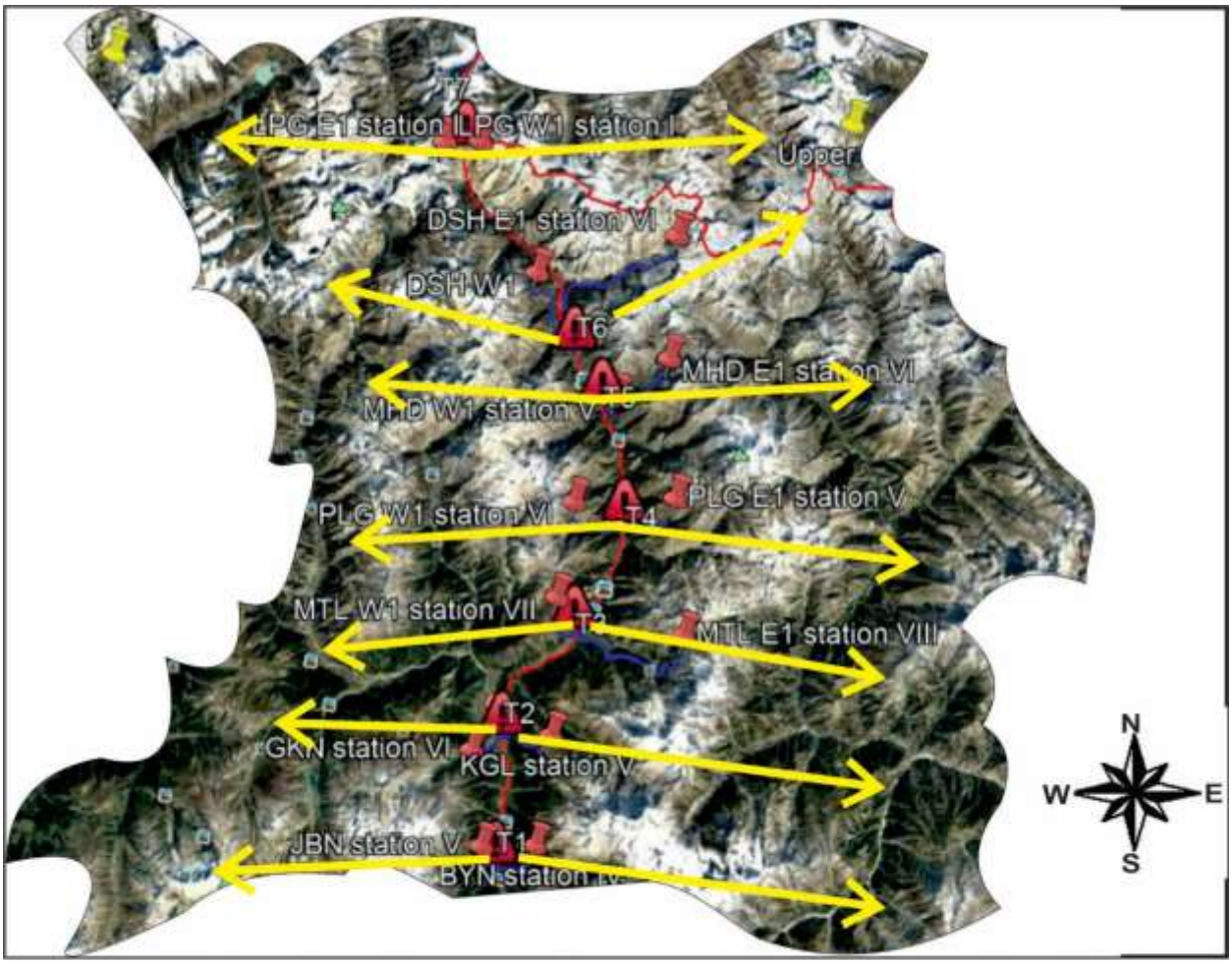

Figure 7. Map showing sampling area with the central red line representing as base line from which 14 transects are given off on both east and west sides containing a total of 73 study stations and 1095 quadrants.

a base line to be used by analysts of IUCN conservation program along with other such data provided from many concerned quarters.

Conclusion

The present research project reveals that Kalam Valley due to its specific topography (hilly tract ranging from southern elevation of 1900 m to northern alpine peaks up to 4600 m) and edaphoclimatic features (temperate, sub alpine and alpine zones with severe winter and acidic soils) is home to some of the most valuable and rare ethno botanically important plants and highly favors the growth of tall coniferous trees. The study area is also unique regarding the occurrence of short lived small herbaceous plants. As the area is located at the junction point of three big mountain chains, that is, Karakorum, Himalaya, and Hindukush so this blend is also expressed in vegetation. The research area is under severe biological stress in the form of severe grazing, burning of forest for coal purposes, deforestation, frequent forest fires, unplanned construction of infra-structure which is likely to reduce the biodiversity of vascular plants in the area. Illegal hunting of many valuable and threatened animals by the locals and outsiders is likely to disturb homeostatic process and productivity of the forest ecosystem. The current study assessed the conservation status of 245 most important plant species and identified that 25 species of vascular plants (10.20%) were endangered; similarly, population of many medicinal plants is likely to reduce drastically within few years which needs both *in-situ* and *ex-situ* conservation measures on urgent basis so as to avoid regional extinction of precious plant species.

RECOMMENDATIONS

Due to a complex of anthropogenic activities, the vegetation cover of research area over the years has been disproportionality reduced which can be replaced to

Table 4. Family profile of threatened plants.

S/N	Plant family	Vulnerable	Endangered	Threatened (Endangered + Vulnerable)
1	Amaranthaceae	1	-	1
2	Amaryllidaceae	1	-	1
3	Apiaceae	3	-	3
4	Asparagaceae	1	-	1
5	Asteraceae	2	1	3
6	Berberidaceae	3	2	5
7	Betulaceae	1	-	1
8	Brassicaceae	1	-	1
9	Buxaceae	1	-	1
10	Caprifoliaceae	1	1	2
11	Colchicaceae		1	1
12	Convolvulaceae	1	-	1
13	Crassulaceae	1	-	1
14	Cupressaceae	1	-	1
15	Dioscoreaceae	1	-	1
16	Dryopteridaceae	1	-	1
17	Ebenaceae	1	-	1
18	Ephedraceae	1	-	1
19	Fabaceae	3	-	3
20	Fagaceae	1	3	4
21	Gentianaceae	2	-	2
22	Geraniaceae	1	1	2
23	Juglandaceae	1	1	2
24	Lamiaceae	8	-	8
25	Lythraceae	1	-	1
26	Melanthiaceae	-	1	1
27	Moraceae	3	-	3
28	Oleaceae	-	1	1
29	Orchidaceae	2	-	2
30	Paeoniaceae	-	1	1
31	Papaveraceae	1	-	1
32	Pinaceae	1	4	5
33	Plantaginaceae	2	-	2
34	Platanaceae	-	1	1
35	Polygonaceae	-	1	1
36	Primulaceae	2		2
37	Ranunculaceae	3	1	4
38	Rosaceae	6		6
39	Rutaceae	-	1	1
40	Salicaceae	-	2	2
41	Santalaceae	1	-	1
42	Saxifragaceae	1	-	1
43	Scrophulariaceae	1	-	1
44	Solanaceae	4	1	5
45	Taxaceae	-	1	1
46	Violaceae	3	-	3

some extent by reforestation and afforestation. In this regard, social sector, local community and other stackholders should be involved to monitor and managetargeted territories specified for both in-situ and

ex-situ conservation of species. There is emerging need of effective legislation on the part of the government related to over grazing, town planning, illegal cutting of trees and encroachment of forests by the local population. The present research will provide a solid baseline to future conservationists and policy planners at general and specific levels.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Structure and diversity of weed communities associated with *Cucurbita pepo* L. cv. Scarlette "Zucchini" in the Eastern Province of Saudi Arabia

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Weed communities constitute an important component of any agro-ecosystem. Weeds are widespread among different crop cultivars and usually cause many changes. *Cucurbita pepo* is a common vegetable cultivated around the world. Additionally, there is a significant increase in the cultivation of *Cucurbita pepo* in Saudi Arabia. During the 2015 and 2017 growing seasons of *Cucurbita pepo* "zucchini," weed communities were investigated in five regions of the Eastern Province of Saudi Arabia. Fifty-four weed species belonging to 20 plant families that occurred within the *Cucurbita pepo* fields in the studied areas were investigated. Community structure, frequency, presence and species diversity were evaluated. In addition, relative abundance and phi-coefficient of association was calculated. The diversity and functional complex of weed communities can help to sustain biodiversity, ecosystem amenities and maintain crop performance.

Key words: Abundance, *Cucurbita pepo,* species diversity, weed community.

INTRODUCTION

As a result of the wide ecological amplitude of weed communities, weeds have become widespread among all different crop cultivars causing many alterations. Evaluations of crop systems divulge a general negative correlation between weed diversity and crop yield (Syswerda and Robertson, 2014), but tallying of a particular weed species does not really necessarily impact crop yield (Epperlein et al., 2014). Although weed communities often affect major constraints to resource-efficient crop production, changing weed communities can also support performance directly or indirectly by providing shelter and food for the beneficial insects and birds (Isbell et al., 2011; Kohler et al., 2011; Marshall et al., 2003). Moreover, weed communities can positively affect ecosystem purpose and stability, like reducing soil erosion, and nitrogen leaching (Carlesi et al., 2013), pest control (Donald, 2004), and pollination (Kremen et al., 2002). Weed communities constitute a highly dynamic collection of plants adapted to frequently disturbed habitats (Stenchly et al., 2017).

The plants of *Cucurbitaceae* family are grown within the tropics and temperate areas, where those with edible fruits were among the earliest cultivated plants in both the Old and New Worlds. The *Cucurbitaceae* family ranks

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among the highest of plant families for the number and the percentage of species that have been used as human food (Lira and Montes, 2013). *Cucurbita pepo* is a common vegetable cultivated in vast and different areas of Saudi Arabia; and in other countries of the world. It is called zucchini in America, courgette in the UK, and kusa in Arabic speaking countries. The geographic origin of *C. pepo* is commonly determined to be between Mexico and eastern North America (Smith, 1992).

One of the important challenges to improve the weed control methods is their identification (Tuo et al., 2013). Studying the composition of the weed flora and its evolution, abundance, diversity and fidelity under the impact of environmental and phytotechnic factors is actually a basic criterion for any advance of weed control methods. Nonetheless, some weed species are more damaging than others; also changes in weed communities may influence the impact of weeds, so it is relevant to determine the structure and diversity of weed communities associated with the crops. Therefore, this work aims to investigate the weed communities associated with *Cucurbita pepo*, their composition, abundance and diversity.

MATERIALS AND METHODS

The study area

This study was done in the Eastern Province of Saudi Arabia, which has an area of approximately 672,500 km^2. This region is one of the country's main vegetable suppliers. Five selected localities with 17 *Cucurbita pepo* fields were investigated. The selected localities from which data were collected are as follows:

Dammam

It is the capital of the Eastern Province, about 800 km^2 area. Dammam has a hot desert climate according to the Köppen climate classification. The winter temperatures range from mild to warm, but regularly decrease to as low as approximately 8°C some days (Table 1). Summer temperatures are extremely hot, typical of most of West Asia and usually exceed 40°C for approximately five months. Rainfall in Dammam is generally sparse, and usually occurs in December. However, some winter rainfall has been comparatively heavy, resulting in filling of water-reservoirs at desert Wadies. The mean annual precipitation is approximately 85 mm (RCC, 2010). Two fields were studied in this region (Table 1).

Al Jubail

It is the host of the largest industrial city in the Middle East, approximately 100 km from Dammam. The average annual temperature here is 26.3°C and average rainfall is 73 mm (RCC, 2010). Here, five fields have been investigated.

Ras Tanur

It is a city in the Eastern Province of Saudi Arabia located on a peninsula extending into the Arabian Gulf within 80 km distance from Dammam (RCC, 2010). The average annual temperature is 25.6°C and about 82 mm of rainfall annually (Table 1). Two fields of *Cucurbita pepo* were studied.

Al-Ahsa (Al Hofuf)

It is a traditional oasis region in eastern Saudi Arabia and it is located about 60 km inland from the coast of the Arabian Gulf. Hofuf climate is a desert climate, without actual precipitation during the year (RCC, 2010). Natural fresh-water springs are scattered at oases, encouraging human habitation and agricultural efforts. Five fields were studied.

Salasel

It is a small community located at 49.449 E and 26.075 N, approximately 70 km from Dammam. The environment more or less varies in this region (RCC, 2010), with sand dunes, sandy plains, gravel valleys, dense vegetation areas and mountains. Three *Cucurbita pepo* fields were studied.

Collection of data

Before cover crop demolition, weed species were collected and weed density and diversity were evaluated in the middle of each cover crop plot and in the weedy fallow by cutting the plants at ground level in a quadrat 100 cm × 100 cm (1 m^2) placed randomly four times over each plot. Weed samples were investigated inside and outside the *Cucurbita pepo* rows. To evaluate weed community structure and composition in the *Cucurbita pepo* crop, weed species density and diversity was assessed at 30 days after *Cucurbita pepo* planting, and finally in all weedy plots when cucurbits were harvested. Additionally, the phi-coefficient of association was calculated according to Chytrý et al. (2002a), where its values ranged between “-1” for least association and “1” for maximum association.

An exhaustive floristic survey was conducted with a whole field browsing technique. This method consists of an integral floristic survey of all weed species present by browsing the whole field until no new species were found. Using this method allows the inclusion of species even if they are heterogeneously distributed within the field (Chicouene, 2000). Weed species were identified according to Chaudhary (2000 and 2001), and native versus exotic status was assigned, and growth form and life history (annual versus perennial) were recorded. For each locality, each species was assigned a qualitative abundance score on a scale of zero to five (0 to V): 0 (if the species was absent), I (if present but rare; 1-5%), II (if frequent; 6-20%), III (if abundant; 21-40%), IV (if common; 41-80%) and V (if the species was very common; 81-100%). We then used the abundance score values and fidelity for clustering recognized weeds species into groups, and examined the relationship between sites as to their abundance of these weeds. Thus, five clusters were initiated. The diversity was calculated by using the species richness and abundance index.

Statistical analysis

All the characteristics were analyzed by ANOVA using JMP statistical software (SAS, 1996). All descriptive statistics were reported as figures (graphs) or as tables.

RESULTS

We investigated fifty –four weed species belonging to 20

Table 1. Climatic data of the study areas according RCC (2010).

Area	Parameter	January	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Damm.	Mean Temp.	15.7	17.1	20.6	25.5	30.4	33.4	34.9	34.4	32.4	27.8	22.5	17.9	26.05
	Min. Temp.	11.5	12.3	15.3	20.3	25.3	28.7	30.6	30.1	27.7	23	17.9	13.2	21.33
	Max. Temp.	19.9	21.9	25.9	30.8	35.6	38.1	39.3	38.7	37.1	32.7	27.1	22.6	30.80
	Mean PPT	17	18	17	8	0	0	0	0	0	0	8	9	**77**
Hofo	Mean Temp.	15.7	17.5	21	25.9	31.1	33.9	35	34.2	32.1	27.8	22.4	17.5	26.17
	Min. Temp.	11.1	12.4	15.5	20.1	25	27.8	29.1	28	26	21.8	17.2	12.6	20.55
	Max. Temp.	20.4	22.6	26.6	31.7	37.2	40.1	41	40.5	38.3	33.9	27.7	22.5	31.875
	Mean PPT	14	14	18	12	2	0	0	0	0	1	5	8	**74**
Ras Tan.	Mean Temp.	15.6	16.9	20.4	25	29.8	32.5	34.3	33.7	31.9	27.6	22.3	17.7	25.64
	Min. Temp.	11.7	12.3	15.2	20.1	25	28.3	30.6	30.1	27.8	23.3	17.9	13.2	21.29
	Max. Temp.	19.6	21.6	25.6	30	34.6	36.8	38.1	37.4	36.1	31.9	26.7	22.2	30.05
	Mean PPT	18	20	16	9	0	0	0	0	0	0	9	10	**82**
Jubail	Mean Temp.	14.9	16.2	19.9	24.5	29.6	32.7	34.3	33.6	31.7	27	21.5	16.8	25.23
	Min. Temp.	10.7	11.3	14.5	19.4	24.6	28.2	30.4	29.6	27.2	22.4	16.9	12	20.60
	Max. Temp.	19.1	21.2	25.3	29.7	34.6	37.2	38.3	37.6	36.2	31.7	26.1	21.6	29.88
	Mean PPT	21	19	15	10	0	0	0	0	0	1	13	9	**73**
Salasel	Mean Temp.	15.3	16.9	20.5	25.6	30.7	33.8	35.2	34.3	32.2	27.5	22	17.1	25.93
	Min. Temp.	10.7	11.7	14.9	19.9	25	28.2	29.9	28.8	26.6	21.9	16.9	12.1	20.55
	Max. Temp.	19.9	22.1	26.2	31.3	36.5	39.4	40.5	39.8	37.8	33.2	27.1	22.2	31.33
	Mean PPT	16	15	18	11	1	0	0	0	0	1	8	8	**78**

Temp. = temperature; PPT= precipitation.

plant families that occurred within the *Cucurbita pepo* fields in the studied areas (Table 2). The set of species is very similar to those in tropical regions of Africa or Asia, with the same species or genera being the most common (Kent et al., 2001; Rodenburg and Johnson, 2009).

Weed community structure

Among the studied sites, species richness ranged from 10 to 36 species with a median value of 25 species (Table 2). The most abundant and diverse family is Poaceae (represented by 13 species), followed by Fabaceae (8 species).

The recorded species can be grouped in 5 clusters (Figures 1 and 2) according to the abundance class and the presence percentage of the species (Legendre and Legendre, 2012).

Cluster one

Abundance class V (above 70% presence), five species were recorded (representing 9.3% of the total recorded species). The prevailing families are Chenopodiaceae, Amaranthaceae, Convolvulaceae, Portulacaceae and Malvaceae.

Cluster two

Nine species comprise 16.7% of the total recorded species. Abundance is in class IV, with presence ranging from 35.5 to 47%.

Cluster three

Fourteen species were recorded here (26% of the total recorded species), with presence values between 20 and 30%.

Cluster four

Ten species were recorded here (18.4% of the total recorded species), with presence values between 6 and 20%.

Cluster five

Here, abundance values were less than 6%, and 16

Table 2. Characteristic of weed species associated with Cucarbita pepo in the studied areas of eastern region of Saudi Arabia.

S/N	Families/species	Life form	Origin	Frequency					Total presence %	Abundance
				Damm.	Huf.	Sala.	Jub.	R. Tun		
1	**Aizoaceae**									
1	*Mesembryanthemum nodiflorum*	A herbs	N	0	0	33.3	0	0	5.9	R
2	**Amaranthaceae**									
2	*Amaranthus gracizans*	A herbs	Native	50	100	100	50	80	82.4	V. Ab.
3	**Asteraceae**									
3	*Ifloga spicata*	A herbs	Native	0	0	33.3	0	0	5.9	R
4	*Launaea capitata*	B herbs	Native	0	0	100	10	0	23.5	F
5	*Launaea cassiniana*	A / B herb	Native	0	60	100	0	0	35.3	Ab.
6	*Launaea nudicaulis*	P herbs	Native	50	80	33.3	40	0	47	V. Ab.
7	*Senecio desfontainei*	A herbs	Native	0	0	33.3	60	0	23.5	R
8	*Sonchus oleraceus*	A / B herb	Cosmop	0	60	66.7	0	0	29.5	F
4	**Boraginaceae**									
9	*Heliotropium bacciferum*	P shrublet	Native	50	20	66.7	20	0	29.5	F
10	*Moltkiopsis ciliata*	P shrublet	Native	0	0	66.7	0	0	11.7	O
5	**Brassicaceae**									
11	*Diplotaxis acris*	A herb	Native	0	0	100	40	0	29.5	F
12	*Eremobium aegyptiacum*	A/P herb	Native	0	0	33.3	0	0	5.9	R
13	*Farsetia aegyptia*	P shrub	Native	0	0	33.3	0	0	5.9	R
6	**Caryophyllaceae**									
14	*Arenaria serpyllifolia*	A herb	Cosmop	0	0	33.3	20	0	11.7	O
15	*Silene Arabica*	A herb	Native	0	0	100	20	0	23.5	F
7	**Chenopodeaceae**									
16	*Beta vulgaris*	A / B herb	Native	0	0	0	0	50	5.9	O
17	*Chenopodium album*	A herb	Cosmop	50	80	0	20	0	35.5	Ab.
18	*Chenopodium ambrosioides*	A herb	Native	100	80	100	100	0	82.4	V. Ab.
19	*Salsola baryosma*	A herb	Native	0	0	33.3	0	0	5.9	R
20	*Suaeda vermiculata*	P shrub	Native	0	0	0	20	0	5.9	O
8	**Convolvulaceae**									
21	*Convolvulus arvensis*	A herb	Cosmop	0	80	100	50	80	70.6	F
9	**Cyperaceae**									
22	*Cyperus conglomeratus*	P herb	Native	50	0	33.3	0	50	17.6	F
10	**Euphorbiaceae**									
23	*Euphorbia heterophylla*	A herb	Native	0	0	0	50	0	5.9	O
24	*Euphorbia prostrate*	A herb	Exotic	0	0	33.3	0	0	5.9	R
11	**Fabaceae**									
25	*Alhagi maurorum*	P shrublet	Native	0	20	0	0	0	5.9	R
26	*Astragalus asterias*	A shrublet	Native	0	0	33.3	0	0	5.9	R
27	*Astragalus corrugatus*	A herb	Native	0	0	33.3	0	0	5.9	R
28	*Hippocrepis bicontorta*	A herb	Native	0	0	33.3	0	0	5.9	R
29	*Lotus garcini*	A shrublet	Native	0	0	33.3	0	0	5.9	R
30	*Melilotus indica*	A herb	Native	50	20	100	20	80	41	V Ab
31	*Trifolium fragiferum*	A herb	Native	0	0	66.7	0	60	29.5	F

Table 2. Contd.

32	*Trigonella stellate*	A herb	Native	0	0	66.7	0	0	11.7	O
12	**Geraniaceace**									
33	*Erodium glaucophyllum*	A herb		0	0	66.7	0	0	11.7	O
13	**Juncaceae**									
34	*Juncus rigidus*	P herb	Native	0	20	0	0	0	5.9	R
14	**Malvaveae**									
35	*Malva parviflora*	A herb	Native	50	100	100	50	80	82.4	V. Ab.
15	Plantagenaceae									
36	*Plantago cylindrical*	A/P herb	Native	0	0	100	20	0	23.5	Ab.
16	**Poaeaceae**									
37	*Aeluropus massauensis*	P. grass	Native	0	60	0	0	60	35.5	F
38	*Chrysopogon aucheri*	A. grass	Native	0	40	0	0	0	11.7	O
39	*Cenchrus ciliaris*	P. grass	Native	0	20	66.7	0	40	29.5	F
40	*Cynodon dactylon*	P. grass	Native	50	80	0	0	20	35.5	Ab.
41	*Dactyloctenium aegyptium*	A. grass	Native	0	40	0	20	0	17.6	O
42	*Lasiurus hirsutus*	P. grass	Native	0	0	33.3	0	0	5.9	R
43	*Phalaris minor*	A. grass	Native	0	60	66.7	0	0	29.5	F
44	*Phragmites australis*	P. grass	Cosmo.	0	20	33.4	20	0	17.6	F
45	*Poa annua*	A. grass	Cosmo.	0	60	100	0	20	41	Ab.
46	*Polypogon monospeliensis*	A. grass	Native	50	0	0	0	50	11.7	O
47	*Promus tectorum*	A. grass	Native	0	40	0	40	0	23.5	F
48	*Setaria viridis*	A. grass	Native	50	0	33.7	60	0	35.5	Ab.
49	*Stipagrostis obtusa*	P. grass	Native	0	60	0	40	0	29.5	F
17	**Polygonaceae**									
50	*Emex spinosus*	A. herb	Native	0	40	0	0	0	11.7	O
18	**Portulacaceae**									
51	*Portulaca oleracea*	A. herb	Exotic	100	80	0	0	100	47	Ab.
19	**Solanaceae**									
52	*Solanum nigrum*	A. herb	Exotic	0	0	0	40	100	23.5	Ab.
20	**Zygophyllaceae**									
53	*Tribulus terrestris*	A. herb	Exotic	0	80	0	40	0	35.3	F
54	*Zygophyllum coccineum*	P. Shrublet	Native	50	20	50	20	50	23.5	Ab.

Life form (A: annual, B: biennial, P: perennial); origin (N: native, E: exotic, C: cosmopolitan), abundance (R: rare, O: Occasional, F: frequent, Ab.: abundant, V. Ab: very abundant), frequency of Fidelity, total presence and abundant.

species represented this cluster (29.6% of the total recorded species).

Weed species richness and abundance

The cumulative number of species recorded in the studied areas with different distributions ranged from 4 to 27 among the studied fields (Table 2) and varied significantly among the investigated areas.

Among the studied areas, Salasel had the highest species richness, frequency abundance and phi-coefficient values (Figures 1 and 2). On the other hand, the lowest values of the studied parameters were

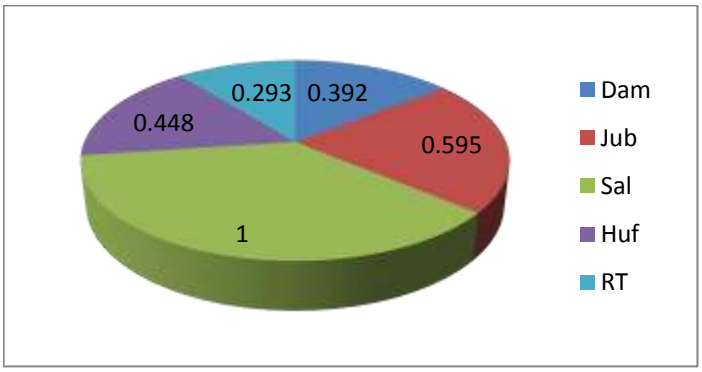
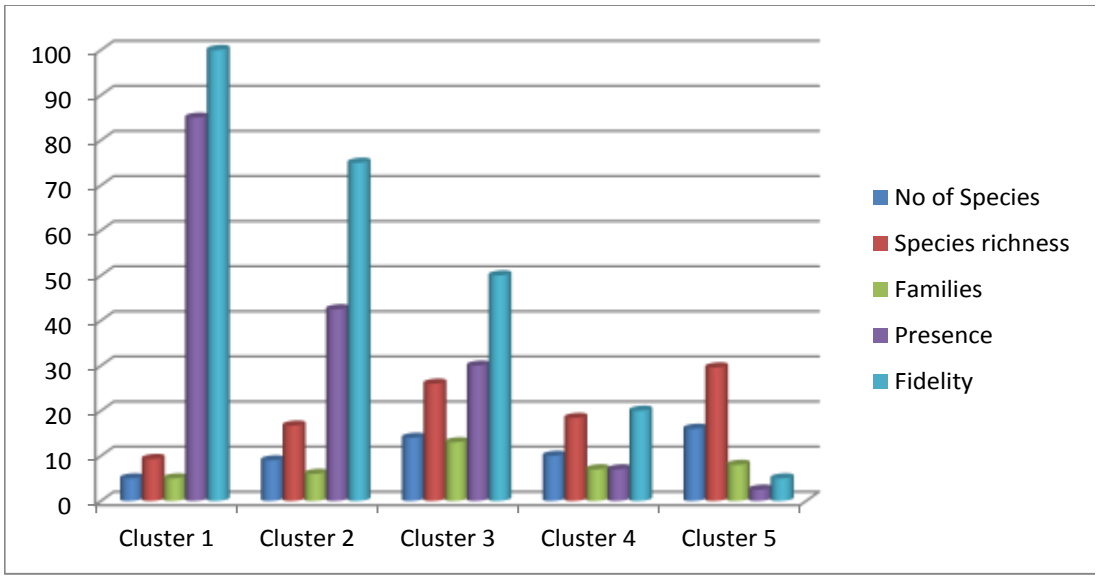


Figure 1. The Phi-Coefficient of Association of weed species within the study areas. According to Chytrý et al. (2002a).



Figures 2. Features of the recognized clusters: number of species, species richness, families, presence % and Fidelity.

recorded within the Ras Tanura region.

DISCUSSION

The study of vegetables around the world is revealing increasing evidence of the fact that different plants have many unexpected ties connecting them with each other (Vivaldo et al., 2016). *Cucurbita pepo* causes novel canopy and sub-canopy microhabitats that enhance the structural diversity of weed and may alter the composition and abundance of associated weed species. The set of associated weed species is very similar to those in tropical regions of Africa or Asia, with the same species or genera being the most common (Kent et al., 2001; Rodenburg and Johnson, 2009).

More broadly, the families Poaceae followed by Fabaceae and Asteraceae were the dominant weed families found within weed communities of *Cucurbita pepo* cultivation fields, as emphasized by Marnotte et al. (2006). The predominance of Poaceae is explained by the metabolic advantages of C4 plants, which are well adapted to hot and dry climates (Stenchly, 2017). Rodenburg and Johnson (2009) suggested more or less the same consistency of the weed flora of Cucurbita pepo as reported here.

Weed communities of Cucurbita pepo are strongly influenced by the cropping practices and water management (Kent et al., 2001) as well as altitude, soil characteristics (including fertility), and weed control techniques (Smith, 1983). Different research showed that squash (*Cucurbita pepo* L. cv. Scarlette) is of an

allelopathic potential on some common weed species (Qasem and Issa, 2010). Definitely, factors other than soil and climate share in determining weed community composition and structure. To take these other factors into consideration, we controlled statistically for the effect of geographical position on our measures of community similarity because more proximate sites are likely to be more similar for general factors. After controlling for geographic position, we detected a significant influence of abundance on weed communities, suggesting that it influences weed communities independent of, over and above, a general effect of geography (Houngbédji et al., 2016). Five clusters were recognized according to the presence percentage and fidelity; thus, particular weed management methods were suitable for each group. Each floristic group was characterized by the percentage of coverage of its constituting species. The results of the internal fidelity analysis reveals that the more heterogeneous a syntaxon is, the higher are the phi-coefficient values of association in the Salasel area (Figure 1). The use of fidelity measures supports and improves the results of phytosociological classification based on comparing more or less numerous sets of species that are nevertheless always limited by the ecological and the geographical contexts (Legendre and Legendre, 2012; Nawaza and Farooq, 2016). The results endorse the requirement of removing the early and frequent weeds, even after long period (reaching four years) to reduce weed infestations and improve crop growth.

Conclusion

The weeds are one of the most limiting factors affecting *Cucarbita* crop yield according to the weed species composition, density and diversity. Crop type, soil and climatic aspects can affect weed community's variation. Improvement of crop yield requires integrated weed studies and management strategies.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Socioeconomic implication of protecting natural vegetation: The case of Gra-Kahsu protecting natural vegetation In Southern Tigray, Northern Ethiopia

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Communities in southern Tigray have established the protection of natural vegetation on formerly degraded grazing lands to promote natural regeneration of plants. Even though same scholars in Tigray have developed their research of environmental management that enjoy great acceptability, the socioeconomic implication of environmental protection has been generally low. Hence, a study on understanding the socioeconomic implication of protecting natural vegetation (PNV) was carried out in Alamata wereda, southern zone of Tigray Region, Northern Ethiopia. A total of 60 households were interviewed to collect information on socioeconomic implications of Gra-kahsu PNV. Data were analysed by using statistical package for social sciences version 20. Respondents reported that PNV is among rehabilitation mechanisms mostly practiced in their locality to return degraded lands and improve agricultural productivity as well. The majorities of the local communities developed a sense of belongingness and developed positive attitudes to the performance of PNV probably due to their active participation in site selection and management of PNV. The local community has benefited from the PNV in the form of wood and grasses for construction, animal feed, fuel wood, farm implements, honey bee forage, health care and farmland protection from clotting with silt and mud from the upper catchments. This has developed a positive attitude by the local community towards PNV establishment. Local communities are aware that PNV generates ecological and socioeconomic benefits. Such perception is a base mark for future sustainability of the practice, and the outlook is optimistic for the establishment and performance of PNV, which is a basis for future rehabilitation programmes.

Key words: Benefit, cut-and-carry system, degraded grazing lands, perception of protecting natural vegetation, rehabilitation.

INTRODUCTION

The establishment of protected natural vegetation can meet a number of needs, including carbon fixing, the provision of a wood supply source that is an alternative to the natural vegetation, the restoration of degraded land and generation of income and employment (FAO, 1999). Natural vegetation like forests give different benefits such as economic, social, environmental and aesthetic values to human beings. They provide raw material for

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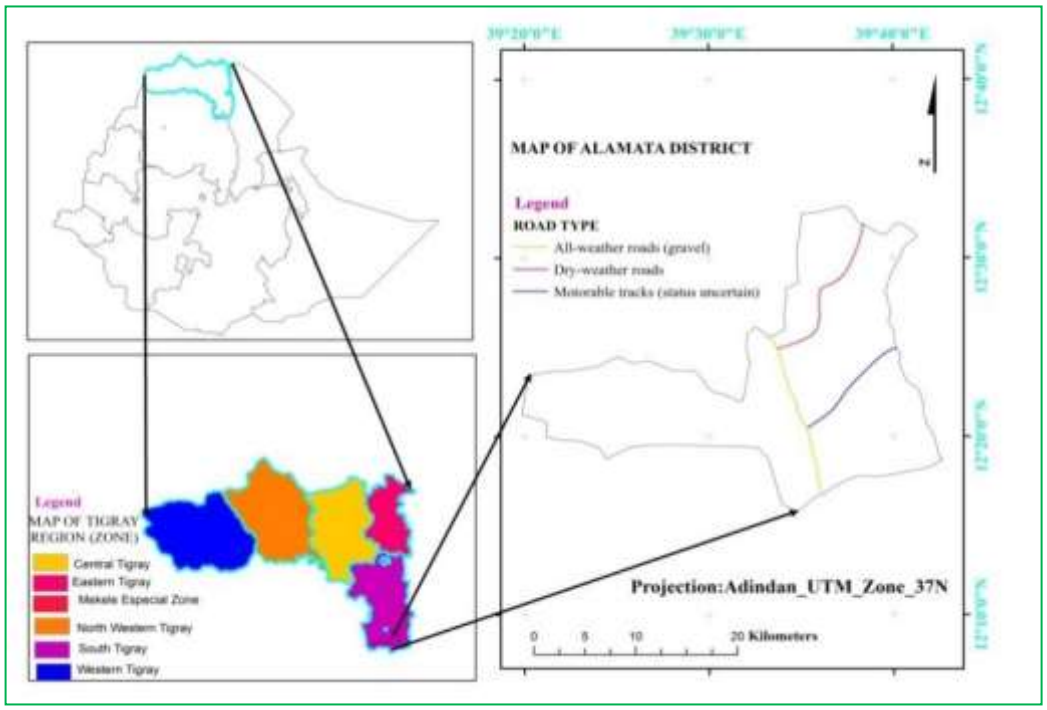

Figure 1. Map of study area (Alamata district).

industries, play an important role in plant improvement programs as well as in regulating local and global climate (Yeshitela, 2008). For instance, the tropical natural vegetation sequestrates a large amount (half of) of terrestrial carbon dioxide (Gorte and Sheikh, 2010) and maintains atmospheric humidity (Lalfa, 2010). Environmentally, natural vegetation is crucial in reducing soil erosion, maintaining soil moisture and regulating stream flow and providing shelter to a diverse variety of flora and fauna (Lalfa, 2010). Sustainable conservation and utilization of the remaining vegetation resources, and rehabilitation of those that have already been degraded, would provide economic, social and ecological benefits (Tefera et al., 2004). Protected natural vegetation is a source of wood for construction, farm implements, and non-timber forest products (Tefera et al., 2005).

Protected natural vegetations are becoming promising assets as sources of not only biomass energy, but also wood for construction, agricultural implements and several other purposes. Encouraged by these results, efforts are underway currently to replenish denuded areas of northern Ethiopia through the establishment of protected natural vegetation to promote conservation-based sustainable agriculture along with maintaining and enhancing the biodiversity of dry lands (Emiru et al., 2002). The principal objective of the practice is to maintain economically productive and biologically diverse vegetation (Zoebisch and Masri, 2002) rather than less valuable open degraded land. The practice has helped to change marginal lands to potentially productive areas, providing important vegetation assets for energy sources based on biomass (EFAP, 1994).

Several case studies in the Northern and Central highlands of Ethiopia have indicated that protecting natural vegetation's can be effective in improving ecological and economic benefits (Amede et al., 2007; Babulo et al., 2009; Mekuria et al., 2011), and controlling runoff and soil erosion (Descheemaeker et al., 2006). Most of the studies documented positive environmental and socioeconomic outcomes from the establishment of protecting natural vegetation on degraded communal grazing lands (Mastewal *et al.,* 2013). Despite the wide establishment of the PNV, the socioeconomic implication of the Gra-kahsu PNV has not been documented. This suggests that there is a need for research to identify these socioeconomic implications in order to sufficiently understand the merits of PNV. Thus, the purpose of the present study was to explore community perceptions and the benefits of protected natural vegetation as an alternative strategy for degraded land rehabilitation.

MATERIALS AND METHODS

Description of study area

The study was conducted at the Gra-Kahsu protected natural vegetation, which is found in the Alamata district. Geographically, the Alamata district is located at the Southern Zone of Tigray Regional state between 12.26° -12.57° North of latitude and 39.24° - 39.76 ° East of longitude (Figure 1). It is about 182 km south of the city of Mekelle and is bordered by the Amhara region in the

Table 1. Perception of farmers on influence of deforestation.

Effect of deforestation	Frequency	Percent
Soil erosion	2	3.3
Shortage of fuel wood and construction	4	6.7
Shortage of feed	4	6.7
Change of climate	8	13.3
Soil erosion, shortage of feed, climate change and shortage of fuel wood and construction	42	70
Total	60	100

south and west, and by the Afar region in the east.

According to Alamata agricultural and rural development (WAOARD, 2016) office report, about 25% of the area of the district are categorized to the highland agro-ecology and 75% as the lowland agro-ecology zones. Rainfall is bimodal between March and May with a short rainy season, and between June and September with the long rainy season. The annual mean precipitation ranges from 615-927 mm with mean maximum and minimum temperatures of 23 and 14°C, respectively. Cultivable land, pasture and forest occupy about 67.8, 8.5, and 8.2% of the total land area, respectively. Available natural vegetation coverage is very small and only residual and pocket forest trees cover 8.2% of the wereda found in communal forests, churches and area closures. The presence of Gra-Kahsu protecting natural vegetation also covers a good part of the forest cover. The lowland parts of the wereda are dominated by *Acacia* species (Tirhas, 2009).

Data collection methods

During socioeconomic survey, data were collected using a structured questionnaire for household interviews and focus group discussion to get background information about the two land use systems. Focus group discussions (10) were selected through development agents. These focus group discussions included individuals who lived for many years in the area and who are assumed to have adequate knowledge of their locality. They consisted of elders, religious leaders, youth and women. In addition to the farmers, livestock experts and Development Agents also participated in the discussion. In the focus group discussions, elders were given a chance to express their views, as they are in a position to compare changes resulting from the use of protecting natural vegetation with previous open access. Households were selected randomly to get information about the socioeconomic implications. A total of 60 individuals were interviewed. All respondents were engaged in farming, and women accounted for 13.3% of the total. The questionnaires were translated to the local language “Tigrigna” to simplify it for the enumerators.

Data analysis

Both qualitative and quantitative data were collected and the data were checked and coded in a computer, which were then analysed to extract meaningful information. Descriptive statistics such as mean, percentage and frequency were used to present the results. The qualitative data that were obtained through focus group discussion were narrated and summarized. The quantitative data obtained through a formal survey was analysed by using statistical package for social sciences (SPSS) version 20. The results were presented using tables, charts and frequency distributions.

RESULTS AND DISCUSSION

The interviewed households consisted of 13.3% female-headed and 86.7% male-headed households, of which 73.3% have lived in/around the study area for more than 49.8 years. The age of the respondents was range minimum of 25 and maximum of 71 years. Less than half (38.3%) of the respondents contributed to the PNV management in the form of PNV guards, 61.7% (37) were participated during the time of site selection, and plantation activities were undertaken in the last 10 years at the PNV. This indicated the level of willingness and involvement of the local community for protection and rehabilitation of local vegetation, where there is a mobilization and centralized coordination with a proper management plan and benefit sharing rules.

Perception of farmers on the effects of deforestation

The majority of the respondents (70%) indicated that soil erosion, shortage of fuel wood and construction, shortage of fodder and climate change were the major influence of deforestation in the study area (Table 1). In central Tigray, Shylendra (2002) and Babulo et al. (2009) also found that there was a rapid forest degradation that adversely affected the households’ livelihood. This latter study stressed that the negative effect of forest degradation on the livelihoods of households was related to the heavy dependence of the households on forest resources to meet their biomass needs, such as fuel wood and construction materials. According to Alemayehu (1998), shortage of feed and water, livestock diseases, low animal productivity and livestock losses, which in turn have resulted in unusual migration, starvation and poverty, are the main effect of range deterioration in Ethiopia. Yates et al. (2000), Belaynesh (2006), Yosef (2007), Amaha et al. (2008), and Solomon (2015) summarized the major effects of range land degradation as follows: loss of livestock holding (drought), food shortage of human and animals, change in

vegetation ecology and increased aridity.

Farmers' attitude on protecting natural vegetation

According to the group discussion, there was a significant increase in the vegetation coverage of PNV in the past 20 years. However, they expressed their concerns on the new phenomenon of dominance of shrubs over trees in the Gra-Kahsu protecting natural vegetation including *Dodonaoea angustifolia, Carissa spinarum* and *Euclea racemosa.* In addition, the succession of shrubs and trees is reducing availability of grass as a feed harvest for their livestock through cut-and-carry system. Similar study of enclosures by Tefera et al. (2005) pointed out that after five years, the protecting natural vegetation showed gradual reduction of availability of grass supply because of closure of canopies of thorny species from the family Fabaceae (kibret, 2008).

All of the interviewed farmers (60) expressed a positive attitude towards PNV currently known as Gra-Kahsu protecting natural vegetation, and indicated that it is contributing to their livelihood. This positive attitude of local communities is fundamental to the sustainability of protecting natural vegetation (Heitschmidt et al., 2004; Emiru et al., 2006) and also for future rehabilitation projects (Wolde et al., 2009). The benefits are in the form of wood and grasses for construction (huts), animal feed (cut-and-carry system), fuel wood, fence, farm implements, honeybee forage, and health care (traditional medicinal plants). The local communities benefit from the increased in number and biomass of perennial and annual grass species in the protecting natural vegetation area, through the ‘‘cut-and-carry’’ protecting natural vegetation management system, for feeding their animals, constructing their grass-thatched huts or both (Tefera et al., 2005; Emiru et al., 2006). All the respondents explained that flooding was a serious problem in CGL, and many farmers had been displaced from their farmland because of silt load from the upper bare catchments.

According to the group discussion, there are three basic benefits identified, namely economic, social and ecological values obtained from protected natural vegetation’s like, Gra-Kahsu protecting natural vegetation. The main contributions of protecting natural vegetation is that it provides forest products including trees that can better the livelihoods though increasing incomes, improving food security, reducing vulnerability and enhancing well-being (FAO, 2001). Resource restoration helps to maintain valuable ecosystem services, reduces flood damage, provides further benefits, and is reinforced as a key building block of development support of the rural communities (Medhin, 2002; GACGCS, 2005). This has significantly affected the sense of ownership and community’s commitment for effective protection and sustainable management of land resources (Nedessa et al., 2005).

Economic importance

Relevant information from the group discussion mainly underlined that due to the exclusion of the natural vegetation and rehabilitation of the vegetation, they could get grasses, both for house cover and feeding of the animal’s especially in drought season under the permission of the district agricultural offices free of charge. The average household income derived from PNV products (mainly grass) was approximately 1740 ETH Birr per household per year. This agrees with studies that states that closures are efficient to increase financial income for households. Besides, more than 1200 Ethiopian Birr could be gained from grass sales on an annual basis (Mengistu, 2011). Natural resources such as forests are among the primary sources of livelihoods of poor people providing food, fodder and fuel wood (Tefera et al., 2005; Mastewal et al., 2013). In the northern highlands of Ethiopia, forest resources are a major source of livelihood, accounting for 27% of total household income (Babulo et al., 2009). Similarly, 34% of household per capita income in the Bale mountains, southern Ethiopia (Tesfaye et al., 2011), and 39% of the average household income in Dendi district, Ethiopia (Mamo et al., 2007) is generated from natural resources.

Social importance

According to the group discussion, Gra-kahsu protecting natural vegetation has a social value. For example, many people move every evening from the town to the PNV for recreation purposes. During January and April, there is a wedding ceremony in the town every year. At the same time, the wedding ceremony owners practiced a wedding ceremony Photoshop program in the PNV free of charge. Ecological restoration has also been able to renew economic opportunities, rejuvenate traditional cultural practices and refocus the aspirations of local communities (SERI, 2004) and higher aesthetics value (Emiru et al., 2006). People around the PNV have been pleased to see the same wildlife and the conserved large woody plant species that engender a sense of wonder. Natural resources generate intangible benefits such as the pleasure that people take in observing plants and wildlife, the sense of wonder and spiritual connection that many people feel when immersed in rangeland landscapes, and studying natural systems (Teague et al., 2009).

Ecological importance/change in the ecosystem

According to the information from group discussion and

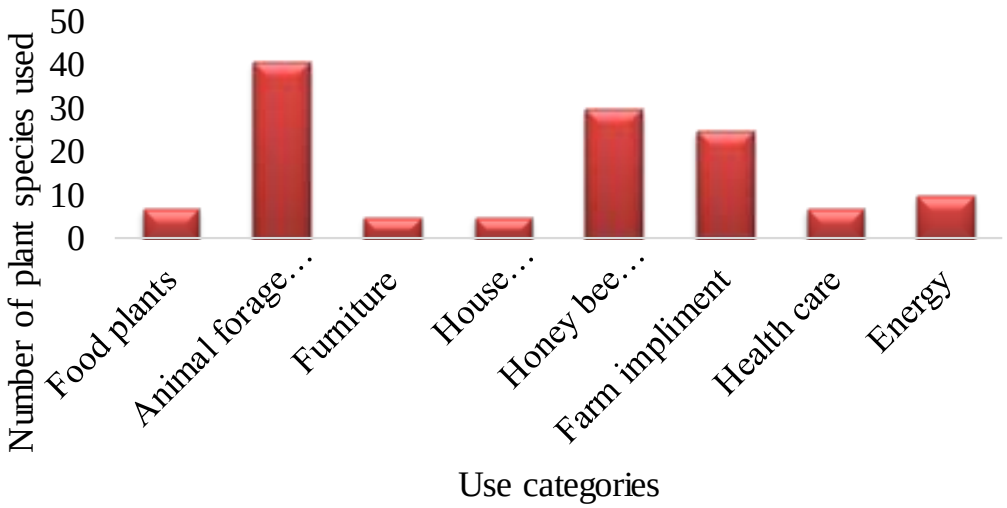

Figure 2. Use categories and the number of species used in the Gra-Kahsu PNV.

individual interview, the major ecological benefit that people of the study area obtained from the PNV includes the rejuvenation of different wood species and grasses and gully stabilization. Respondents explained that PNV are effective strategies in controlling accelerated soil erosion, and agricultural lands below area closures become more productive than lands below grazing. This agrees with studies that state agricultural lands below free grazing were strongly affected by water erosion than below enclosed sites (Wolde et al., 2007). All of the interviewed farmers (60) agreed that there is a significant decrease in soil erosion in the PNV from time-to-time. Accordingly, the PNV is an important contributing factor to the ecology of area in minimizing flood hazard in the lower stream and reduces soil erosion. Farmers' perception is supported by studies made in Tigray, where they reported that irrespective of land rehabilitation efforts, such as enclosures, resulted in decreased sheet and rill erosion (Nyssen et al., 2007; Wolde et al., 2007). The level of soil erosion decreased, and even springs started to flow after protecting natural vegetation was established in some parts of eastern Tigray (Emiru et al., 2006). Participants in the focus group discussion also revealed that the PNV provides ecosystem services such as regulation and maintenance of climatic conditions.

Traditional utilization of the two-land use system

The plant species in the study area have been known to have multiple uses. The group discussion revealed that the plant species are primarily used for livestock forage, medicinal use, energy (firewood and charcoal), fence, farm implements, honeybee forage, furniture, house construction values as well as food resources for humans. Among the plant species registered in the study area, the local community uses 7 species as food plants, 41 species for forage, 30 species as bee forage, 25 species for farm implements, 10 species for energy and 7 species for human and veterinary medicine (Figure 2). Use of plant resources for livestock feed being a more frequent purpose, honey bee forage, farm implements, provision of energy for cooking and heating in the form of wood fuel and charcoal), human food, traditional medical care and construction in that order of importance has been reported (Figure 2).

Fencing was the common use, this could be attributed to the traditional, cultural fencing practices among the local communities; particularly thorny species like *Ziziphus spina-christi,* and *Acacia tortilis* were used for fencing. More than half of the respondents (85%) used woody fences in the study area whereas, nine (15%) of the interviewed did not use wood plant fence (stone building). Out of 60 households interviewed (the respondents), about 32 (53.3%) collected fence materials (woody plant) from CGL. However, 19 (46.7%) of the respondents collect their fence materials from both PNV and CGL. According to the information from group discussion, many plant species fit into more than one use categories. For example, *Z. spina-christi, Acacia albida, Acacia etbaica, A. tortilis, Dodonaoea angustifolia, Eucalyptus camaldulensis* and *Olea europaea* subsp. *cuspidate* serve different purposes (honeybee forage, farm implements, house construction, animal forage and health care).

Food plants

A total of 7 plant species belonging to 6 genera and 5 families were identified to be used as food in the study area. These fruits are sweet and so preferred more by

Table 2. List of plant species uses for food in the Gra-Kahsu PNV.

Scientific name	Family	Life form
Ziziphus spina-christi (L.) Desf.	Rhamnaceae	Tree/Shrub
Grewia ferruginea Hochst. Ex A. Rich.	Tiliaceae	Tree/Shrub
Dovyalis verrucosa (Hochst.) Warb.	Flacourtiaceae	Shrub
Sageretia thea (Osbeck) M. C. Johnston	Rhamnaceae	Shrub
Ficus sycomorous L	Moraceae	Tree
Carissa spinarum (Forssk.) Vahl	Apocynaceae	Shrub
Dovyalis abyssinica (A. Rich.) Warb.	Flacourtiaceae	Tree/Shrub

children and youngsters in the study area. Out of these, one (14.29%) is a tree, three (42.86%) are shrub/tree and three (42.85%) are shrubs (Table 2).

Forage plants (browse)

41 plant species that belong to 26 families and 31 genera were documented as forage plant species. Out of these, nine species belong to Fabaceae that constitute 34.61% and three species belong to Anacardiaceae that constitute 11.53% of the forage species. Shrubs comprise the highest percentage (41.46%), followed by trees (36.58%) and trees/shrubs (21.95%) (Table 3). Leaves, pods, twigs and flowers were the plant parts utilized by livestock. The browse species were used as livestock feed both in the wet and dry season. In the wet season, most of the leaf were consumed directly from the live plant and some of them were lopped and sometimes offered as cut and carry feed. In the dry season, leaves and pods from deciduous trees and shrubs were consumed after they had fallen naturally to the ground.

Fuel wood

From the group discussion point of view, *Dodonaoea angustifolia, Olea europaea* subsp. *cuspidate, A. abyssinica, A. etbaica* and *A. tortilis* species were the best-preferred fuel wood sources in the study area. Most woody species from the Fabaceae family commonly are preferred as fuel wood sources because of their high calorific values (Kindeya, 2004). The majority of respondents do not use fuel saving stoves in their home. Only 13 (21.7%) have been using an improved stove. The rest has not used any either because of lack of awareness and/or the high cost of the improved stoves. Improved stoves were provided by the government (3), non-governmental organizations (7) and some buy by themselves (3). A lack of awareness on fuel-efficient mechanisms and inability to purchase improved stoves was the main reason for not using alternative energy sources in dryland of Eastern Tigray (Emiru et al., 2006).

Traditional medicinal use plants

The local communities in the study area make use of seven woody species of medicinal plants that belongs to seven genera and seven families for both human and livestock. *Conyza hypoleuca, Rumex nervosus, Dodonaoea angustifolia, Hagenia abyssinica* and *Calpurnia aurea* plant species are the most medicinal use plants that are used in the area, of which two (28.57%) were trees and five (71.43%) were shrub/tree species (Table 4). The plant parts used widely to treat human and animal include roots, leaves and seeds.

House construction and furniture

D. angustifolia, A. etbaica, Eucalyptus camaldulensis, Juniperus procera and *Cadia purpurea* are plant species that are used for house construction in the study area. In addition, *Cupressus lusitanica, J. procera, Eucalyptus camaldulensis, Acacia etbaica* and *Olea europaea* subsp. *cuspidate* are plant species that are used locally for house furniture in the study area.

Farm implements (tools)

A total of 25 plant species belonging to 18 genera and 17 families were identified to be used as farm implements (handle, wings, neck yoke and beam) in the study area. These woody plant species so preferred more by local communities. Out of these, 15 (60%) are trees, 6 (24%) are shrub/tree and 4 (16%) are shrubs (Table 5).

Honeybee forage

A total of 30 plant species, belonging to 21 families and24 genera, were documented as honeybee forage plant species. Out of these, seven species belong to Fabaceae that constitute 33.33% and two species belong to Apocynaceae and Celastraceae that constitute 9.52% of the honeybee forage species. Shrubs and trees

Table 3. List of forage plant species in the Gra-Kahsu PNV.

Scientific name	Family	Life form
Gomphocarpus fruticosus (L.) Ait. F.	Asclepiadaceae	S
Rhus retinorrhoea Oliv.	Anacardiaceae	S
Rhus natalensis Krauss	Anacardiaceae	T/S
Rhus glutinosa A. Rich.	Anacardiaceae	T/S
Carissa spinarum (Forssk.) Vahl	Apocynaceae	S
Conyza hypoleuca A. Rich.	Asteraceae	S
Laggera tomentosa (Sch. Bip. ex. A. Rich.) Oliv. and Hiern	Asteraceae	S
Ehretia cymosa	Boraginaceae	T
Maerua angolensis DC.	Capparidiaceae	T
Maytenus undata (Thunb.) Blakelock	Celastraceae	T
Maytenus senegalensis (Lam.) Excell.	Celastraceae	T/S
Combretum molle R. Br.ex G. Don.	Combretaceae	T
Cordia ovalis	Cordiaceae	T
Euclearacemosa subsp. *schimperi* (A.DC.) Dandly	Ebenaceae	S
Clutiaabyssinica Jaub. And Spach.	Euphorbiaceae	S
Acacia tortilis (Forssk.) Hayne	Fabaceae	T
Acacaia albida Del.	Fabaceae	T
Dichrostachys cinerea (L.) Wight and Arn.	Fabaceae	S
Pterollobium stellatum (Forssk.) Brenan	Fabaceae	S
Astragalus atropilosulus (Hochst.) Bunge	Fabaceae	S
Acacia abyssinica Hochst. ex Benth.	Fabaceae	T
Acacia seyal Del.	Fabaceae	T
Acacia etbaica Schweinf.	Fabaceae	T
Acacia asak (Forssk.) Will.	Fabaceae	T/S
Dovyalis abyssinica (A. Rich.) Warb.	Flacourtiaceae	T/S
Dovyalis verrucosa (Hochst.) Warb.	Flacourtiaceae	S
Leucas abyssinica (Benth.) Briq.	Lamiaceae	S
Nuxiacongesta R. Br. ex. Fresen	Loganiaceae	T/S
Myrsineafricana L.	Myricinaceae	S
Olea europaea subsp *cuspidate* (Wall. ex DC.) Cifferri	Oleaceae	T
Jasminum grandiflorum (R. Br. ex. Fresen.) P. S. Green	Oleaceae	T
Pittosporum viridiflorum Sims	Pittosporaceae	T
Rumex nervosus Vahl	Polygonaceae	S
Ziziphus spina-christi (L.) Desf.	Rhamnaceae	T/S
Cassipourea malosana (Baker) Alston	Rhizophoraceae	T
Psydrax schimperiana (A. Rich.) Bridson	Rubiaceae	S
Rosa abyssinica Lindely	Rosaceae	S
Osyris quadripartite Decn.	Santalaceae	T
Dodonaoea angustifolia L. F.	Sapindaceae	S
Grewiaferruginea Hochst. ex A. Rich.	Tiliaceae	T/S
Grewiamollis Juss.	Tiliaceae	T/S

comprised the highest percentage (33.33% for each), followed by trees/shrubs (26.67%) and climber (6.67%) (Table 6). From the interviewed farmers, only 5% of the respondents had beehives in the PNV. A majority of the farmers participate in beekeeping at their backyard. In the future, as the vegetation coverage and diversity of flowering plants increase, apiculture could make the PNV highly suitable for sustaining large numbers of bee colonies and promoting beekeeping practices as an option for its management.

According to the group discussion, plant species that decreased in the PNV from time to time were due to 1) preference of the plants (highly preference for multipurpose), illegal cutting, disease at root (*Juniperus*

Table 4. List of plant species for medicinal use in the Gra-Kahsu PNV.

Scientific name	Family	Life form	Purpose
Conyza hypoleuca A. Rich.	Asteraceae	Shrub	Human and livestock
Calpurnia aurea (Ait) Benth.	Fabaceae	Shrub	livestock
Eucalyptus camaldulensis Dehn.	Myrtaceae	Tree	Human and livestock
Phytolacca dodecandra L Herit.	Phytolaccaceae	Shrub	livestock
Rumex nervosus Vahl	Polygonaceae	Shrub	Human and livestock
Dodonaoea angustifolia L. F.	Sapindaceae	Shrub	Human
Hagenia abyssinica (Bruce) J. F.Gmel.	Rosaceae	Tree	Human

Table 5. List of farm implement plant species in the Gra-Kahsu PNV.

Scientific name	Family	Life form
Rhus retinorrhoea Oliv.	Anacardiaceae	S
Rhus natalensis Krauss	Anacardiaceae	T/S
Rhus glutinosa A. Rich.	Anacardiaceae	T/S
Maerua angolensis DC.	Capparidiaceae	T
Maytenus undata (Thunb.) Blakelock	Celastraceae	T
Acacia tortilis (Forssk.) Hayne	Fabaceae	T
Acacaia albida Del.	Fabaceae	T
Acacia abyssinica Hochst. ex Benth.	Fabaceae	T
Acacia seyal Del.	Fabaceae	T
Acacia etbaica Schweinf.	Fabaceae	T
Acacia asak (Forssk.) Will.	Fabaceae	T/S
Nuxia congesta R. Br. ex. Fresen	Loganiaceae	T/S
Ficus sycomorous L	Moraceae	T
Eucalyptus camaldulensis Dehn.	Myrtaceae	T
Olea europaea subsp. *cuspidate* (Wall. ex DC.) Cifferri	Oleaceae	T
Jasminum grandiflorum (R. Br.ex. Fresen.) P. S. Green	Oleaceae	T
Pittosporum viridiflorum Sims	Pittosporaceae	T
Ziziphus spina-christi (L.) Desf.	Rhamnaceae	T/S
Cassipourea malosana (Baker) Alston	Rhizophoracea	T
Psydrax schimperiana (A.Rich.) Bridson	Rubiaceae	S
Rosa abyssinica Lindely	Rosaceae	S
Osyris quadripartite Decn.	Santalaceae	T
Dodonaoea angustifolia L. F.	Sapindaceae	S
Grewiamollis Juss.	Tiliaceae	T/S
Celtis africana Burm. F.	Ulmaceae	T

procera), 2) settlement increase, population growth, mismanagement, livestock grazing, not planted by the communities (*Ficus sycomorous*, *Cupressuslusitanica*) and 3) aging (*J. procera*), *Olea europaea* subsp. *cuspidate, C. lusitanica, A. etbaica, E. camaldulensis* and *J. procera*. However, plant species due to low preference as compared to other, good regeneration status and planted by the communities (*Dodonaoea angustifolia* and *Acacaia albida*), *D. angustifolia, Acacia abyssinica, Acacia tortilis, Acacia asak* and *Carissa spinarum* are increased in the PNV from time to time.

According to the group discussion, the community believed that, there is no free access to use the PNV in the study area. However, most of the community people used the PNV without permission for different purposes like animal forage, house construction, fuel wood and charcoal, farm implement as well as a fence. In addition, no one can get benefit out of the surrounding kebele except they have permission. Threats of Gra-kahsu PNV were identified from the analysis of the questionnaire survey and the main threats were firewood, cutting of thorny bushes for fencing and charcoal making. All the

Table 6. List of honeybee forage in the Gra-Kahsu PNV.

Scientific name	Family	Life form
Acokanthera schimperi (A. DC.) Benth.	Apocynaceae	T/S
Carissa spinarum (Forssk.) Vahl	Apocynaceae	S
Cynanchum abyssinicum Decn.	Asclepiadaceae	C
Ehretia cymosa	Boraginaceae	T
Maytenus undata (Thunb.) Blakelock	Celastraceae	T
Maytenus senegalensis (Lam.) Excell.	Celastraceae	T/S
Euclea racemosa subsp. *schimperi* (A. DC.) Dandly	Ebenaceae	S
Clutia abyssinica Jaub. And Spach.	Euphorbiaceae	S
Acacia asak (Forssk.) Will.	Fabaceae	T/S
Acacia abyssinica Hochst. ex. Benth.	Fabaceae	T
Pterollobium stellatum (Forssk.) Brenan	Fabaceae	S
Acacia etbaica Schweinf.	Fabaceae	T
Acacia tortilis (Forssk.) Hayne	Fabaceae	T
Acacia albida Del.	Fabaceae	T
Acacia seyal Del.	Fabaceae	T
Dovyalis abyssinica (A. Rich.) Warb.	Flacourtiaceae	T/S
Leucas abyssinica (Benth.) Briq.	Lamiaceae	S
Nuxia congesta R. Br. ex. Fresen	Loganiaceae	T/S
Eucalyptus camaldulensis Dehn.	Myrtaceae	T
Olea europaea subsp. *cuspidate* (Wall. ex. DC.) Cifferri	Oleaceae	T
Rumex nervosus Vahl	Polygonaceae	S
Clematis hirsute Perr and Guill	Ranunculaceae	C
Teclea simplicifolia (Engl.) Verdoorn	Rutaceae	T/S
Pavetta oliveriana Hiern	Rubiaceae	S
Cassipourea malosana (Baker) Alston	Rhizophoraceae	T
Rosa abyssinica Lindely	Rosaceae	S
Dodonaoea angustifolia L. F.	Sapindaceae	S
Solanum schimperianum Hochst. ex. A. Rich.	Solanaceae	S
Dombeyatorrida (J. F. Gmel.) P. Bamps	Sterculiaceae	T/S
Grewiamollis Juss.	Tiliaceae	T/S

respondents agreed firewood was the primary threat of the area followed by cutting of thorny bushes for fencing, and the second threat next to this was charcoal as major threats to the PNV.

Farmers' attitude on communal grazing land

Out of the 60 respondents, the homestead of 49 (81.7%) were situated 1-3 km from the CGL. The rest 15% were 4-6 km away and 3.3% were >7 km from the CGL. This suggests that more than half of the respondents existed close to the CGL. The majority (81.7 %) of the respondents explained that the purposes of CGL in the study area were for animal grazing, farm implement, house construction, and fence and fuel wood collection. However, 18.3% (11) of the respondents used the CGL for animal grazing and fuel wood collection. All of the respondents indicated that disappearance of vegetation cover at the hillside was due to human population increment and overgrazing caused by high livestock pressure. Main factors responsible for the destruction of natural vegetation are a combination of agricultural expansion, free livestock grazing, unsustainable firewood collection and charcoal production (Wassie, 2007). According to the group discussion, due to free grazing and deforestation, there is a significant decrease in the vegetation coverage of CGL from time to time.

More than half of the respondents (55%) agree that the degree of soil erosion in the CGL was moderate (gully and rill), but 30% (18) and 15% (9) of the farmers agree that the degree of soil erosion in the CGL was severe (gully and George) and minimum (rill and sheet), respectively. Tree planting and establishment of protection practices for natural vegetation (41.7%) were the options to re-vegetate the CGL in the study area. However, only 38.3% (23) of the farmers agree with the practice of rehabilitation of the CGL through

establishment of practices to protect natural vegetation, since this is the longest lasting resource access land with no restriction to the community.

Conclusion

Apart from the plant species diversity and soil organic carbon improvement, the local community has benefited from protecting natural vegetation in the form of various affordances and resources such as forage for livestock, provision of energy for cooking and heating in the form of wood fuel and charcoal and farmland protection from clotting with silt and mud from the upper catchments. Feed, firewood, food, house construction materials, medicinal plants and reduced rate of erosion on and off sites of the protected natural vegetation due to the increment of vegetation cover provides evidence that communities around the area are gaining benefits both in the form of products and services. Majority of the farmers support the government's conservation activity. The high level of awareness and favorable attitude of local people towards protecting natural vegetation could be explained from the fact that most people depend on the natural resources and other materials obtained from protecting natural vegetation.

Recommendations

Forage supply of protecting natural vegetation through cut-and-carry system is reducing year-by- year due to closure of the growing tree canopy, thus it would be important to integrate the introduction of productive forage species with soil and water conservation measures. Incorporation of integrated farming practices with protecting natural vegetation development including off-farm activities is recommended. Encouraging greater use of apiculture is very crucial.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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