

**ECOLOGICAL EVALUATION OF PLANT RESOURCES AND
VEGETATION STRUCTURE OF CHAIL VALLEY, DISTRICT
SWAT, PAKISTAN**

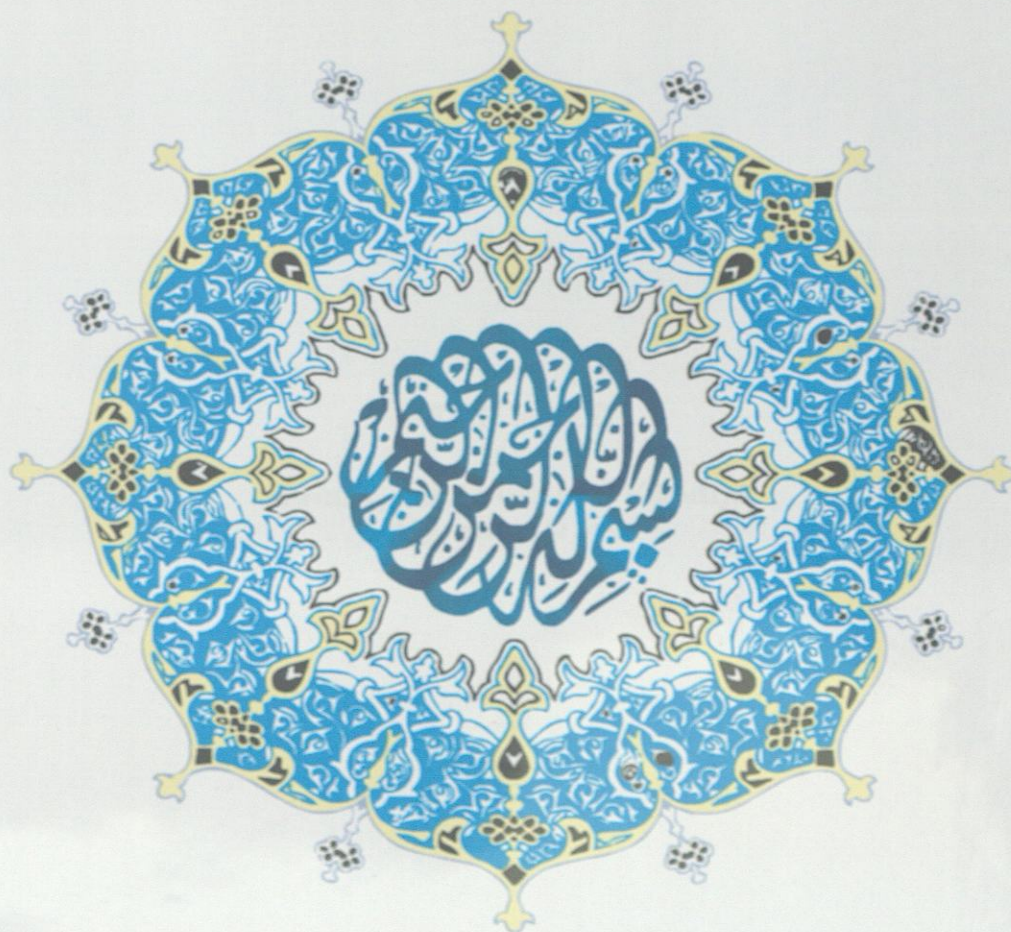


BY

ASGHAR ALI

**DEPARTMENT OF BOTANY
UNIVERSITY OF PESHAWAR
2017**

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In the Name of Almighty

"ALLAH"

The Most Beneficent, the Most Merciful

University of Peshawar

Peshawar

ECOLOGICAL EVALUATION OF PLANT RESOURCES AND
VEGETATION STRUCTURE OF CHAN VALLEY, DISTRICT SWAT,
PAKISTAN

DEDICATED

to

Hamza, Ali Abbas and Khadija

My reasons to live

University of Peshawar

Peshawar

ECOLOGICAL EVALUATION OF PLANT RESOURCES AND
VEGETATION STRUCTURE OF CHAIL VALLEY, DISTRICT SWAT,
PAKISTAN

A dissertation submitted in partial completion
of the requirement for the degree of
Doctor of Philosophy

in

Botany

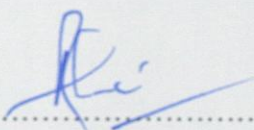
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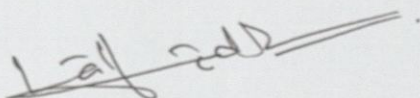
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ABSTRACT

The present study was carried out during 2012-2015 to enumerate the floristic and ecological characteristics of plants of Chail Valley, District Swat. A total of 463 species were recorded belonging to 104 families. Leading families were Asteraceae (42 Spp.), Poaceae (35 Spp.), Rosaceae and Lamiaceae (each with 26 Spp.), Papilionaceae (25 Spp.), Brassicaceae and Boraginaceae (each with 16 Spp.), Apiaceae (14 Spp.), Solanaceae (13 Spp.) and Ranunculaceae (12 Spp.). Each of the remaining families had less than 12 species. Therophytes were dominant life form with 188 species (40.60%) followed by hemicryptophytes (77 species, 16.63%) while *Cuscuta europaea*, *C. reflexa* and *Viscum album* (Mistletoe) were the three shoot parasites. The leaf spectra was dominated by mesophylls (147 Spp; 31.75%) followed by microphylls (140 Spp.; 30.24%) and nanophylls (136 Spp.; 29.37%). Two species were aphyllous. Majority of the species (305 Spp., 65.87%) had simple lamina while eight species (1.73%) had spiny leaves.

Soil analysis revealed that textures ranged from loamy sand to silt loam and loam. Soil pH ranged from 5.2 to 6. The organic contents varied from 1.38% to 2.48% among the sites. Highest CaCO_3 contents were found at Bishigram (10%) while lowest in the Chail village (2.5 %). EC ranged from 0.023 to 0.08 dsm^{-1} . TDS estimated were 16 ppm up to 51 ppm. Soil moisture contents were recorded between 0.12% to 0.18%. Nitrogen contents ranged from 0.069% to 0.138%. Phosphorous, Potassium, Calcium, Magnesium, Cobalt, Manganese, Copper and Zinc levels were in moderate ranges. Sodium levels were high with maximum value of 16161 $\mu\text{g/g}$ recorded from Dabargai. Iron levels were considerably high in all sites with maximum values at Chail village (46845 $\mu\text{g/g}$). Aluminum levels ranged from 49339 $\mu\text{g/g}$ up to 60326 $\mu\text{g/g}$. Barium levels were in tolerable range at all sites. Among heavy metals Titanium showed highest values viz. 1438 $\mu\text{g/g}$ to 1708 $\mu\text{g/g}$. Sulphur, Chloride, Vanadium, Chromium, Nickle and Cadmium were low in the investigated sites. Lead levels were high at Bishigram (89 ppm). Traces of Silver were also very high especially at Bishigram (5.1 ppm).

Phytosociological study summed up 15 communities, 5 each for trees, shrubs and herbs. Among tree species highest Family Importance Value was recorded for Pinnaceae (190.85) and lowest for Anacardiaceae (2.39). For shrubs Rosaceae (101.44) had highest FIV and lowest for Rubiaceae (1.89). For herbaceous members highest FIV was recorded for Poaceae (182.15) and lowest for Paeoniaceae (0.42). Three communities viz. *Pinus- Diospyros- Quercus* community, *Indigofera- Cotonaster-*

Jasminum community and *Apluda-Cynodon-Heteropogon* community were established at Chail village site. While Chail valley floor comprised *Pinus-Quercus-Juglans*, *Rubus-Isodon-Ricinus* and *Apluda-Heteropogon-Poa* communities. Community structure was quite different at Shanku site which established *Quercus-Abies-Pinus*, *Sarcococca-Daphne-Berberis* and *Cynodon-Apluda-Bergenina* communities respectively. Similarly, *Cedrus-Abies-Pinus*, *Parrotiopsis-Viburnum-Berberis* and *Chrysopogon-Themeda-Cynodon* communities were established at Dabargai. At Bishigram, *Picea-Pinus-Abies*, *Parrotiopsis-Cotoneaster-Indigofera* and *Cenchrus-Medicago-Rumex* communities were present. Ward's clustering technique, PCA and NMS separated the trees vegetation into three and understory vegetation into four distinct groups. PCA ordination axis of trees were significantly correlated with EC, TDS, pH, CaCO₃, P, Na, V, Pb, S, SO₄, Cd and Cu, while that of understory vegetation, PCA axis were significantly correlated with CaCO₃, TDS, V, Ag, Cd, S, SO₄ and P. NMS ordination axis of understory vegetation showed significant correlation with pH and Cu.

Study on ethno-conservational aspects documented 174 plants along with their Relative Frequency of Citation and FIV. Highest FIV was recorded for Pinnaceae (23.97) among gymnosperms, Alliaceae (33.56) in monocotyledons and Lamiaceae (97.94) in dicotyledons. Traditional uses of these medicinal plants were documented. Ethno-flora had a poor conservation status with 107 rare species, 42 vulnerable species and 24 infrequent species, following IUCN criteria.

Plant palatability was assessed by classifying plants into five palatability classes. Mineral profile of five plant species was enumerated at pre-reproductive and post-reproductive stages in *Aristida cyanantha*, *Andrachne cordifolia*, *Quercus baloot*, *Indigofera heterantha* var. *heterantha* and *Cotoneaster nummularia*. Except P, K, Cu and Zn other mineral contents showed increase in post-reproductive stage in *A. cyanantha*. In *A. cordifolia* mineral contents decreased with increasing age of the plant. In *Q. baloot* K, Ca, S and Ba levels were low in post-reproductive stage. A marked increase in P, K, Mg, Ca and S contents was observed in *I. heterantha* var. *heterantha* at maturity. For *C. nummularia* significant decrease was recorded in P, Mg, Ca, Cu, Na, Si and Ba contents in post-reproductive stage.

Table of contents

	Page
1. Introduction	
1.1 District Swat	1
1.2 Chail valley	1
1.2.1 Location	1
1.2.2 Area	2
1.2.3 Geology	2
1.2.4 Population	2
1.2.5 Social composition	4
1.2.6 Languages	4
1.2.7 Education	4
1.2.8 Livelihood	4
1.2.9 Fauna	5
1.2.10 Natural resources	5
1.2.11 Climate	5
1.3 Objectives of the study	8
2. Literature review	9-29
a. Floristic composition and ecological attributes	9-11
b. Edaphology	11-12
c. Phytosociology	12-19
d. Ethnobotany	19-22
e. Palatability of vegetation	23-25
f. Chemical evaluation of forage plants	25-29
3. Materials and Methods	30-38
3.1 Floristic structure and ecological attributes	30
3.1.1 Biological spectra	30
3.1.2 Leaf size spectra	31
3.2 Edaphology	31
3.2.1 Soil texture	32
3.2.2 pH	32
3.2.3 Organic matter	32
3.2.4 Calcium carbonate	32
3.2.5 Electrical conductivity	32
3.2.6 Total dissolved solids	32
3.2.7 Available water	32
3.2.8 Chloride	32
3.2.9 Sodium absorption ratio	32
3.2.10 Sulphates	32
3.2.11 Elemental analysis	33
3.2.11a Sample preparation	33
3.2.11b Analysis	33
3.3 Phytosociology	33
3.3.1 Density	35
3.3.2 Herbage cover	35
3.3.3 Frequency	35
3.3.4a Importance value	36
3.3.4b Family importance value	36
3.3.5 Maturity index	36
3.3.6 Similarity index	36
3.3.7 PC-Ord analysis	36

3.4 Ethnobotany	37
3.5 Chemical analysis of selected forage plants	37
3.5.1 Sampling	37
3.5.2 Microwave digestion	38
3.5.3 Mineral analyses	38
4. Results and discussion	39-203
4.1. Floristic composition and ecological attributes	39-58
4.1.1 Life form	40
4.1.2 Leaf size spectra	42
4.1.3 Habitat	42
4.2. Edaphology	59-73
4.2.1 Soil texture	60
4.2.2 Physicochemical characteristics	61
4.2.3 Macronutrients	63
4.2.4 Micronutrients	65
4.2.5 Heavy metals	67
4.3. Phytosociological attributes of Chail valley	74-138
4.3.1 Chail Village (Stand I)	75
1. <i>Pinus-Diospyros-Quercus</i> community	75
2. <i>Indigofera-Cotoneaster-Jasminum</i> community	77
3. <i>Apluda-Cynodon-Heteropogon</i> community	77
4.3.2 Chail valley floor (Stand II)	78
1. <i>Pinus-Quercus-Juglans</i> community	78
2. <i>Rubus-Isodon-Ricinus</i> community	79
3. <i>Apluda-Heteropogon-Poa</i> community	79
4.3.3 Shanko (Stand III)	79
1. <i>Quercus-Abies-Pinus</i> community	80
2. <i>Sarcococca-Daphne-Berberis</i> community	80
3. <i>Cynodon-Apluda-Bergenia</i> community	81
4.3.4 Dabargai (Stand IV)	81
1. <i>Cedrus-Abies-Pinus</i> community	81
2. <i>Parrotiopsis-Viburnum-Berberis</i> community	82
3. <i>Chrysopogon-Themeda-Cynodon</i> community	82
4.3.5 Bishigram (Stand V)	82
1. <i>Picea-Pinus-Abies</i> community	83
2. <i>Parrotiopsis-Cotoneaster-Indigofera</i> community	83
3. <i>Cenchrus-Medicago-Rumex</i> community	84
4.3.6 Maturity index	84
4.3.7 Index of similarity	84
1. Tree communities	84
2. Shrub communities	85
3. Herbaceous communities	85
4.3.8 PC-Ord analysis	104
4.3.8a Ward's cluster analysis for tress	104
Cluster I. <i>Pinus wallichiana-Diospyros lotus</i> community	104
Cluster II. <i>Pinus wallichiana-Quercus baloot</i> community	105
Cluster III. <i>Abies pindrow-Pinus wallichiana</i> community	105
4.3.8b Ward's cluster analysis for understory vegetation	109
Group I. <i>Cynodon dactylon-Apluda mutica</i> community	109

Group II. <i>Parrotiopsis jaquemontiana</i> - <i>Viburnum grandiflorum</i> community	110
Group III. <i>Cenchrus pennisetiformis</i> - <i>Cotoneaster nummularia</i> community	111
Group IV. <i>Rubus ulmifolius</i> - <i>Isodon rugosus</i> community	112
4.3.9a Principle component analysis for Trees	119
Correlation of PCA axis of trees with edaphic variables and nutrients	119
4.3.9b Principle component analysis for understory vegetation	123
Correlation of PCA axis of understory vegetation with edaphic variables and nutrients	125
4.3.10 NMS ordination of understory vegetation	127
Correlation of NMS axis of understory vegetation with edaphic variables and nutrients	127
Correlation among edaphic and mineral parameters	130
4.4 Ethnobotany and conservation status of medicinal plants	139-160
4.4.1 Conservation status	140
4.4.2 Family importance value	140
4.4.3 Relative frequency of citation	141
4.4.4 Recommendations	143
4.5 Palatability and chemical evaluation of forage plants	161-203
4.5.1 Palatability and related characteristics	162
4.5.2 Chemical analysis of some selected plants	186
4.5.2.1 <i>Aristida cyanantha</i> Nees ex Steud	186
4.5.2.2 <i>Andrachne cordifolia</i> (Wall. Ex Dcne.) Muell. Arg	187
4.5.2.3 <i>Quercus baloot</i> Griffith	188
4.5.2.4 <i>Indigofera heterantha</i> Wall. Ex Brandis var. <i>heterantha</i>	188
4.5.2.5 <i>Cotoneaster nummularia</i> Fisch. & Mey.	189
Conclusions	204
Recommendations	206
References	207-240

List of Figures

Fig.	Table	Page No:
1	Map of study area	3
2	Life form spectra	58
3	Leaf form spectra	58
4	Soil texture	73
5	Map of monitoring sites showing quadrates	76
6	PCA ordination axis 1, 2 of stands of tree species in relation to edaphic variables and soil nutrients	120
7	PCA ordination axis 1, 3 of stands of tree species in relation to edaphic variables and soil nutrients	120
8	PCA ordination Axis 2, 3 of stands of tree species in relation to edaphic variables and nutrients	121
9	PCA ordination Axis 1, 2 of stands of understory species in relation to edaphic variables and soil nutrients	123
10	PCA ordination Axis 1, 3 of stands of understory species in relation to edaphic variables and soil nutrients	124
11	PCA ordination Axis 2, 3 of stands of understory species in relation to edaphic variables and soil nutrients	124
12	NMS ordination plot of understory species in relation to edaphic variables and soil nutrients	128
13	Family importance value	160
14	Conservation status of medicinal plants	160
15	Highest scores for RFC	160
16	Palatability classes	192
17	Macro- Micronutrients and trace element analysis of <i>Aritida cyanantha</i>	198
18	Macro- Micronutrients and trace element analysis of <i>Andrachne cordifolia</i>	199
19	Macro- Micronutrients and trace element analysis of <i>Quercus baloot</i>	200
20	Macro- Micronutrients and trace element analysis <i>Indigofera hetaerantha</i> var. <i>heterantha</i>	201
21	Macro- Micronutrients and trace element analysis of <i>Cotoneaster nummularia</i>	202
22	Mean values for minerals in all plants analyzed	203

List of Tables

Table	Title	Page No:
1	Area of the Chail Valley	2
2	Population & Household Size of Chail Valley	4
3	Meteorological data of Chail Valley and adjoining areas	7
3.1	Reference range for mineral analysis in soil	34
3.2	Cover classes	35
3.3	Plant species selected for chemical analysis	37
3.4	Reference range for mineral analysis	38
4.1	Floristic list and ecological attributes of Chail valley	44
4.2	Ecological characters of Chail valley Swat	56
4.3	Life form and Leaf size spectra	57
4.4	Soil texture	70
4.5	Physicochemical characteristics	70
4.6	Macronutrients in soil	70
4.7	Micronutrients in soil	71
4.8	Heavy metals in soil	71
4.9	Summary of ANOVA for edaphic variables	72
4.10	Results of ANOVA for edaphic variables	72
4.11	FIV data for the families	88
4.12	IVI data for Plant communities of Chail valley	91
4.13	Maturity index	102
4.14	Similarity index of tree communities	102
4.15	Similarity index of shrubby communities	102
4.16	Similarity index of herbaceous communities	103
4.17	Clusters of trees vegetation obtained through Wards cluster analysis	107
4.18	Edaphic variables and soil nutrients associated with different associations of trees	108
4.19	Associations of understory vegetation obtained through Wards cluster analysis	113
4.20	Edaphic Variables and soil nutrients associated with groups of understory vegetation	118
4.21	Correlation of PCA Ordination axis of trees vegetation with edaphic parameters and soil nutrients	122
4.22	Correlation of PCA ordination Axis 1, 2 and 3 of understory vegetation with edaphic variables and soil nutrients elements	126

4.23	Correlation of NMS ordination Axis of understory vegetation with edaphic variables and soil nutrients	129
4.24	Correlation of edaphic and mineral parameters	138
4.25	Ethnomedicinal plants, RFC, FIV and their conservation status	145
4.26	Palatability and related characteristics	165
4.27	Forage plants selected for chemical analysis	186
4.28	Mineral profile of <i>Aristida cyanantha</i>	193
4.29	Mineral profile of <i>Andrachne cordifolia</i>	194
4.30	Mineral profile of <i>Quercus baloot</i>	195
4.31	Mineral profile of <i>Indigofera heterantha</i> var. <i>heterantha</i>	196
4.32	Mineral profile of <i>Cotoneaster nummularia</i>	197

INTRODUCTION

1.1 District Swat

Swat, an area of matchless natural beauty, was known as "Udyana" when Buddhism flourished in this region. Word "Udyana" means a lush green meadow. Swat is often termed as Switzerland of Asia, is an important tourist attraction. Buddhists enriched the culture of the land and later this area became a bounty for several invaders. Alexander of Macedonia invaded the area in 327 BC and his official historian Aryaan has given detailed accounts of Swat Valley in his chronicles. Swat in 2 BC was ruled by son of Great Ashuk, Prince Kunal who used to rule this region from Takhtbhai, Mardan. In 11th century Raja Gira was the King of this region who was overpowered by Mehmud of Ghazna. Ultimately Yousafzais took Swat and they still dominate the Swat valley to date in terms of population.

Geographically the District Swat is located from 34° 34' to 35° 55' North latitudes and 72° 08' to 72° 50' East longitudes. To its North are Districts of Chitral and Ghizer, on the East it is bounded by Districts of Kohistan and Shangla, towards South of Swat valley are District Buner and Malakand Agency and in its West there are District Lower and Upper Dir. Whole of the Swat is bisected by river Swat, which majestically flows throughout the length of the valley.

Swat remained a princely state till 1969, after which it got merged into Islamic Republic of Pakistan. Founder of Swat state was popularly known as "Badshah Sahib". Rulers of Swat were visionary and progressive, unlike other rulers of such princely states. They developed a sprawling network of Educational institutions and hospitals throughout the Swat valley. Their secular and kind attitude encouraged minorities like Hindus and Sikhs to live peacefully in Swat and even to date they play a constructive and positive role in the Valley. Swat can be topographically divided into two regions, 1. Swat-Kohistan and 2. Swat proper (District census report of Swat, 1998). Swat-Kohistan region falls under Kalam Forest Division which comprises of Utror, Kalam and Madyan including Chail Valley.

1.2 Chail Valley

1.2.1 Location

Chail valley is situated to the East of Madyan and is at a distance of 50 km from District headquarters Saidu Sharif. Chail valley comprises of four main villages (Fig. 1):

1. Chail
2. Bishigram
3. Dabargai, and
4. Shinku.

The valley shares its borders with Mankial and Gornay in North, in its East are located Dubeer and Lelawanai while in its North is Pia. The Chail valley is located between $72^{\circ} - 36'$ E longitude and $35^{\circ} - 09'$ N latitude. Its elevation varies from 1375 m to 4270 m from sea level.

1.2.2 Area

Total area of the Chail valley is 24148 acres. Out of this 18418 acres of land is included in the category of protected forests while Barani areas and agricultural land contributes 2025 acres. Only 1289 acres are the irrigated lands. A detail of the total area of the main villages of the valley is given in Table. 1.

Table.1 Area of the Chail Valley

S.No	Village	Total area (Acres)	Forest (Acres)	Rangeland (Acres)	Rainfed area (Acres)	Irrigated area (Acres)
1	Chail	1813	750	423	288	352
2	Bishigram	10689	8893	681	847	268
3	Dabargai	4957	3842	1412	226	275
4	Shinku	6689	4933	698	664	394
Total		24148	18418	3214	2025	1289

(Source: NWFP FSP 2001)

1.2.3 Geology

Rocks in the valley are mainly composed of quartz, ultramaphic and pegmatite. Parent material seems to have originated from sedimentary rocks. Soil is mostly of residual and transported type. Soil in the valley varies in texture from one location to another but mostly it is loamy sand, silt loam and loam. In recent times removal of vegetation cover has paved way for soil erosion which is modifying the top soil and its impacts are visible in the valley.

1.2.4 Population

According to District census report of 1998, total population of the Chail valley is 13761, out of which 6913 are male and 6848 are female. Chail is a rural area but fast transforming into a modern town. The percolation effects of development in nearby Madyan are visible in Chail valley and most of the Chail valley people have

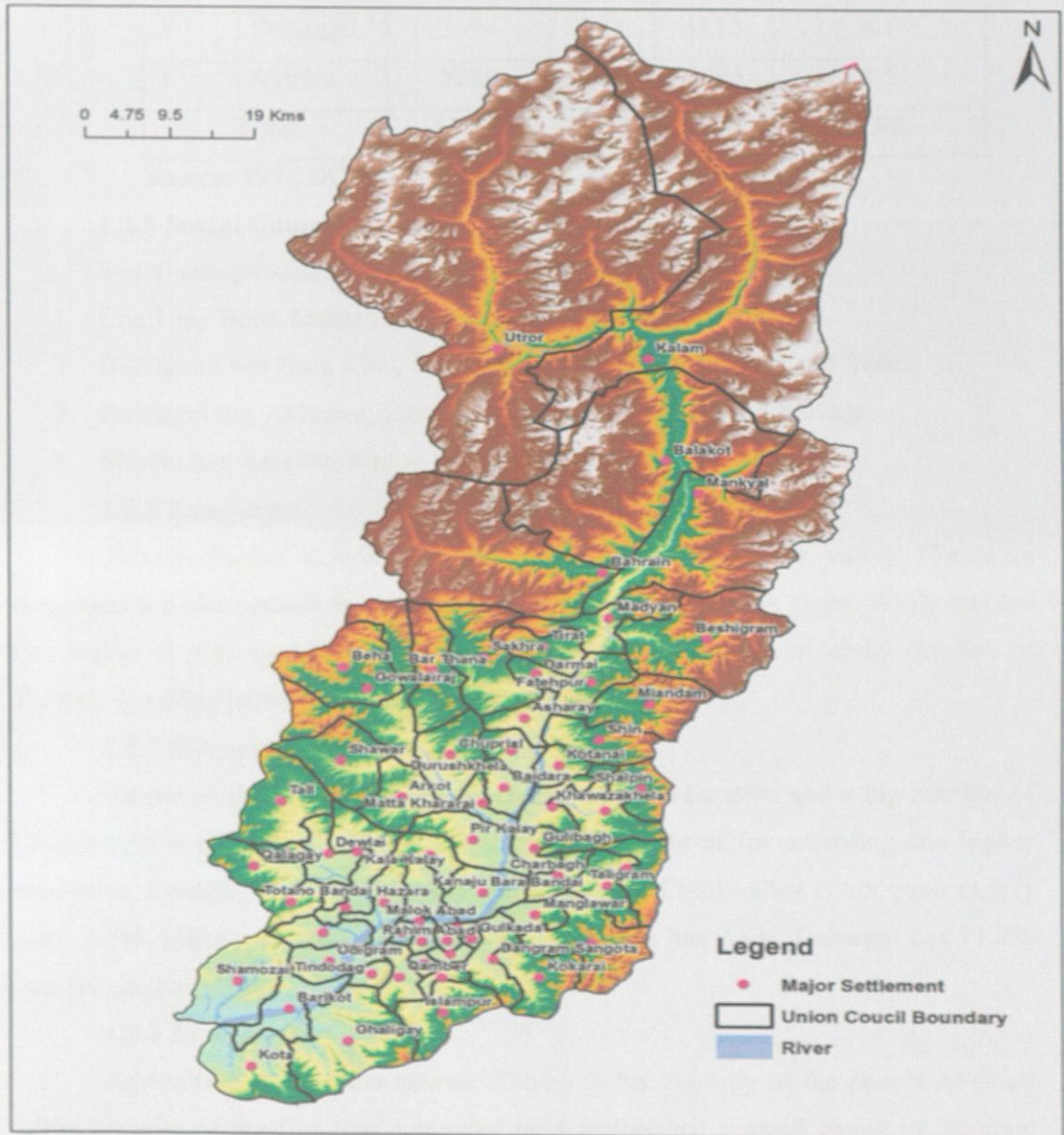


Fig 1. Map of the study area

access to modern facilities. A breakup of Chail valley population is given in Table. 2.

Table. 2 Population & Household Size of Chail Valley

S. No	Village	Population	Males	Female	Household size
1	Chail	3712	1864	1848	6.5
2	Bishigram	2673	1312	1361	7.1
3	Dabargai	2096	983	1113	6.1
4	Shinku	5280	2754	2526	8.5
Total		13761	6913	6848	7.05

Source: 1998 DCR Swat

1.2.5 Social Composition

Social complexion of the Chail valley is quite diverse.

1. Chail has Bore, Danorh, Dre Khel and Gorniwal.
2. Bishigram has Bara Khel, Gorniwal, Kala Khel, Kashkary and Swati.
3. Dabargai has Akhtaror, Bargat, Dador, Danor, Avan and Mullahs.
4. Shinku has Arashot, Kador, Bijor, Avan and Jator.

1.2 6 Languages

Though Pashto is widely spoken and understood in the valley, Kohistani languages are also spoken by the locals. Ajars and Gujjars speak Gujri. While Kalami i.e., Garwi is also spoken by few families living in this area. A small fraction of Torwali speaking people is also present in the valley.

1.2.7 Education

People of the valley are now more inclined to education and a big number of Chail youth is in Mingora, Saidu Sharif or even Peshawar for schooling and higher education. Despite of this the average literacy rate of Chail valley is not good as it is just 12.2%. Literacy rate of Chail is 22.1%, Bishigram has 7.8%, Dabargai has 11.2% and Shinku has 7.9 %.

1.2.8 Livelihood

Agriculture is the main source of income for majority of the people of Chail valley despite of the fact that cultivated land makes just a small chunk of the total area. Fuel wood is obtained from forest and this is worst of all the biotic pressures on the ecosystem. Few poultry forms are also seen and quite a few are eyeing this flourishing business. Before 2010 flood there were a total of eight fish farms which mostly cultured Trout. Floods damaged these fish farms big time and few of them

were completely washed out. Some NGOs also tried to develop cottage industry of mushroom farming but it never gained popularity among the locals.

1.2.9 Fauna

Chail valley is known to be home of a variety of wild animals like Bears, Monkeys, Jackals, Deer, Foxes, Rabbits, Vampire bats (Flying fox), Black and Gray Partridges, Flying Squirrels, Pheasants etc. Some locals speak of the presence of Leopards in the mountains. Deforestation is playing havoc with the wild life and habitat destruction is telling upon the biodiversity. Forest fires are also a factor responsible for decreased biodiversity.

1.2.10 Natural Resources

Valley is rich in wild medicinal plants and locals collect them and market them in Madyan and Mingora. These medicinal plants are also used by local healers. Some NGOs have designed projects on proper collection of these medicinal plants to educate people as well as to minimize the threat of extinction by improper collection. Mushrooms of different varieties grow wild in the valley and they are collected and sold by the locals in Madyan as well as Mingora. In recent years Apiculture is gaining popularity in the valley. Few years back only bee-keepers from down districts use to come to the valley but now few locals are also making a living out of it.

1.2.11 Climate

Most of the valley falls under the category of Moist Temperate region with very cold winters and pleasant summers. During winters the population from high altitudes is compelled to migrate to lower parts of the valley where they stay till the end of winter. The area is mostly mountainous and possesses moderate to steep slopes and fertile soils. The parent rock is said to be plutonic, sedimentary, metamorphic and volcanic. Climatic data of Chail valley is presented in Table. 3. In the study area May, June and July are the hottest months in terms of temperature when temperature may touch 24.6 °C. Even in August the temperatures are around 21 °C. Meteorological data collected for the years 2011, 2012 and 2013 indicate clearly that temperatures never exceeded 22.6 °C. Winters are harsh in this region and coolest months are December, January and February. Lowest temperature recorded over a span of three years i.e. from 2011 to 2013, was -5.4 °C in January 2012. Same year mean minimum temperature of -5.6 °C was recorded in February. The meteorological data collected indicates that temperature ranges between 0 °C to -5.6 °C during the months of December to February. Lower elevations of the valley fall under moist temperate zone

which have considerably high rainfall. The area receives maximum precipitation from months of January to September. In February 2013, 380 mm of rainfall was recorded while next highest downpour was recorded in April 2012 i.e. 273.5 mm. Year 2011 was comparatively a dry year, and April 2011 was driest month with just 2 mm of rainfall recorded. Atmospheric humidity is higher in months of January, February, March, April, August and September. In year 2011 highest value for atmospheric humidity was recorded i.e. 86, while lowest values were observed during June 2012 i.e. 44. Mean wind speed data shows that wind velocity is highest during months of January, February and March. Highest wind speed was recorded during January and March 2013 i.e. 0.5 knots. Lowest values were observed during May, July and August 2013 i.e. 0.1 knots. Wind speed data for the years 2011 and 2012 was not available. The region receives snowfall during the months of November, December, January, February and March. The collected data indicates that February 2013 received maximum snowfall i.e. 180.5 inches, which is highest value recorded in the decade so far. In February 2011 the snowfall was recorded as 101.5 inches.

[illegible]

1.3 OBJECTIVES

This study will be carried out to achieve following objectives:

1. To prepare floristic list along with ecological characteristics.
2. To know the present status of vegetation structure.
3. To characterize the relationship between local flora and community in terms of:
 - a) Fuel wood
 - b) Forage plants
 - c) Medicinal plants
 - d) Timber, and any other utility
4. To evaluate the availability and palatability of fodder plants in relation to animals.
5. To investigate the edaphology of the area in relation to vegetation.
6. To enumerate some key palatable plants chemically and nutritionally at different phenological stages.

REVIEW OF LITERATURE

a. Floristic Composition and its Ecological Attributes

Mark *et al.* (2001) reported 80 vascular plants from the alpine zone vegetation in Southern Tierra and collected data on vegetation cover and life forms. Antje (2002) compared between Inselberg floras and studied their dependence on environmental factors at macroscale level. Batalha & Martins (2002) prepared Raunkiaer's life-form spectra of diverse vegetation types in Brazil. Gutkowski *et al.* (2002) prepared floristic list of plants from Dynow foothills. Kwiatkowski (2002) recorded 600 species from Kaczawskie Mountains and Plateau in Western Sudety Mountains, Poland. 160 of these species were rare. Luis *et al.* (2002) reported 46 plant species from Cufada Lagoon, Guinea-Bissau. Antje *et al.* (2003) investigated the plant biodiversity in southern African Nama Karoo. Changwe & Balkwill (2003) documented 254 plant species from Dunbar Valley in the Barberton Greenstone Belt. The reported 2% endemism in their study area. Lehnebach (2003) prepared a preliminary checklist of Orchids found in Chile. He listed 7 genera and 50 species out of which 25 are endemic to Chile. Musila *et al.* (2003) reported 156 plant species from coastal dune vegetation of Kenya. Eilu *et al.* (2004) documented 574 species from Albertine Rift, Western Uganda. Gimenez *et al.* (2004) reported 516 plant species from Iberian Peninsula. Golluscio *et al.* (2005) worked out the relationship between phenology and life form. They stated that phenology and life form collectively determine the ability to use resources. Mendez (2005) recorded 240 plant species and their life forms from Laguna de Llanqueto Provincial Reserve, Argentina. Muoghalu & Okeesan (2005) collected 49 climbers from northern Chobe National Park, Botswana. Muthuramkumar *et al.* (2006) reported 312 plant species from tropical rain forest fragments of the Western Ghats, India. Ssegawa & Nkuutu (2006) recorded 179 species from Ssesse islands in Lake Victoria, Central Uganda. Costa *et al.* (2007) listed 133 species belonging to 47 families while studying the flora and life-form spectrum in an area of deciduous thorn woodland (Caatinga) in Northeastern, Brazil. Laidlaw *et al.* (2007) reported Meliaceae, Euphorbiaceae, Lauraceae, Myrtaceae and Apocynaceae as dominant plant families from tropical rain forests. Yadav & Gupta (2007) studied the impact of micro-environmental factors on species richness of herbaceous flora in Rajasthan, India. Francisco *et al.* (2009) documented 46 species from 12 genera of Commelinaceae from Equatorial Guinea. Manhas *et al.* (2010) listed 206 species belonging to 159 genera and 59 families from Pathankot, Hoshiarpur and Garhshanker, India. Alsherif *et al.* (2013)

reported 251 plant species belonging to 160 genera and 50 families from Khulais region, Western Saudi Arabia.

In Pakistan work on the floristic listing, composition and ecological characteristics has been done which is reviewed as follows.

Stewart (1967) was the first worker to prepare the floristic list of Northwest Pakistan including Swat. Bhatti *et al.* (2001) reported 150 plant species belonging to 110 genera and 42 families from Nara desert including one species of gymnosperm, 3 sedges and 20 grasses. Malik & Malik (2004) documented 58 plant species from subtropical chir-pine vegetation of Kotli Hills, Azad Jammu and Kashmir. Out of these 9 species were woody, 13 shrubby and the remaining 36 were herbaceous. Durrani *et al.* (2005) investigated the Harboi rangeland Kalat and documented 202 species of plants, their life form and leaf form spectra. Qureshi & Bhatti (2005) conducted a floristic survey in Nara desert Pakistan and reported 160 plant species belonging to 118 genera and 45 families. Qureshi & Bhatti (2006) prepared a floristic check list of monocotyledons in Nara desert. They reported 25 plant species of monocotyledons from Nara Desert. Perveen *et al.* (2008) investigated the plant biodiversity and phytosociological attributes of Dureji (Khirthar Range). They reported 79 species from 32 families. Three of these species were rare. Quantitative attributes and phenology were documented. Qureshi & Bhatti (2008a) gave first records of five species of the genera *Anticharis*, *Bacopa*, *Kickxia* and *Schweinfurthia* from Nara Desert. Qureshi and Bhatti (2008b) identified five habitats for plant communities from Nara desert, Pakistan. Species composition was found to be different in different habitats. Hussain *et al.* (2009) reported 69 species belonging to 29 families from District Chakwal. Durrani *et al.* (2010) studied the ecological characteristics and floristic composition of Aghberg range lands of Quetta Pakistan. They described 123 plant species.

In Khyber Pakhtunkhwa Province too some work on the floristic composition is available.

Marwat & Qureshi (2000) listed 383 species belonging to 110 families from upper Siran reserved and guzara forests, District Manshera. Sher *et al.* (2003) reported 78 plant species of medicinal value from Udigram, Swat. Hussain *et al.* (2005) listed 92 species of 56 families from Ghalegay Hills, District Swat. They also recorded their life form and leaf form spectra. Sher & Khan (2007) prepared a floristic inventory of plants of Chagharzai Valley, Buner and listed 222 species. Zabihullah *et al.* (2007) documented 279 plant species from Manzaray Baba Valley Malakand Agency. They

documented 279 species belonging to 229 genera and 81 families. Fazal *et al.* (2010) produced a checklist of phanerogamic flora of District Haripur. They recorded 211 species belonging to 170 genera and 66 families. Saima *et al.* (2010) reported 167 species of 139 genera from 65 families from Ayubia National Park Abbottabad. Badshah *et al.*, (2013) worked on flora of Tank and prepared a floristic inventory. They recorded 205 species from the area. They found that threophytes and hemicryptophytes were dominant life forms. Ahmad *et al.* (2014) reported 50 plants of medicinal value from Chail valley.

b. Edaphology

Several references are available on edaphology, from abroad.

Tug & Duman (2010) evaluated the accumulation of heavy metals in soils around a salt-lake, Turkey. They estimated the levels of Pb, Cr, Cu, Mn, Ni, Zn and Cd. Fardous *et al.* (2011) investigated the levels of Fe, Co and Mn in soils at a rural livestock farm in Sargodha. They also enumerated the same minerals in forage. Wu *et al.* (2011) enumerated soil salinity, soil moisture and soil pH from Hangzhou Bay, China. They reported a positive correlation between altitude and vegetation while a negative correlation was observed with soil salinity and moisture. Chamizo *et al.* (2012) reported that biological soil crusts influence the water holding capacity, organic carbon, nitrogen content and soil aggregate stability. Shah *et al.* (2012) analyzed soil samples from 51 citrus orchards in Swat valley. This study was focused on estimation of Zn, Cu, Fe, Mn and B. Soil samples were found to be deficient in Zn, Fe and Mn while Cu and B were found to be in adequate concentrations. Daur & Bakhshwain (2013) the impact of humic acid on growth and fodder quality of maize. Anyasi & Atagana (2014) studied edaphic parameters and their effect on growth of *Chromolaena odorata*. They concluded that the plant showed good responses cow manure as an amendment.

In Pakistan the work on edaphology is described below:

Khan *et al.* (2004) studied the in soil samples from semiarid region of Pakistan for the concentrations of Ca, Mg, K and Na. In most of the samples Na was found to be deficient in soil as well as forage. Khan *et al.* (2005) evaluated the concentrations of Cu, Zn, Fe, Co, Mn and Se. They reported that variations in Cu, Zn and Se were observed in different sampling periods. Concentration of Fe, Zn, Co and Se were higher in winter season while in Cu and Mn were low. Hamid *et al.* (2006) studied the effect of soil pH on growth and rooting on *Camellia sinensis*. Loan *et al.* (2006) estimated lead content from various localities of Rawalpindi. Ashraf & Ali (2007) studied the

effects of Ag, Zn and Pb on soil microorganisms and Been seed germination. Ag was found to be of highest toxic value as its minimum concentration appeared to inhibit the growth of soil microbes. Higher levels of Ag also delayed the seed germination in Beens. Khan *et al.* (2007) analyzed soil samples to estimate the Ca, Na, Cu and Zn levels. They studied the seasonal variation in concentration of these elements in soils of their study area; Ca and Cu values were higher in winter season. Arain *et al.* (2000) studied the physicochemical attributes of soil in Nawabshah. They correlated the yield of Sugarcane with that of organic matter, pH, electrical conductivity, exchangeable Na and Na absorption ratio. Raza *et al.* (2005) studied the effects of sub-soil compaction on soil properties, nutrient uptake and yield of Maize. Lodhi *et al.* (2009) studied the impact of changes mineral contents of the soil in relation to salinity, moisture and temperature. Malik *et al.* (2010) estimated the heavy metal contamination in soil and few wild plants from the industrial area of Islamabad. They assessed the total contents of Pb, Cu, Zn, Co, Ni and Cr in soil and plants selected. Levels of Co were found to high while those of Cu were the lowest. Arshad *et al.* (2011) studied the correlation between Cu and Zn availability with soil texture. Ahmad *et al.* (2012) estimated Fe and Zn concentrations in soil under semiarid environmental conditions. According to their study highest value of Fe appeared to be 3 mg/kg while that of Zn was 1 mg/kg. Noor & Khatoon (2013) correlated the vegetation dynamics with that of soil's physicochemical characteristics. They determined the soil texture, pH, electrical conductivity, total dissolved solutes and organic matter content. Aisha *et al.* (2015) studied the effect of nutrients on photosynthetic efficiency and net yield in *Citrus reticulata*. Rehman *et al.* (2015) enumerated soil pH, electrical conductivity and total dissolved solutes from soil and water of Gomal Zam Dam. The values obtained were in tolerable range.

c. Phytosociology

Tabanez *et al.* (2000) recognized four physiognomic units in during a study carried out in southeastern Brazil. They observed a decrease in species diversity, basal area and tree density from lower to higher elevations. Grillini *et al.* (2001) conducted a phytosociological study in Chambura Gorge, Queen Elizabeth National Park (QENP). They reported that the area was completely under forest cover and least exploited. Species composition and vegetation structure was also less known. Height of the species was also very low in comparison to other areas especially that of a rain forest. Luis *et al.* (2002) stated that inventories of floristic groups correspond to two main

vegetation types and can be spatially arranged in Cufada Lagoon (Guinea-Bissau). Mosugelo *et al.* (2002) assessed the changes in vegetation cover by using aerial photographs in northern Chobe National Park (Botswana). They observed that between 1962 and 1998 the woodland vegetation cover decreased from 60% to 30% while shrubland vegetation increased from 5% to 33%. It was also noticed that woodland gradually retreated away from the river banks. Claros (2003) recorded the changes in structure of the forest and species diversity at two sites in Bolivian Amazon throughout secondary succession. Species diversity, basal area and canopy height increased with the age of the stand which indicated that secondary forest rapidly attained a forest structure. Kennedy *et al.* (2003) investigated the interactions between ecosystem stability and species richness in Krugar National Park South Africa. From 189 sites they collected 489 species of grasses and forbs. A negative correlation between species richness and ecosystem stability was observed. Salvatori *et al.* (2003) studied the impact of grazing and fire on small mammal populations and vegetation structure in Maasai Mara National Reserve. They compared vegetation maps of the study area from 1979 to 1998. They observed that considerable portion of reserve area was changing from shrubby vegetation to grasslands due to severe grazing. Brown & Bredenkamp (2004) prepared classification scheme of plants by using Two-Way indicator species analysis. They also documented the dispersion of tree species among various plant communities. DeWalt & Chave (2004) elaborated the impacts of soil fertility by measuring the density and basal area of trees, lianas and palms on two different soil types. Cocha Cashu and KM41 had higher tree basal area and AGB than La Selva or Barro Colorado Island. Dondeyne *et al.* (2004) investigated the soils and vegetation of woodlands in South Eastern Tanzania in nine sites. They reported 133 species in total of which only 74 were previously documented. Nazarian *et al.* (2004) studied the ecological factors affecting parts of vegetation in Northern Iran. They found several edaphic factors important with reference to their impact on plant life. During a comprehensive study on tropical dry forest Hurka (2004) analyzed plant species diversity and composition of life form categories in Northwestern Costa Rica. Along succession changes it was noticed that species richness was greatest after 15 years and decreased significantly in older plots. The number of non-woody species was highest after three years of succession. Patrick *et al.* (2004) studied vegetation structure in Lufuka, Mpanga and Degeya forests in central Uganda to determine the density, size classes distribution and regeneration of trees. Walpole *et al.* (2004) studied the fire and

elephant pressure on woodlands of the Masai Mara National Reserve in Kenya. A dramatic decline was observed in the study area due to both of these pressures. Yuming *et al.* (2004) documented the density of Bamboo and its long history of use for different purposes in various mountain communities in China. Angassa (2005) enumerated the impact of shrub dispersion on growth and yield of grasses in Borana rangeland ecosystem. During this study focus was on examining vegetation on the bases of yield and botanical composition of the herbaceous layer. Yield was higher in non-encroached sited and it varied with altitude. Jorge *et al.* (2005) conducted an extensive study in dry tropical forest on the island of Providencia, southwest Colombia. They compared vegetation structure and species richness across a 56 years' chronological sequence of six replicated age classes. Karsten *et al.* (2005) worked on plant communities of the Gobi Gurvan Sayhan National park, Mongolia. Prakash (2005) reported that population density of medicinally important plant species varied within the protected area. Highest species richness was found in Indian Himalayas, the valley of Flowers. Costa (2006) studied herb abundance and richness in Central Amazonia. It was observed that soil fertility and climatic conditions influence the diversity and density of understory vegetation. An increase in herb richness, diversity, density and cover was observed with an increase in altitude and slope. Dharani *et al.* (2006) described the woody vegetation of Lake Nakuru National Park Kenya along rivers, lakeshores and flood plains. Vegetation structure in these four woodlands was not significantly different but these localities differed in the relative density of *Acacia* trees. Fleischmann *et al.* (2006) studied the species diversity, structure and regeneration of an endemic palm forest on the Seychelles. This study sprawled over a period of 13 years and the stand characteristics were found to be mostly stable. Frances & Shahroukh (2006) reported forbs communities Kopjes (rock outcrops) in the Lolinodo, Maasai and Simba, areas of Serengeti National Park. Community similarity and species turnover between sites were examined by Species diversity measures and multivariate ordination techniques. Gould *et al.* (2006) assessed the structure and composition of vegetation along an elevation gradient in Puerto Rico. Out of total 374 species only 92% were native and 4 % critical elements. Endemic species contributed 14% species. Exotic species were widespread in moist forest communities. Lovett *et al.* (2006) reported a total of 2143 woody stems of ≥ 3 cm dbh from 204 species from Mwanihana forest, Udzungwa Mountains National Park, Tanzania. Species diversity was highest at high altitudes but there was no clear zonation of elevational vegetation types. Maestre *et al.* (2006) documented the

vegetation structure along with species richness and edaphic parameters in Amazonian Ecuador. Zheng *et al.* (2006) studied biomass and structure of tropical rain forest in Xishuangbanna, China. During this study they noticed 9.4 stems/ha density for large trees. Devineau & Fournier (2007) assessed the preference of species in relation to various ecological factors in Sudan-type savanna, Western Burkina Faso. Ecological and phytosociological affinities of each species were compared. Mohandass & Vijayan (2007) listed 2279 plant species from tropical montane forest in Palni hills, Western Ghats, India. They applied Fisher's alpha index for trees and lianas. Trees and lianas had 13.15 and 4.54 index respectively. Tripathi & Shukla (2007) compared two grassland communities of Gorakhpur, Uttar Pradesh for various vegetation parameters. One was on the managed and protected site and the other moderately grazed, open natural site of University campus. They reported 100 species out of which 65 were common to both sites, 9 species occurred exclusively at site I and 26 species at site II. Wahab *et al.* (2008) enumerated the sampled vegetation structure, age and growth in 5 places of Dargam District of Afghanistan. They also presented the Vegetation compositions of non-tree species. They recognized two monospecific and one bispecific communities were recognized in the study area on the basis of floristic composition and importance value index of tree species. Guo *et al.* (2009) elucidated the phytosociology of *T. sutchuenensis* community. Phanerophytes were dominant in the study area followed by hemicryptophytes. Plant with simple leaves dominated the landscape followed by microphylls. Digiovinnazzo *et al.* (2010) worked on a pool of woodland indicators and features of forest fragments in Italy to evaluate the phytosociological relationship between the both. Focus of their study was on the assumption that ecological thresholds might provide guidelines for conservation. Adam & Crow (2010) used TWINSpan technique to study the floristic composition and vegetation of Timber Island, Lake Winnepesaukee, New Hampshire, U.S.A. They analyzed the abundance and frequency data recorded from 106 study plots. The Simple Matching Index showed higher levels of similarity. Altay *et al.* (2012) studied the plant communities in urban habitats of Istanbul, Turkey. They described 13 plant communities and enumerated the soil properties such as H₂O holding capacity, soil texture, EC, pH, Lime content, phosphorous and potassium.

In Pakistan the studies made on vegetation structure and phytosociology is reviewed below.

Peer *et al.* (2001) documented about 100 plant species from Hindu Kush and Karakorum Range, and rated them according to their morphological and functional features. They recognized three types of steppes on the basis of microclimatic and phytomass data. Malik & Malik (2004) recorded seven plant communities from Kotli Hills during monsoon season of 2000. These plant communities were; *Adiantum-Olea*, *Acacia modesta*, *Dodonaea-Acacia-Themeda*, *Pinus-Themeda*, *Imperata-Pinus*, *Pinus roxburghii* and *Pinus-Carissa-Themeda*. They stated that vegetation belongs to Chirpine forest type. Ahmad *et al.* (2006) documented the vegetation structure of Himalayan forests in Pakistan. They recognized 24 different plant communities and 4 monospecific forest vegetation. These communities showed marked similarities. Malik & Hussain (2006) presented their study on ordination and structure of plant communities of Lohibehr reserve forest and its adjoining areas, Rawalpindi. They recognized four plant communities. Results based on floristic composition were found to be similar to those obtained by classification and ordination techniques. Peer *et al.* (2007) applied TWINSpan and CCA techniques for classification of plant communities and interrelationships between these communities and environmental characteristics in Eastern Hindukush ranges. This study resulted in establishing four communities (1) the desert steppe; (2) the *Artemisia brevifolia* steppe, (3) the alpine scree vegetation, and (4) the alpine mats. Perveen & Hussain (2007) examined the phytosociological and phenological status of plants i.e. flowering and fruiting condition in Gorakh hill Dadu District. In addition to phytosociological attributes quantitative analysis on species diversity were conducted. They determined the life form, cover, density, relative density and relative frequency of plant species the area. Ahmad *et al.* (2008) studied the spatio-temporal effects on association of plant species in Soone valley of Pakistan. Marked seasonal variation was observed in floristic composition of herbaceous flora. Ahmad *et al.* (2008) carried out their research on Soone Valley. They reported that most commonly occurring species among woody leguminous plants was *Acacia modesta*. *Dalbergia sissoo* was absent altogether while *Prosopis juliflora* occurred very commonly and formed mono-species stands. *Melilotus indica* and *Medicago polymorpha* were dominant in winter season. *Acacia modesta* and *Olea ferruginea* displayed strong association on higher elevations. *Dodonaea viscosa* and *Justicia adhatoda* were very abundant in the study area because of their resistance to grazing pressure and lesser use as fuel plants. Arshad *et al.* (2008) documented the quantitative attributes of vegetation structure in Cholistan desert. Influence of chemical composition

of soils was evident from the association of certain plant species to certain soil types. They concluded that plant species showed strong relationships to soil characteristics. Perveen *et al.* (2008) carried out phytosociological studies in Dureji game reserve. They documented density, relative density, cover, relative cover, frequency and relative frequencies of each species. Malik & Hussain (2008) studied the phytosociological attributes of Lohibehr scrub forest in the Foothills of Himalaya, Pakistan. Multivariate techniques viz. PCA, TWINSpan and CCA were employed to enumerate the ecological and phytosociological attributes by using remote sensing data. Qureshi (2008) studied vegetation parameters like cover, frequency and density by quadrat method in Sawan Wari of Nara Desert. On the basis of Importance values he established five plant communities. Wazir *et al.* (2008) established five vegetation types in Chapursan Valley, Gilgit. These communities were identified on the basis of edaphic variables and aspect. Hussain & Perveen (2009) documented the plant biodiversity and phytosociological attributes of the Tiko Baran, Khirthar range Dadu district. They conducted quantitative and phonological studies on the vegetation of the area. They recorded the life forms, species density, species cover, species relative density and frequency. Hussain *et al.* (2009) determined the relative species composition and seasonal plant communities of Nurpur reserved forest in scrub rangelands of District Chakwal. It was observed that plant density, frequency and cover in Chakwal varied among grasses, trees and shrubs across the three growth seasons. Ali & Malik (2010) studied vegetation structure of diverse localities in Islamabad. Based on TWINSpan they classified the vegetation into four major community types. Ahmad *et al.* (2010) established two major and sixteen sub-communities along 358 km long motorway, M-2 through TWINSpan technique. These communities were split into sixteen sub communities. Ahmad *et al.* (2010) presented a review of work on status of vegetation analysis in Pakistan. Siddiqui *et al.* (2010) studied the phytosociology of moist temperate Himalayan forests in Pakistan and AJK. On the basis of ordination, they distinguished three major groups. Nawaz *et al.* (2010) worked on impact of fencing on vegetation structure in Lehri and a Jindi sub mountainous open scrub forest. This study revealed that vegetation (tree) cover in the study area was 60%. Plant diversity was also quite high over 140 species. Significant difference was observed between vegetation of protected and non-protected area. Khan *et al.* (2010) studied the phytosociology, structure and soil characteristics in *Quercus* forests of Chitral Hidukush range. *Quercus baloot* made five pure stands and at 3 sites co-dominant *Quercus dilatata* at high

altitudes having high H₂O content and water holding capacity. Shaheen *et al.* (2011) carried out their research on vegetation dynamics on Lesser Himalayan Subtropical forests of Bagh Districk, Kashmir. They reported 72 plant species belonging to 31 families. This study also focused on anthropogenic impacts on vegetation. Noor & Khatoon (2013) analyzed the vegetation pattern and edaphic characters of Astore Valley, Gilgit Baltistan. They found herbaceous plants dominant in the area, especially in alpine and sub-alpine zones. They documented a total of 668 plant species from the valley. Altitude, texture, organic matter and some edaphic variables influenced vegetation structure. Urooj *et al.* (2016) reported their results on vegetation analysis on wetland area around Mangla Dam, Azad Kashmir. They documented 37 plant species belonging to 17 families.

In Khyber Pakhtunkhwa the phytosociological work is summarized as follows:

Hussain & Badshah (1998) studied the vegetation structure of Pirghar Hills South Waziristan, Pakistan. They stated that vegetation, life form, leaf size of south and north slopes differed at similar altitude in the study area. It was also noticed that the original woody species were present on the hills as isolated individuals due to degradation. Hussain *et al.* (2005) described 7 plant communities from Ghalegay Hills, District Swat. They classified these communities into subtropical semi-evergreen forest, subtropical pine forest and blue pine temperate forests. Ahmad *et al.* (2009b) studied the Abbottabad roadside vegetation by using multivariate analysis techniques *i.e.* (DCA) and (CCA) in vegetation. They stated that lead and copper, and zinc were most important factors influencing the roadside vegetation. This study provides information on improving the roadside vegetation and conserving the native flora. Jabeen & Ahmad (2009) used TWINSpan to classify vegetation of Ayub National Park. The results showed species dichotomy, represented by two major communities. Four major plant communities were established by using the Detrended Correspondence Analysis (DCA). Shah & Hussain (2009) conducted phytosociological studies in Hayat Abad, District Peshawar. The study revealed 5 plant communities, each having its own species composition. Therophytes (48%) and cryptophytes (19%) dominated in all stands. Among leaf spectral classes microphyllous (40%) and leptophylls (22%) species were dominant. Ahmad *et al.* (2010) conducted phytosociological studies on some graveyards in Swat District. They observed that vegetation of the selected graveyards was comparatively less disturbed and the floristic composition was different from elsewhere due to religious sanctities in Upper Swat.

Badshah *et al.* (2010a) investigated the phytosociological parameters and edaphic features of vegetation of Tabai during autumn. Differences were noticed in air and soil temperature due to elevation. This study revealed that grazing and deforestation were altering the original vegetation structure. Wahab *et al.* (2010) used quadrat method for sampling twenty-five forest types in District Dir during his phytosociological studies. He described parameters like frequency, density, basal area and importance values for establishing communities. Ilyas *et al.* (2012) described the vegetation composition of temperate forest vegetation of Qalagai Hills Swat. They reported 209 species of vascular plants belonging to 167 genera and 75 families. This study revealed that vegetation in the area was under immense anthropogenic pressure.

No reference was available on the phytosociology and vegetation dynamics of Chail valley, Swat. Therefore, phytosociology and vegetation of this area require enumeration.

d. Ethnobotany

Plenty of references are available on ethnobotanical research from abroad.

Kappelle *et al.* (2000) worked on Campesino community in a Costa Rican montane cloud forest and reported 590 species from the locality. Mathooko & Kariuki (2000) reported that about 55% of the riparian vegetation species in Rift Valley stream are used as medicine, for curing more than 330 health problems. Only 11% of the plants were edible. Macia (2004) reported 37 Palm species used by the Huaorani communities in Huaorani in Amazonian Ecuador. He documented 191 different uses in 8 ethnobotanical categories. Most of the plant species (64.9%) were used as timber and food. More than 50% were used in making domestic utensils etc. Tardio *et al.* (2006) prepared a review of wild edible plants in Spain. He listed 419 species belonging to 67 families. A checklist of these plants was prepared with their uses, times of harvesting and their localities. Arenas & Scarpa (2007) reported that Chorote people in Gran Chaco, Argentina use 57 plant species as food which they consumed in 118 different ways. A comparison with neighboring ethnic groups revealed that one third of these plants were unique to Chorote Indians only. Mizaraite *et al.* (2007) conducted an extensive study in Lithuania on possibilities of increasing the use of wood from private forests. Through statistical data and literature review they investigated the consumption and potential wood fuel supply. Economic simulation was used to calculate the costs of wood chip production. Okello & Ssegawa (2007) presented an ethnobotanical survey in Ngai sub-county in Apac District, northern Uganda. They found that most commonly

harvested plant parts were roots which had greatly affected the regeneration of medicinal plants. The locals believed that plants collected from wild were more effective. Miah *et al.* (2009) reported that use of wood fuel per family per year in Bangladesh was significantly affected by the family size, income, amount cooked and burning hours. After studying different families of different sized it was revealed that on average a family used 4.24 tone fuel woods per annum. The main source of biomass fuel was homestead forests. Maoe *et al.* (2009) described the rich plant resources and the huge amount of ethnobotanical knowledge with various tribes of the world. A review in this regard was prepared which highlighted some important medicinal plants as well as their status in the wild. They also discussed the potential economic exploitation of this rich bio-resource. Meena & Yadav (2010) reported 31 species of medicinal plants belonging to 31 genera and 22 families. This study was carried out in Chittorgarh, Udaipur, Banswara and Dungarpur districts of Rajasthan.

In Pakistan the ethnobotanical studies are reviewed as follows:

Gillani *et al.* (2003) reported 54 medicinal plant species from Parachinar Kurram agency which had various local uses. Most of these were used in stomach disorders as first medical aid. People in winters depended on fuel wood from Afganistan and average daily fuel wood consumption was 60 kg/household/day. Hussain *et al.* (2004) documented 11 plant species which were used for various timber purposes in South Waziristan Pakistan. *Populus afghanica*, *Cedrus deodara*, and *Pinus wallichiana* were considered as the best timber wood in the area by the locals. Elders and illiterates were found to be more knowledgeable than youth and the educated lot during the survey. Wazir *et al.* (2004) conducted an ethnobotanical study in Chapursan Valley District Gilgit. They documented 41 species of medicinal value which belonged to 29 families. They reported that locals knew the importance of these plants and were frequently using these herbs, shrubs and trees to cure a number of diseases. Ishtiaq *et al.* (2007) documented medicinal plants and their local uses from Samahni valley, Azad Kashmir. They observed that *Solanum miniatum* and *Momordica balsamina* was used respectively to cure rheumatism and external wounds. Khan and Khatoon (2007) reported 48 species of trees and shrubs of ethnobotanical value from Bugrote Valleys in District Gilgit. These were used in everyday life for medicine, shelter, agricultural tools and fuel. Qureshi & Bhatti (2008a) reported 51 plant species of medicinal value from Nara Desert. These plants belonged to 43 genera and 28 families. Of these 21 species were recorded for novel uses in the Indo-Pak folk herbal medicinal literature.

Most abundant families were found to be Boraginaceae and Amaranthaceae. Sardar & Khan (2009) reported 102 species belonging to 93 genera and 62 families from Tehsil Shakargarh, District Narowal. These plants were used by locals as fuel, timber, fodder, making baskets and mats, miswak etc. Few were used as vegetables either taken raw or cooked. Ajaib *et al.* (2010) described 38 species belonging to of 36 genera and 25 families from District Kotli, Azad Jammu & Kashmir, of economics importance. These plants were utilized in medicine, fuel, fodder and in making agricultural tools. Tareen *et al.* (2010) conducted a detailed study in Kalat and Khuzdar, Baluchistan. He documented 61 species of medicinal plants used by women for treating various diseases. Lamiaceae (9 species) was the largest family followed by Asteraceae. Qasim *et al.* (2010) recorded 48 wild coastal plant species from 26 families used in Hub, Lasbela District, Baluchistan. These plants were used for 12 different purposes. These uses included fodder, medicine, edible, household and for increasing milk production in cattle. (3%) and other uses (8%). Among these Poaceae and Amaranthaceae were the dominant taxon.

In Khyber Pakhtunkhwa the ethnobotanical studies done are summarized as follows:

Ahmad *et al.* (2004) reported local uses of medicinal plants in Galliyat areas, Abbottabad. They described 41 plants belonging to 40 genera and 33 families which were used as medicine. Badshah *et al.* (2006) reported 26 species from South Waziristan of which *Quercus baloot*, *Olea ferruginea* and *Monothea buxifolia* were considered as best fuel woods. Hussain *et al.* (2006) recorded 67 species belonging to 40 families from South Waziristan. These plants were used in traditional health care system. Some important plants reported were *Morchella esculenta*, *Mentha longifolia*, *Thymus serpyllum* and *Citrullus colocynthis* etc. Wazir *et al.* (2007) recorded 20 halophytes from District Karak which were used as medicine by the locals. These halophytes were found to be common in the area up to Bahadar Khel salt range. Manan *et al.* (2007) reported 52 plants belonging to 35 families from District Upper Dir. These plants were used to treat several diseases. Badshah & Hussain (2008) reported 20 plants species belonging to 20 genera of 18 families of medicinal importance in Village Tabai, South Waziristan. Of these, 50% species were found to be more commonly used to treat few diseases of women such as excessive menstrual flow, stop menses and for tightening the flagged breast. Ali & Qaiser (2009) collected ethnobotanical data from Chitral Valley. Khan *et al.* (2009) reported 51 medicinal plants used as crude drugs in

Naltar, Hunza, Astore, Skardu, Ghizar and Diamer, Pakistan. Kamal *et al.* (2009) listed 50 plants of ethnomedicinal importance from Bannu, Pakistan. Locals used these plants to treat cough, diarrhea, dysentery, constipation and stomach problems. Zahoor *et al.* (2009) described the traditional uses of 52 plant species from Darra Pezo, District Lakki Marwat. Forty-seven of these plants were medicinal. It was noticed that some of these species were under threat due to unsustainable activities. Khan *et al.* (2009) conducted ethnobotanical studies in FR Bannu and reported 50 plants which were used to cure different disorders. Leading families in this study appeared to be Poaceae and Moraceae. Akhtar & Begum (2009) enumerated ethnopharmacological important plants of Jalala, District Mardan they described a total of plants belonging to 38 families. *Calotropis procera* and *Boerhavia diffusa* were noticed to have multipurpose medicinal uses. Taj *et al.* (2009) reported 29 plants belonging to 25 families from Godi Khel District Karak, which were used for medicinal purposes. Hazrat *et al.* (2010) reported 50 medicinal plants from Ushera valley. These plants grew wild and were frequently used by the locals to treat various diseases. Attaullah *et al.* (2010) conducted an ethnobotanical study along Kurram River beds of District Bannu. They documented 27 species belonging 19 families. It was noticed that poor lot was more frequently using these plants as medicine. Some of the plants were used by local healers. Badshah *et al.* (2010b) described 41 plant species which were used for different purposes by inhabitants of Parachinar Kurram Valley. Some of these were medicinal plants used to cure common diseases in the area. Jan *et al.* (2011) listed 62 plant species from Dir Kohistan which are being used as crude drugs. Nasrullah *et al.* (2012) documented traditional uses of 67 plant species from Jandool Valley. Shah & Hussain (2012) reported 82 plants with different traditional uses from Mastuj valley, Hindukush range.

In District Swat some work has been done on ethnobotanical aspect as follows:

Hussain *et al.* (2006) documented 126 species of medicinal plants from Ghalegay area of District Swat, which were used for treating different health disorders. Ahmad *et al.* (2011) listed 140 medicinal plants from Kabal along with traditional medicinal recipes. Ahmad *et al.* (2013) documented 100 plants of medicinal importance from Madyan. Ahmad *et al.* (2014) reported 50 medicinally important plants from Chail Valley. They also calculated the relative frequency of citation (RFC) for each species. *Origanum vulgare*, *Geranium wallichianum* and *Skimmia laureola* were found to have highest RFC values.

e. Palatability of Vegetation

Karki *et al.* (2000) carried out an extensive study in grazing lawns in Terai grasslands, Royal Bardia National Park, Nepal. They compared the community structure, nutritive quality and above ground biomass to adjacent grasslands. Lee *et al.* (2000) studied the effects of natural and artificial herbivory in a tropical rain forest. Depending upon vegetation structure, these effects varied. They reported herbivory as an important predictor of mortality in reproductive fragments of under story plants. Watson & Smith (2000) found that of all the annual diet of eland browse contributed 94% of the total. They preferred dwarf shrubs so grasses were abundant in the habitats favored by eland. Angassa & Baars (2001) elucidated the ecological condition of encroached and non-encroached rangelands in Borana, Ethiopia. They reported 41 grasses, 4 legumes, 3 sedges and 28 tree and/or shrub species from the study area. Common or dominant species in all sampled areas were *Aristida adscensionis*, *Cenchrus ciliaris*, *Chrysopogon aucheri* and *Panicum coloratum*. Wassenaar & Aarde (2001) concluded that effects of grazing were apparently related to site-specific internal vegetation changes and there were indications that precipitation interacted with level of grazing. It was reported that grazing had a little effect on species richness. Brits *et al.* (2002) during a study on Kruger National Park (KNP) calculated that on average 3 % of the total area was affected by large herbivores congregating around artificial watering points. They concluded that decline in large trees in the study area was mainly due to artificial water, grazing and browsing gradients. Mapfumo *et al.* (2000, 2002) reported that grazing had a profound impact on litter and root mass, C and N pools of perennial grasses, *Bromus inermis*, *Bromus riparius* and *Tritico secale*. Hickman *et al.* (2004) studied the grazing management effects on plant species diversity in tall grass prairie. They found high species density of grasses in grazed areas in comparison to ungrazed grasslands. Lucas *et al.* (2004) carried out an extensive study on the response of Riparian vegetation to different intensities and seasons of grazing. They found that cottonwood population was not significantly affected by increased grazing pressure. Species richness and diversity of herbaceous plants showed marked correlation to seasonal grazing. Mapinduzi *et al.* (2004) concluded that calf-grazing pastures had more herbaceous species than non-calf pastures, which were richer in woody species. They observed that local system of landscape classification provided a base for assessing rangeland biodiversity. Wang (2004) revealed that total biomass as rhizomes increased considerably with increased grazing intensity. Highest of rhizome biomass

values were recorded on very high grazing treatment. Soil organic matter content and soil moisture were found to be negatively correlated to shoot and tiller densities, and the proportion of the total biomass as rhizomes. Brereton *et al.* (2005) proposed a model for forage consumption by cattle in a grazing system. Two phases were sorted out during the course of this study. Selection of a feeding station was found to be based on preference for leafiness of the encountered state and the phase. Chocarro *et al.* (2005) conducted a prolonged study for 3 years to study the effects of one severe winter-grazing of Lucerne in the Ebro Valley, Spain. It was noticed that grazing lucerne with sheep once in the winter season, resulted in only a limited reduction in yield in the spring. Hirata *et al.* (2005) reported that grazing impacts were higher on higher cover of herbaceous vegetation and it reduced that available forage at the end of growing season. While lighter grazing was observed with thick cover of shrubby vegetation. They also recommended the maintenance of a vegetation cover over the area to minimize the soil erosion. Miller & Thompson (2005) found *Cortaderia pilosa* as the most common species during winters in Falkland Islands. In summers *Agrostis capillaris*, *Festuca magellanica* and *Poa spp* were abundant. Ross *et al.* (2005) studied the impact of harvest timing on total yield. They reported that total yield decreased as the proportion of berseem clover in the intercrops increased. Dalle *et al.* (2006) studied the encroachment of woody plants and its impact on pastoral livestock production in the Borana lowlands, Southern Oromia, Ethiopia. They studied 192 plots. Woody plant cover was 52% showing an increased trend from $\leq 40\%$ cover reported in the early 1990s. This clearly indicated that density of woody plants had crossed the critical threshold and has entered into the encroached condition. Knoop & Smith (2006) documented changes in the extent of grazing of different grass species, intensity of cropping per tuft and height differences between grazed and ungrazed tillers. Extent of grazing in upland exceeded that in bottomland in a dry year and many upland grasses were found to be more grazed than previous years. Milewski & Madden (2006) observed the intensive browsing in a wildlife ranch in Kenya. There was intensive browsing of shoot tips, produce long thorns, and have relatively few flowers and fruits. Plant parts consumed were associated with increased lateral branching and with an increased occurrence of short, thickened spines. Pavlu *et al.* (2006) found an increase in the number of forbs plants, particularly in the number of *Taraxacum spp* due to delayed defoliation probably due to an enabling of its seed production. Similarly, density as a function of intensive defoliation was not confined to effect on grass tillers

but may occur in several leguminous plants and forbs in grassland with high species richness. Randall & Diaz (2006) revealed that spring-fed wetland and riparian plant communities respond differently to alter grazing intensity. Herbaceous cover was low under moderate grazing while high in areas with light or no grazing. Variations were seen in species composition from year to year for 10 years. Smit *et al.* (2006) concluded that unpalatable plants facilitate tree sapling survival in wooded pastures. High grazing intensities were seen in plots without unpalatable plants, and it was higher in plots with *Cirsium* than with *Gentiana*. Sapling survival rate was high for large trees than small ones. This study clearly indicated that unpalatable plants enhance tree regeneration in woody pastures. Loeser *et al.* (2007) reported that impacts of high grazing lead to a decline in perennial forbs cover. It also resulted in an increase in annual plants especially the exotic *Bromus tectorum*. Moderate level of cattle grazing may maintain greater levels of native plant diversity. Peters (2007) elucidated the role of gastropods and small mammals in affecting the production and composition of California annual grassland. These gastropods and small mammals selectively consumed grasses which partially altered the competitive advantages related to their early germination.

The following research is available on palatability of range plants in Pakistan.

Neal & Miller (2007) documented some herbaceous plants which were adversely affected by grazing. Ecosystems were resisting the grazing pressure as species richness was found to be more or less same after seasonal rains. Grass cover which got removed due to grazing would reappear after seasonal rainfall in Khirthar National Park, Pakistan. Akram *et al.* (2009) concluded that grazing pressure lead to overgrazed pastures with low species richness. Pakistan Council of Research in Water Resources converted more than 100 ha at Dingarh Cholistan into productive land as a model. Once a desert, now the area is under forest cover and possesses an orchard of grafted *Zizyphus*, date palms, fodder crops and grassland.

f. Chemical Evaluation of forage Plants

Storeheier *et al.* (2002) determined the chemical constituents in members of family Poaceae. They reported that wintergreen parts of Graminoids had high contents of crude protein (0.072-0.108 g/kg dry matter (DM)) and water-soluble carbohydrates (0.098-0.167 g/kg DM) and were highly digestible (50-65% IVDMD) compared with the withered parts of the plants (27-53% IVDMD). Dave & Dave (2003) reported that P and K levels were adequate for beef cattle early in growing season, but a decline was observed by July and August. Iron levels were also good in all grasses sampled. This

study was conducted in 7 northern Great Basin grasses. Enujiugha (2003) conducted a proximate analysis of freshly harvested *Tetralcarpidium conophorum*. High phosphorus content (465.95 mg/100g) and comparatively low Cadmium content (0.01 mg/100g) and Nickel contents (0.38 mg/100g) were recorded in the raw Conophor nut. Seiler & Campbell (2004) worked on the genetic variability for mineral element concentrations of wild Jerusalem artichoke forage. They worked on the levels of N, P, Ca, Mg, K, and the Ca/P ratio in the forage. The study revealed that N, Ca, Mg, and K as adequate, P inadequate, and the Ca/P ratio as excessive. Genotype differences were observed among nine populations for N, K, P, Ca, Mg, and the Ca/P ratio. Starks *et al.* (2004) estimated the concentrations of nitrogen (N), neutral detergent fiber (NDF) and acid detergent fiber (ADF) in live standing forages. The study revealed that remote sensing approach would enable real time assessment of forage quality. This will result in better management of the pastures and will help in making good harvest decisions. Carvalho & Saraiva (2005) stated that drought periods were responsible for increase in sugar, ash, both macro (Ca, Na, K, Mg) and microelements (Fe, Zn, Mn, Cu) as well as other chemical contents in seeds of two Lupins (*Lupinus albus* and *Lupinus mutabilis*). These results are of great help in selecting seeds from Lupin species for seeds of two lupins (*Lupinus albus* and *Lupinus mutabilis*) Cherney & Cherney (2005) enumerated that species selection, harvest management and fertilizer addition can have a significant impact on K concentration in forage and low K is critical for non-lactating dairy cow forage. Potassium rich fertilizers resulted in 5.6% higher yield of dry matter. But forage quality showed no significant impact by adding K fertilizer although the K concentration of forage increased by 12%. Smith *et al.* (2005) examined indehiscent fruits of six tree species, common in Matabeleland in *in-vitro* trials. Phenolic compounds were higher in *Acacia nilotica ssp. Nilotica* as compared to *D. cinerea*. But nitrogen (N) and fiber content was low in *Acacia nilotica ssp. Nilotica*. Staaland *et al.* (2006) analyzed several reindeer forage plants in Svalbard for content of minerals. Ash contents, crude protein, crude fiber, ether extracts and nitrogen free extracts were also examined in these plants. Svalbard vegetation was found to have higher contents of Na, Ca, Mg, Cl, Fe and Co, than similar plants from Southern Norway. Starks *et al.* (2006) conducted proximate analysis of *Cynodon dactylon* to study the variation patterns during different seasons. Dairo & Adanlawo (2007) evaluated the nutritional potentials of *Crassocephalum crepidioides* and *Senecio biafrae*. *Crassocephalum crepidioides* contained $27.17 \pm 0.51\%$ crude protein (CP) while that of *Senecio biafrae* was

28.93±0.68% but were not significantly different. They recorded 20.81 nitrogen free extract for *Senecio bialfrae* while value for *Crassocephalum crepidioides* was 19.03. Garg *et al.* (2007) examined mineral composition of 15 wild herbs. Most of these herbs were rich in mineral content. They possess antibacterial and antipyretic qualities and were also used as fodder. This study was important in establishing a correlation between elemental contents with the therapeutic importance of various herbs. Phillips *et al.* (2007) compared the performance of calves grazing in summers in warm season grass pastures. Reduced grazing was seen in last half of summers because with plant maturity the protein content falls below the dietary nutrient requirement. Provision of protein to calves during the last half of the summer grazing season can increase animal performance. Alshammary (2008) studied sodium and potassium values in *Salvadora persica* and *Atriplex halimus*. Chiesa *et al.* (2008) studied the age of as a factor affecting the nutritive value of *Pennisetum clandestinum*. Organic matter, neutral-detergent fiber and nitrogen intake, as well as rumen Ammonia-N concentration, decreased linearly with age of regrowth. During all treatments similarities were observed between Acid-detergent fiber and indigestible intakes. Gutierrez *et al.* (2008) examined the mineral profile of 14 weed species in Mexico. Mineral composition, crude proteins and phenolic contents were examined during this study. Most of these weed plants showed appropriate crude fiber and protein contents. But phenolic contents of weed extracts were higher than that reported for several Mediterranean forage species. Leheska *et al.* (2008) reported that previous data suggested antioxidant content in been increased with grass based diet. Although the fatty acid composition of grass-fed and conventionally fed beef was different. Zhao *et al.* (2008) reported that forage quality may be assessed on the basis of forage nitrogen and carbohydrate.

The review on chemical evaluation of forage plants in Pakistan are summarized as follows.

Sabir *et al.* (2003) studied the chemical profile of pulses, vegetables and others plants. They estimated total dietary fiber, crude protein, fat, ash, moisture and carbohydrate. Khan *et al.* (2005) evaluated the variation in soil and forage micro-mineral concentrations in a semiarid region of Pakistan. Sampling period affected soil Cu, Zn, Se while all forage minerals except Se were affected by sampling times. Forages were slightly deficient in Co during winter as compared to summer. Khan *et al.* (2006) recorded seasonal changes in all soil micro-minerals except Zn, while forage Fe, Zn and Se were affected by seasonal changes. With the exception of Co and Se all

soil minerals were sufficiently high to meet the requirements of plants for normal growth during both seasons. During summers forage Zn levels at marginal deficient levels while rest of the minerals were in a good range for the use of ruminants during both seasons. Khan *et al.* (2006) estimated the micro minerals of herbaceous forages of a grazing pasture in District Leiah, Punjab, Pakistan. They have different Ca and Mg concentrations. But their values were slightly higher than the minimum recommended levels in the diets of ruminants. Micro mineral content varied among the grazing pasture forages. Cu levels were low while Zn levels were from slightly low to moderate. Kiyani *et al.* (2007) determined alkaloids, tannins, saponins and quantified total phenolic contents in plants of Hazarganji Chiltan National Park Quetta. All three secondary metabolites were recorded from *Caragana ambigua*, *Clematis graveolens*, *Juniperus excelsa* and *Pistacia khinjak* while *Chrysopogon aucheri*, *Ferula oopoda*, *Fraxinus xanthoxyloides*, *Pennisetum orientale*, *Saccharum griffithii* and *Verbascum erianthum* lacked the secondary metabolites. Sultan *et al.* (2007) analyzed in vitro metabolizable energy and dry matter digestibility in some selected grasses at pre-reproductive stage. Khan *et al.* (2007) examined forage plants of Punjab for levels of Ca, Na, Cu, and Zn. They observed that mineral levels of plants increased with their increasing maturity from summer to winter. Grazing animals were thought to be deficient in most of these minerals and supplementation will prevent mineral deficiency diseases. Hussain & Durrani (2008) carried out an extensive study on some grasses and shrubs in Harboi rangeland, Kalat, Baluchistan. These plants were studied at 3 phenological stages and were analyzed for mineral composition including K, P, Cu, Mn, Fe and Zn. Differences were insignificant between these grasses and shrubs in terms of K, P, Fe and Zn contents. Levels of Cu were higher in shrubs while grasses had higher levels of Mn. Rehman & Iqbal (2008) recorded high levels of Fe, Pb, Cu, Cr and Zn in foliage of *Senna holosericea*, *Abutilon indicum* and *Prosopis juliflora*. This study revealed that foliage of naturally growing plants from the industrial areas Korangi and Landhi Karachi showed high accumulation of metals. Rahim *et al.* (2008) studied dry matter digestibility in 12 grass species of Himalayan foothills in Pakistan. A decrease in nutritive value was observed with maturity of these plants. Macro and micro mineral composition, IVDMD, RP and PIR values of marginal land grasses were suitable for feeding to livestock. Ahmad *et al.* (2008) studied macro-minerals, Na, P, K, Ca and Mg in different plant parts such as leaves, leaflets and pods, which were lavishly grazed by the grazing animals in Soone Valley, Punjab, Pakistan. They concluded that these

samples were having sufficient K, P, Ca, Na and Mg for the requirement of grazing animals. Pods were found to be rich in macro minerals in comparison with leaves and leaflets. Abbasi *et al.* (2009) carried out a comparative study of grasses and legumes. They stated that white clover forage had high nutritional value. Forage plants were analyzed for N, P, K, Ca, Mg, Fe, Mn, Cu and Zn. Mineral profile of white clover showed that it was rich in minerals than grasses. It possessed high P, K, N, Ca and Mg content. Similar trends were recorded for micro nutrients. Cheema *et al.* (2010) worked on impacts of different nitrogen rates on total dry matter (TDM), crop growth rate (CGR), leaf area duration (LAD), seed yield, oil yield and protein content in *Brassica napus*. Results showed that these factors were significantly affected by different nitrogen rates. At highest nitrogen levels (120 kg/ha) maximum values of these traits were recorded

No work can be traced from on the nutritional and mineral composition of forage plants of Chail Valley. This gap of knowledge is being filled during this study.

MATERIALS AND METHODS

2.1 Floristic Survey and Ecological Analysis

Floristic survey was conducted throughout Chongqing from 1972 to 1982 during six seasons. Plants that were new to China were collected, preserved and identified with the help of Flora of China (Chen & Li, 1979, 1982; Li & Chen, 1979, 1982; Li & Qian, 1981, 1982). The identification was done by the Institute of Botany, Chinese Academy of Sciences, Beijing and the Institute of Botany, Department of Botany, University of Wisconsin. The material was collected and plants were arranged initially early. The collected specimens were numbered and deposited in Herbarium, Department of Botany, University of Wisconsin.

2.1.1 Botanical Specimens

Plants were collected into various lots during six seasons. The lots were numbered 1-100 and 101-200 as follows:

MATERIALS AND METHODS

3.1. Floristic Structure and Ecological Attributes

Floristic survey was conducted throughout Chail valley from 2012 to 2015 during all seasons. Plants from various localities were collected, preserved and identified with the help of Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1992; Ali & Qaiser, 1995-2015). The identification was later on confirmed at Herbarium of National Agriculture Research Council, Islamabad and Herbarium, Department of Botany, University of Peshawar. A floristic list was prepared and plants were arranged alphabetically. The voucher specimens were numbered and deposited in Herbarium, Department of Botany University of Peshawar.

3.1.1 Biological Spectra

Plants were classified into various Life-form classes following Raunkiaer (1934) and Hussain (1989) as follows:

i. Therophytes (Th)

These are the annual seed bearing plants which complete their life cycle in one year and over winter the unfavorable seasons by means of seeds only.

ii. Geophytes (G)

These are the plants with perennating buds located below the surface of the soil and include plants with deep rhizomes, bulbs, corms, tubers and may also include hydrophytes which may be submerged, partly submerged, free-floating and leaf-floating.

iii. Hemicryptophytes (H)

These are the herbaceous perennials in which aerial portions of the plants die at the end of growing seasons leaving a perennating bud at or just below the ground surface covered by litter.

iv. Chamaephytes (Ch)

Their perennating buds are located close to the ground surface up to the height of 25cm.

v. Phanerophytes

These are further classified as follows.

a. Nanophanerophytes (NP)

Their perennating buds are borne on aerial shoots from 25 cm up to 6 ft above the ground surface.

b. Microphanerophytes (MicP)

These are plants with perennating buds located above the height of 2 m to 7.5 m.

c. Mesophanerophytes (MesP)

These are small trees with their perennating buds are located from 7.5 m to 30 m high.

d. Megaphanerophytes (MgP)

These are tall tree species whose perennating buds are located above the height of 30 m (100 ft).

Raunkiaerian and quantitative spectra were calculated as follows.

$$\text{a. Raunkiaerian Life form spectrum} = \frac{\text{No. of species falling in a particular life form class}}{\text{Total number of all the species}} \times 100$$

b. Quantitative life form spectra were calculated on the basis of importance value of each species encountered in sampling by quadrat following Cain & Castro (1956) and Qadir & Shetvy (1986).

3.1.2 Leaf Size Spectra

Plants were classified into various Raunkiaerian (Raunkiaer, 1934) and quantitative leaf sizes as follows:

i. Leptophyll (L).	Leaf area up to 25 mm ²
ii. Nanophyll (N).	Leaf area from 25 to 225 mm ²
iii. Microphyll (Mic).	Leaf area from 225 to 2025 mm ²
iv. Mesophyll (Mes).	Leaf area from 2025 to 18225 mm ²
v. Macrophyll (Mac).	Leaf area from 18225 to 164025 mm ²
vi. Megaphyll (Meg).	Leaf area larger than class v.

a. Raunkiaerian spectrum was calculated as follows:

$$\text{Leaf size spectrum} = \frac{\text{Number of species falling in a particular leaf-size class}}{\text{Total number of all species for that community}} \times 100$$

b. Quantitative leaf size spectra were calculated using importance value indices of plant species following Cain & Castro (1956).

3.2 Edaphology

Soil samples were collected during 2012 and 2015, from 0-15 cm depth at 3 different places from each of the monitoring sites. From each site a total of 8 soil samples were collected which were later mixed to make one soil sample for each site. Each of the collected samples were taken in clear polythene bags which were duly labeled and sealed on the spot. Later on the soil samples were dried in an oven at 30 °

C. After drying soil samples were screened for impurities such as stones, plant roots etc. Soil samples were ground and passed through a 2 mm sieve (Ryan *et al.*, 2001)

3.2.1 Soil Texture

A soil texture was determined by Hydrometer method (Bouyoucos, 1936) and textural classes were determined with the help of textural triangle (Brady, 1990).

3.2.2 pH

Soil pH was measured in 1:5 soil water suspensions with a pH meter (Jackson, 1962).

3.2.3 Organic matter

Soil organic matter was determined by oxidation with potassium dichromate in sulphuric acid medium under standard wet combustion method of Rayan *et al.* (1997).

3.2.4 Calcium Carbonate

Calcium carbonate was determined by acid neutralization method (Rayan *et al.*, 1997).

3.2.5 Electrical Conductivity

Electrical conductivity of the soil was determined in 1: 5 soil water suspensions with EC meter.

3.2.6 Total Dissolved Solids

Total Dissolved Solids (TDS) was determined by a procedure based on residue weight after evaporation to dryness after filtration (Rhoades, 1996).

3.2.7 Available water

Available water in the soil was determined by using following formula.

Available water (%) = Field capacity – Wilting point

3.2.8 Chloride

Dissolved chlorides (Cl) were determined by titrating the soil solution extract with Silver nitrate using Potassium chromate as an indicator (Richard, 1954).

Chlorides (Meq/liter) = $\frac{\text{ml. of AgNO}_3 \text{ for sample} - \text{AgNO}_3 \text{ for blank} \times 0.005 \times 1000}{5(\text{i.e. ml of water})}$

3.2.9 Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio (SAR) was determined after Richards (1954) as follows:

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{\text{Ca}^{++} + \text{Mg}^{++}}} / 2$$

3.2.10 Sulphates

Sulphate (SO₄) was determined by precipitation as Barium sulphate (Richards, 1954).

$$\text{SO}_4 \text{ (Meq/liter)} = \frac{\text{mg of BaSO}_4 \text{ precipitate} \times 8.568}{\text{Volume of Soil extract}}$$

3.2.11 Elemental Analysis

3.2.11. a. Sample preparation

Soil samples were digested in Concentrated HNO_3 and 30% H_2O_2 . Total Nitrogen was determined by the Kjeldahl method of Bremner & Mulvaney (1982).

3.2.11. b. Analysis

Mineral analysis was done by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Spectroscopic source in this technique is inductively coupled argon plasma. Sample to be analyzed is injected as a nebulized mist into the center of argon plasma. Intensive heat (may reach up to 10000 K) dissociates the chemical components and the energy that the component atoms absorb causes them to undergo excitation and ionization energy transitions. Spectral emissions are produced by these transitions which are characteristic of elements present in the sample. The resultant spectra is split into individual spectral lines by ICP's spectrometer. Each spectral line is converted into concentrations of respective elements by the ICP's computer. Present analysis was done on ICP-OES spectrometer iCAP 6500 (Thermo Fisher, UK) equipped with an echelle polychromator having charge injection device detector enabling all wavelengths to be measured simultaneously. The operating conditions were as follows: viewing height 15 mm radial, nebulizer gas flow rate 0.7 L min⁻¹, auxiliary gas flow rate 0.5 L min⁻¹, coolant gas flow rate 12 L min⁻¹, flush pump rate 100 rpm, analysis pump rate 50 rpm and pump stabilization time 5 s. The wavelength (nm) used are given in Table. 3.1.

3.3 Phytosociology

Phytosociological studies were conducted in 5 selected sites. These sites were chosen on the basis of species composition, habitats, and physiognomic contrast. Vegetation was analyzed by using 5 (10 x 10 m) quadrats for trees, 10 (5 x 5 m) quadrats for shrubs and 15 (1x1 m) quadrats for herbs in each site. Density, cover and frequency of each species were measured and values were changed to relative values to calculate IVI. The plant communities were established based on highest importance values following Ahamd & Shaukat (2012); Hussain (1989).

Table. 3.1 Reference range for mineral analysis

S. No	Elements	Symbol	Wavelength (nm)
1	Boron	B	249.773
2	Calcium	Ca	315.887
3	Cobalt	Co	228.616
4	Copper	Cu	324.754
5	Iron	Fe	238.204
6	Potassium	K	766.490
7	Magnesium	Mg	285.213
8	Manganese	Mn	257.610
9	Molybdenum	Mo	202.030
10	Sodium	Na	589.592
11	Nickle	Ni	231.604
12	Phosphorous	P	178.287
13	Sulphur	S	182.034
14	Silicon	Si	212.412
15	Zinc	Zn	213.856
16	Aluminum	Al	396.152
17	Barium	Ba	455.403
18	Titanium	Ti	337.280
19	Vanadium	V	292.402
20	Lead	Pb	220.353
21	Chromium	Cr	205.550
22	Silver	Ag	328.068
23	Cadmium	Cd	228.802

3.3.1 Density

Density is the average number of individuals of a species in unit / area

$$\text{Density} = \frac{\text{No: of individuals of a Species in Quadrats}}{\text{Total No: of Quadrats}}$$

$$\text{Relative Density} = \frac{\text{Density of a particular Species}}{\text{Densities of all the Species in a stand}} \times 100$$

3.3.2 Herbage Cover

Cover is the vertical projection of foliage shoots/crown of a species to the ground surface expressed as fraction or percent of a surface area.

$$\text{Cover} = \frac{\% \text{ Cover of a Species}}{\text{Total cover of all species}}$$

$$\text{Relative Cover} = \frac{\text{Cover of a particular Species}}{\text{Cover of all the Species in a stand}} \times 100$$

In Table 3.2 are given ten cover classes used for estimating plant cover. Mid-point values were used for calculation.

Table. 3.2 Cover classes

Class	Range (No. of individuals)	Mid-point value
1.	Up to 10	5
2.	11 – 20	15
3.	21 – 30	25
4.	31- 40	35
5.	41 – 50	45
6.	51 – 60	55
7.	61 – 70	65
8.	71 – 80	75
9.	81- 90	85
10.	91 – 100	95

3.3.3 Frequency

Frequency is the percentage occurrence of species in an area.

Frequency was determined as follows.

$$\text{Frequency} = \frac{\text{No: of Quadrats in which a Species was present}}{\text{Total No: of Quadrats}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a particular Species}}{\text{Frequencies of all the Species in a stand}} \times 100$$

3.3.4 a. Importance Value

The relative values of each parameter for species were added to get the importance values. The community was named after the three leading species having the highest importance values as follows.

$$IV = RD + RC + RF$$

3.3.4 b. Family Importance Value

Importance value of each species in a particular family was added together to give rise to FIV for all the quantitatively recorded families.

3.3.5 Maturity Index

The community maturity index was obtained by Pichi-Sermolli (1948) method.

$$\text{Degree of maturity index} = \frac{\text{Frequency values of all species in a stand}}{\text{Total number of species in a stand}}$$

3.3.6 Similarity Index

Similarity index was calculated by using Sorensen's index (Sorensen, 1948) as modified by Motyka *et al.* (1950), which used quantitative value rather than simply computing presence or absence of species. The similarities among the stands were compared.

$$IS_{MO} = \frac{2W}{A + B} \times 100$$

Where: W = Sum of the lowest quantitative value of the species pair common to both communities,

A = Sum of quantitative value of all species in community A.

B = Sum of quantitative value of all species in community B.

Index of dissimilarity was calculated as, ID = 100 - Index of Similarity

3.3.7 PC-Ord Analysis

Following Curtis & McIntosh (1950) PC-Ord (Windows Version 5.10) was used for data analysis. Quantitative data for trees and understory vegetation in relation to edaphic characteristics as well as major gradients that existed in vegetation

structure was compared following McCune & Mafford (2005). Vegetation was classified using Ward's cluster analysis while PCA and NMS were applied for ordination according to Gauch & Whittaker (1981). The IVI data of 33 trees and 29 edaphic parameters was used for cluster analysis PCA ordination, which resulted in three prominent groups. Later IVI data of understory vegetation was analyzed through PC-Ord for cluster analysis, PCA and NMS ordination. The understory vegetation was classified into four major groups. The IVI data set of trees and understory plant species as well as edaphic characteristics was used to calculate mean and standard error through descriptive statistics. Edaphic characters were correlated with PCA score and NMS axis after Gupta *et al.* (2008). Vegetation and edaphological attributes were correlated through Regression analysis and Pearson product movement.

3.4 Ethnobotany

Plants were classified into various categories of uses in the area. The information was gathered from local knowledgeable elderly persons and also supplemented with personal observation during the field surveys following Sher *et al.* (2011), Alam *et al.* (2011) and Barkatullah *et al.* (2009).

3.5 Chemical analysis of selected forage plants

3.5.1 Sampling

Five plant species were selected for chemical analysis. Each species was sampled in Pre-Reproductive and Post-Reproductive stage in order to know the changes in mineral profile of each plant and their impact on grazing preferences of animals. Five kg of plant sample for each species were collected. Plants were cleaned to avoid any particulate contamination. Each sample was taken in perforated plastic bags which were duly labeled. Plants were dried and ground to 0.5 to 1 mm particle size.

Table. 3.3 Plant species selected for chemical analysis

S.No	Species	Family
1	<i>Aristida cyanantha</i> Nees ex Steud.	Poaceae
2	<i>Andrachne cordifolia</i> (Wall.ex Dcne.) Muell. Arg.	Euphorbiaceae
3	<i>Quercus baloot</i> Griffith	Fagaceae
4	<i>Indigofera heterantha</i> Wall. ex Brandis var. <i>gerardiana</i> (Wall. ex Baker) Ali	Papilionaceae
5	<i>Cotoneaster nummularia</i> Fisch. & Mey.	Rosaceae

3.5.2 Microwave digestion of plant samples

200 mg of ground plant material was digested with H_2O_2 and HNO_3 taken in 2:1 ratio by closed vessel microwave digestion.

3.5.3 Mineral analyses

Each digested sample was diluted with deionized water. Following minerals were estimated in plant samples (Table. 3.4) by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Analysis was done on ICP-OES spectrometer iCAP 6500 (Thermo Fisher, UK).

Table 3.4. Reference range for minerals in plant samples

S.No	Parameter	Symbol	Wavelength (nm)
1	Phosphorous	P	178.287
2	Potassium	K	766.490
3	Calcium	Ca	315.887
4	Magnesium	Mg	285.213
5	Sulfur	S	182.034
6	Iron	Fe	238.204
7	Manganese	Mn	257.610
8	Boron	B	249.773
9	Molybdenum	Mo	202.030
10	Copper	Cu	324.754
11	Zinc	Zn	213.856
12	Nickle	Ni	231.604
13	Cobalt	Co	228.616
14	Sodium	Na	589.592

FLORISTIC COMPOSITION
AND ECOLOGICAL
RESULTS AND DISCUSSION

FLORISTIC COMPOSITION AND ECOLOGICAL ATTRIBUTES

4.1 Floristic composition and ecological attributes

Flora refers to all the plant species found in a particular locality. It differs from vegetation, which refers to the population, distribution, size and relative importance of plant species (Ali, 2008). Floristic inventories help in understanding various attributes of vegetation, soil and climatic features. Chail Valley possesses diverse flora of Sino-Japanese region. The major part of this valley lies in moist temperate region. Stewart (1967) was the first worker to prepare the floristic list of Northwest Pakistan including Swat. Valuable contributions in preparation of floristic lists are made by many workers from abroad such as Alsherif *et al.* (2013), Blanckaert *et al.* (2004), Djaha *et al.* (2008), Addo *et al.* (2009), Ozgur and Ansin (2003) and Yalcin *et al.* (2011). Similarly, floristic inventories and ecological characteristics of different localities in Pakistan are enumerated by Abbas *et al.* (2013), Fazal *et al.* (2010), Haq *et al.*, (2010), Hussain *et al.* (2015), Qureshi and Bhatti (2010), Saima *et al.* (2010; 2009). Ahmad *et al.* (2014) reported 50 plants of medicinal value from Chail valley. There is no record available on floristic composition and ecological attributes of Chail Valley apart from the references of Ilyas *et al.* (2013) and Rashid *et al.* (2011) on Kabal Valley and Malam Jabba respectively.

Floral diversity refers to all the plants present in any geographic locality, both wild and cultivated. Floristic composition of any area reflects the prevalent climatic conditions, edaphic characteristics, anthropogenic pressure and other natural stresses. Flora of Chail Valley consisted of 104 families, 332 genera and 463 species. Of these Gymnosperms was represented by 3 families (9 Spp), Monocots with 17 families (70 Spp) and Dicots with 84 families (384 Spp). Largest families were Asteraceae (42 Spp), Poaceae (35 Spp), Rosaceae and Lamiaceae (26 Spp) each, Papilionaceae (25 Spp), Brassicaceae and Boraginaceae each with (16 Spp), Apiaceae (14 Spp), Solanaceae (13 Spp), Ranunculaceae (12 Spp), Polygonaceae, Caryophyllaceae and Scrophulariaceae (8 Spp each), Primulaceae and Caprifoliaceae (7 Spp), Araceae, Moraceae, Cucubitaceae, Euphorbiaceae, Amaranthaceae and Rubiaceae (each with 6 Spp), Pinaceae and Salicaceae (5 Spp. each), Liliaceae, Fagaceae, Geraniaceae, Onagraceae, Malvaceae, Gentianaceae, Convolvulaceae and Oleaceae (each with 4 Spp). Rest of the families were having less than 4 species (Table. 3.1).

Durrani *et al.* (2005), Marwat and Qureshi (2000), Musharaf *et al.* (2011; 2014) and Parveen *et al.* (2008) also reported these families as dominant ones in their study areas. Asteraceae, Poaceae, Rosaceae, Lamiaceae and Papilionaceae have a wide ecological amplitude and therefore distributed along a diverse range of micro-habitats. The present result is also supported by the Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1992; Ali & Qaiser, 1995-2015), which also shows these families to be major families.

In Chail Valley winter is very cold while summer is pleasant. Highest number of species was recorded in summer (396 Spp. 38.04%) followed by spring (279 Spp. 26.80%). Due to chilling frozen winters the number of species was declined to 173 Spp. (16.62%). In autumn 193 Spp. (18.54%) were found (Table. 4.2). Seasonal variation has no effect on woody, shrubby and perennial plants. Some perennial herbs were present in all the seasons. However most of the herbaceous flora has varied distribution pattern in different seasons. Studies by Badshah *et al.* (2013) and Durrani *et al.* (2010) also indicate that summer and spring flora had more species richness in comparison to autumn and winter aspects. Based on habit, herbs were the most abundant with 340 Spp. (73.43%), followed by shrubs with 64 Spp. (13.82 %), trees with 49 Spp. (10.58%), climbers with 10 Spp. (2.16%).

4.1.1 Life form: Physiognomy of flora and vegetation depends upon the life forms and environmental conditions. Raunkiaer (1934) proposed life form classification which is based on position of perennating structures during unfavorable conditions. When Raunkiaerean classification was applied, it was found that most abundant life form was therophytes (188 Spp., 40.60%), followed by hemicryptophytes (77 Spp., 16.63%) and nanophanerophytes (71 Spp., 15.33%). Geophytes (57 Spp., 12.31%), chamaephytes (19 Spp., 4.10%), mesophanerophytes (18 Spp., 3.89%), megaphanerophytes (17 Spp., 3.67 %) and microphanerophytes (13 Spp., 2.81%) were the next most prevailing life forms. Parasitic life form was represented by *Cuscuta europaea* L., *C. reflexa* Roxb. and *Viscum album* L. (0.65%). (Table. 4.2, Fig. 2) Biological spectrum is modified by anthropogenic pressure, agriculture, grazing and climatic shift. Seasonal variation in life form displayed a diverse picture. In spring season the dominant life form was therophytes with 92 species (32.97%), which were followed by nanophanerophytes 71 species (25.45%). Geophytes and hemicryptophytes were represented by 29 species each (10.39%), mesophanerophytes with 18 species (6.45%), megaphanerophytes with

17 species (6.09%) and microphanerophytes were represented by 13 species (4.66%). During summer the species richness was at its maximum. The most abundant were therophytes 146 species (36.87%), followed by nanophanerophytes 71 species (17.93%), hemicryptophytes 68 species (17.17%), mesophanerophytes 18 species (4.55%), chamaephytes & megaphanerophytes with 17 species each (4.29%) and microphanerophytes were represented with 13 species (3.28%). Nanophanerophytes dominated the autumn season with 71 Spp. (36.79%), followed by therophytes 47 species (24.35%), hemicryptophytes 19 species (9.84%), mesophanerophytes 18 species (9.33%), megaphanerophytes 17 species (8.81%), microphanerophytes 13 species (6.74%) and chamaephytes with 5 species (2.59%). Lowest number of species was recorded in winter. The dominant life form was nanophanerophytes 71 species (41.04%), followed by therophytes 41 species (23.70%), mesophanerophytes 18 species (10.40%), megaphanerophytes 17 species (9.83%), microphanerophytes 13 species (7.51%), hemicryptophytes 4 species (2.31%) and chamaephytes with 2 species (1.16%) (Table. 3.3). The life form spectra in present study clearly show that Therophytes dominated in terms of species richness followed by Hemicryptophytes, Geophytes and Nanophanerophytes. Our results are in line with the work of Cain and Castro (1959), Batalha and Martins (2002), Badshah *et al.* (2013) and Musharaf *et al.* (2011). During the course of evolution, Therophytes have emerged as life form which is capable to cope with unfavorable conditions (Guo *et al.*, 2009; Manhas *et al.*, 2010 and Badshah *et al.*, 2013).

Vegetation in the valley shows definite stratification. The tree layer comprises of Megaphanerophytes (such as *Abies pindrow*, *Cedrus deodara*, *Picea smithiana*, and *Pinus wallichiana*), Mesophanerophytes (such as *Pinus roxburghii*, *Pinus wallichiana*, *Alnus nitida* and *Quercus baloot*) and Microphanerophytes (*Pistacia chinensis*, *Crataegus songarica*, *Prunus armeniaca* and *Zanthoxylum armatum*). Shrub layer is represented by nanophanerophytes. Below these are chamaephytes, hemicryptophytes, therophytes and geophytes respectively. Anthropogenic pressures such as deforestation and grazing are destroying the characteristic vegetation that has resulted in loss of herbaceous and shrubby vegetation.

Vegetation with open physiognomies have a relative abundance of therophytes and chamaephytes (Batalha and Martins, 2002). In Chail Valley chilling winter creates unfavorable conditions which contribute to the abundance of these life forms. Work of Sher and Khan (2007) also supports our findings who reported the

nanophanerophytes and therophytes as characteristic life forms from District Bunir. Similar life form spectra were obtained by Kar *et al.* (2010), during their studies in grasslands of Odisha, India.

4.1.2 Leaf size spectra: Study of leaf size spectra revealed that there were 147 Spp. of mesophylls (31.75%), followed by microphylls with 140 Spp. (30.24%), nanophylls with 136 Spp. (29.37%), leptophylls with 25 Spp. (5.40%), macrophylls with 10 Spp. (2.16%) and megaphylls with 3 Spp. (0.65%). There were only 2 aphyllous i.e. *Cuscuta europaea* L. and *C. reflexa* Roxb. (Table 4.2, Fig. 3). Seasonal variation among leaf form classes showed that in spring the mesophyllous forms were dominant (93 Spp. 33.33%), followed by microphylls with 85 Spp. (30.47%) and nanophylls with 76 Spp. (27.24%). In summer, mesophylls dominated with 128 Spp. (32.32%). Next to them were nanophylls with 119 Spp. (30.05%) and microphylls with 117 Spp. (29.55%). In autumn the most abundant leaf spectra appeared to be mesophyll with 72 Spp. (37.31%), microphyll with 53 Spp. (27.46%) and nanophylls with 52 Spp. (26.94%). Mesophyll were also dominant in winter (62 Spp., 35.84%) followed by microphylls with 48 Spp. (27.75%) and nanophylls with 46 Spp. (26.59%) (Table. 4.3). Leaf size is related to climatic features in any geographic locality (Batalha and Martins, 2004). Variation among different leaf size classes is also affected by elevation. During this study it was observed that seasonal variation in leaf size classes was mainly due the presence of geophytes and therophytes. Evergreen plants remain persistent, such as *Abies pindrow*, *Taxus fauana*, *Picea smithiana* etc. Studies conducted in Waziristan and District Tank reported the relative dominance of microphyllous and nanophyllous (Badshah *et al.*, 2010a, 2013). Leaf size is an indicator of the prevailing climatic and edaphic conditions but it cannot be trusted as a criterion for sorting distinct leaf zones. Leaf size classes in combination with morpho-anatomical data yield much accurate results in establishing leaf zone or climates.

4.1.3 Habitat: Highest number of species (175 Spp., 37.79%) were found growing on dry exposed mountain sloop. These were followed by 78 species (16.84%) recorded from agricultural fields, 77 species (16.63%) within forest, 43 species (9.28%) from waste places and 31 species (6.69%) from wet places. The area is under tremendous anthropogenic pressure as people from the locality obtain fuel wood and timber from the forest and rapid deforestation is resulting in habitat disturbance and destruction. Some medicinally important plants such as *Trillium*

govanianum and *Hypericum perforatum* are under the threat of extinction from the locality because of their lavish and improper collection methods. Results of present study strongly advocate the further exploration of the floristic details of the area. It is further recommended to restore the degraded forest by encouraging In-situ conservation as plants would flourish well in their original habitat rather going for Ex-situ practices.

Table. 4.1 Floristic list and ecological attributes of Chail Valley, Swat Pakistan

S.No	Taxon	SEASONLALITY				Life Form	Leaf Size	Lamina	Habit
		Spring	Summer	Autumn	Winter				
Gymnosperms									
Cupressaceae									
1	<i>Cupressus sempervirens</i> L.	+	+	+	+	Micp	L	N	I
2	<i>Juniperus communis</i> L. var. <i>saxatilis</i> Palls	+	+	+	+	Np	L	N	D
3	<i>Thuja orientalis</i> L.	+	+	+	+	Np	L	N	I
Pinaceae									
4	<i>Abies pindrow</i> Royle.	+	+	+	+	Megp	N	N	F
5	<i>Cedrus deodara</i> (Roxb. ex Lamb.) G. Don	+	+	+	+	Megp	N	N	F
6	<i>Picea smithiana</i> (Wall.) Boiss.	+	+	+	+	Megp	N	N	F
7	<i>Pinus roxburghii</i> Sargent	+	+	+	+	Mesp	N	N	F
8	<i>Pinus wallichiana</i> A.B. Jackson	+	+	+	+	Megp	N	N	F
Taxaceae									
9	<i>Taxus fauana</i> (Zucc.) Pilger	+	+	+	+	Mesp	N	N	F
Monocotyledonae									
Alismataceae									
10	<i>Alisma plantago- aquatica</i> L.		+			H	N	S	M
11	<i>Sagittaria trifolia</i> L.	+	+			G	Mes	Dis	M
Alliaceae									
12	<i>Allium cepa</i> L.	+				G	Mes	S	CU
13	<i>Allium sativum</i> L.	+				G	Mes	S	CU
Amyryllidaceae									
14	<i>Ixiolirion tataricum</i> (Pall.) Herb.	+				G	Mic	S	R
15	<i>Narcissus tazetta</i> L.				+	G	Mes	S	GY
Araceae									
16	<i>Acorus calamus</i> L.		+			G	Mes	S	W
17	<i>Arisaema flavum</i> (Forsk.) Schott		+			G	Mes	Comp	F
18	<i>Arisaema jacquemontii</i> Blume		+			G	Mes	Comp	F
19	<i>Arum jacquemontii</i> Blume	+				G	Mes	S	D
20	<i>Colocasia esculenta</i> (L.) Schott	+			+	G	Meg	S	CU
21	<i>Sauromatum venosum</i> (Ait.) Schott.	+	+			G	Mes	S	D
Asphodelaceae									
22	<i>Eremurus himalaicus</i> Baker		+			G	Mes	S	D
Colchicaceae									
23	<i>Colchicum luteum</i> Baker	+			+	G	N	S	R
Commelinaceae									
24	<i>Commelina benghalensis</i> L.		+			Th	Mic	S	M
25	<i>Commelina paludosa</i> Blume		+			G	Mes	S	M
Cyperaceae									
26	<i>Cyperus cyperoides</i> (L.) Kuntze		+			G	Mic	S	WC
27	<i>Cyperus rotundus</i> L.		+			G	N	S	WC
Dioscoraceae									
28	<i>Dioscorea deltoidea</i> Wall. ex Kunth		+			G	Mes	S	A
Iridaceae									
29	<i>Iris germanica</i> L.	+				G	Mes	S	R
30	<i>Iris hookeriana</i> Foster		+			G	Mes	S	R
31	<i>Moraea sisyrinchium</i> (L.) Ker.	+	+			G	Mic	S	WP

76	<i>Trillium govanianum</i> Wall. ex Royle		+			Ch	Mes	S	F
Dicotyledonae									
Acanthaceae									
77	<i>Dicliptera bupleuroides</i> Nees var. <i>ciliata</i> Malik & A. Ghafoor	+	+	+		H	Mes	S	GY
78	<i>Justicia adhatoda</i> L.	+	+	+	+	Np	Mes	S	GY
79	<i>Strobilanthes urticifolia</i> Wall. ex Kuntze		+	+		Np	N	S	M
Aceraceae									
80	<i>Acer cappadocicum</i> Gled.	+	+	+	+	Megp	Mac	Dis	F
Amaranthaceae									
81	<i>Achyranthes aspera</i> L. var. <i>pubescens</i> (Moq.) C.C. Townsend			+	+	Th	Mic	S	WP-A
82	<i>Amaranthus spinosus</i> L.		+			Th	Mic	S	WP
83	<i>Amaranthus viridis</i> L.		+			Th	Mic	S	D
84	<i>Celosia argentea</i> L. var. <i>cristata</i> (L.) Schinz		+			Th	N	S	WP
85	<i>Deeringia amaranthoides</i> (Lam.) Merr.	+	+	+	+	Np	Mic	S	F
86	<i>Digera muricata</i> (L.) Mart.		+			Th	Mic	S	R
Anacardiaceae									
87	<i>Pistacia chinensis</i> Bunge ssp. <i>integerrima</i> (J.L.S) Rech. f.	+	+	+	+	Micp	Mic	Comp	F
88	<i>Rhus punjabensis</i> J. L.	+	+	+	+	Micp	Mes	Comp	F
89	<i>Rhus javanica</i> L.	+	+	+	+	Micp	Mes	Comp	F
Apiaceae									
90	<i>Ammi visnaga</i> (L.) Lam.	+	+		+	Ch	L	Dis	D-A
91	<i>Anethum graveolens</i> L.	+	+			Th	L	Dis	D
92	<i>Angelica glauca</i> Edgew.		+			Th	N	Comp	D
93	<i>Bunium persicum</i> (Boiss.) Fedtsch.		+			Th	L	Dis	WP
94	<i>Bupleurum falcatum</i> L.		+			Th	Mic	S	F
95	<i>Bupleurum longicaule</i> Wall. ex DC. var. <i>ramosum</i> Nasir		+	+		Th	Mic	S	D
96	<i>Coriandrum sativum</i> L.		+	+		Th	L	Dis	CU
97	<i>Eryngium coeruleum</i> M-Bieb.		+	+		H	N	S	D
98	<i>Foeniculum vulgare</i> Mill.		+	+		Th	N	Dis	A
99	<i>Oenanthe javanica</i> (Blume) DC.		+	+		Th	N	Comp	R
100	<i>Pimpinella diversifolia</i> DC.		+	+		Th	Mes	Comp	A
101	<i>Scandix pecten-veneris</i> L.	+			+	Th	Mic	Comp	A
102	<i>Torilis leptophylla</i> (L.) Reichb. f.	+			+	Th	N	Dis	R
103	<i>Trachyspermum ammi</i> (L.) Sprague	+	+			Th	L	Dis	D
Apocynaceae									
104	<i>Nerium oleander</i> L.	+	+	+	+	Np	Mes	S	D
Araliaceae									
105	<i>Hedera nepalensis</i> K. Koch	+	+	+	+	Np	Mes	S	F-GY
Asclepiadaceae									
106	<i>Cynanchum jacquemontianum</i> Decne.	+	+			Th	Mes	S	D
Asteraceae									
107	<i>Achillea millefolium</i> L.		+			H	L	Dis	A-D
108	<i>Anaphalis adnata</i> Wall. ex DC.		+			Th	Mes	S	A
109	<i>Anaphalis triplinervis</i> (Sims.) C.B. Clarke		+			G	Mes	S	A-D
110	<i>Artemisia absinthium</i> L.		+	+		Th	N	Dis	R
111	<i>Artemisia santolinifolia</i> Turcz. ex Krasch.		+	+		Ch	N	Dis	R-GY
112	<i>Artemisia scoparia</i> Waldst. & Kit.		+	+		Th	N	Dis	W
113	<i>Artemisia vulgaris</i> L.		+			Ch	Mic	Dis	A-R
114	<i>Aster mollisculus</i> (DC.) C.B. Clarke	+				Th	Mic	S	D

115	<i>Bidens biternata</i> (Lour.) Merrill & Scheriff				+	Th	Mic	Dis	WP-R
116	<i>Bidens cernua</i> L.				+	Th	Mic	S	WP
117	<i>Calendula arvensis</i> L.	+				Th	Mic	S	A
118	<i>Calendula officinalis</i> L.	+	+	+	+	Th	Mes	S	A
119	<i>Carduus edelbergii</i> Rech. f.	+			+	Th	Mac	Sp	D
120	<i>Carthamus oxyacantha</i> M.B.		+			Th	Mic	S	A
121	<i>Centaurea iberica</i> Trev. ex Spreng.	+				Th	Mic	Dis	WP
122	<i>Cichorium intybus</i> L.		+	+	+	Th	N	S	WP
123	<i>Cirsium falconeri</i> (Hk. f.) Petrak		+			H	Mes	Sp	D
124	<i>Cnicus benedictus</i> L.	+				H	Mes	Dis	D
125	<i>Conyza Canadensis</i> (L.) Cronquist		+			Th	N	S	WP
126	<i>Echinops griffithianus</i> Boiss.		+			Ch	N	S	D
127	<i>Erigeron multicaulis</i> Wall. ex DC.		+			Th	Mic	S	D
128	<i>Koeleria linearis</i> Pallas		+	+		Th	Mic	S	D
129	<i>Lactuca dissecta</i> D. Don	+	+			Th	Mic	Dis	A
130	<i>Lactuca orientalis</i> Boiss.	+	+			Th	N	Dis	D
131	<i>Lactuca serriola</i> L.	+	+			Th	Mes	Dis	D
132	<i>Launaea procumbens</i> (Roxb.) Ramayya & Rajagopal	+			+	H	L	Sp	D
133	<i>Onopordum acanthium</i> L.	+	+			G	Mes	Dis	A
134	<i>Pseudognaphalium affine</i> (D. Don.) Anderb.	+	+			H	Mes	S	F
135	<i>Scorzonera virgata</i> DC.		+			Th	Mes	S	WP
136	<i>Senecio chrysanthemoides</i> DC.	+	+			Th	Mes	S	R
137	<i>Seriphidium brevifolium</i> (Wall. ex DC.) Ling & Y. R. Ling	+	+	+	+	Np	Mes	Dis	F
138	<i>Serratula palida</i> DC.		+			G	N	Dis	WP
139	<i>Silybum marianum</i> Gaertn.	+	+			Ch	Mes	Sp	WP
140	<i>Solidago virgaurea</i> L.		+			Th	Mic	S	WP
141	<i>Sonchus arvensis</i> L.		+			Th	Mic	Dis	A-D
142	<i>Sonchus asper</i> (L.) Hill		+			Th	Mic	Dis	A-D
143	<i>Sonchus oleraceus</i> L.		+			Th	Mic	Dis	A
144	<i>Tagetes erecta</i> L.		+			Th	N	Comp	GY
145	<i>Taraxacum officinale</i> Wigg.	+	+			Th	Mic	Dis	D
146	<i>Tragopogon gracilis</i> D. Don	+	+			H	Mic	S	D
147	<i>Tussilago farfara</i> L.	+	+			G	Mes	S	WP
148	<i>Xanthium strumarium</i> L.		+			Th	Mes	S	WP
Balsaminaceae									
149	<i>Impatiens bicolor</i> Royle ssp. <i>pseudo bicolor</i> (Grey-Wilson) Y. Nasir		+			Th	Mes	S	W
150	<i>Impatiens brachycentra</i> Kar. & Kir.		+			Th	Mic	S	M
151	<i>Impatiens edgeworthii</i> Hk. f.		+	+		Th	Mes	S	W
Berberidaceae									
152	<i>Berberis lycium</i> Royle	+	+	+	+	Np	N	Sp	F
153	<i>Berberis parkeriana</i> Schneid.	+	+	+	+	Np	N	S	D
Betulaceae									
154	<i>Alnus nitida</i> (Spach) Endl.	+	+	+	+	Mesp	Mes	S	F
155	<i>Betula utilis</i> D. Don.	+	+	+	+	Mesp	Mes	S	F
Boraginaceae									
156	<i>Anchusa arvensis</i> (L.) Bieb.	+	+			Th	Mic	S	D
157	<i>Arnebia linearifolia</i> A. DC.	+	+			Th	Mic	S	D
158	<i>Buglossoides arvensis</i> (L.) Johnston	+	+			Th	N	S	WP
159	<i>Cynoglossum glochidiatum</i> Wall. ex Bth.	+	+			H	N	S	W
160	<i>Cynoglossum lanceolatum</i> Forssk.		+			H	N	S	W
161	<i>Heliotropium bacciferum</i> Forssk.	+			+	G	L	S	D
162	<i>Heliotropium strigosum</i> Willd. ssp.		+	+		Th	Mic	S	D

	<i>brevifolium</i> (Wall.) Kazmi								
163	<i>Lindelofia longiflora</i> (Bth.) Baill. var. <i>longiflora</i>		+			H	Mes	S	WP
164	<i>Myosotis alpestris</i> F. W. Schmidt var. <i>albicans</i> (H.Riedl) Y.Nasir		+			H	Mic	S	F
165	<i>Myosotis caespitosa</i> C. F. Schultz.		+			H	Mic	S	D
166	<i>Nonea caspica</i> (Willd.) G.Don ssp. <i>caspica</i>	+			+	Th	Mic	S	F-D
167	<i>Onosma dichroantha</i> Boiss.	+			+	Th	N	S	A-D
168	<i>Onosma griffithii</i> Vatke	+	+			Th	N	S	A-D
169	<i>Onosma hispida</i> Wall. ex G. Don	+			+	Th	Mic	S	D
170	<i>Pseudomertensia parvifolia</i> (Decne.) Riedl	+	+			Th	Mic	S	F
171	<i>Trichodesma indicum</i> (L.) R. Br.	+	+			Th	Mic	S	D
Brassicaceae									
172	<i>Alliaria petiolata</i> (M. Bieb.)	+	+	+	+	Th	N	S	A
173	<i>Arabidopsis thaliana</i> L.	+	+			Th	N	S	A
174	<i>Brassica rapa</i> L. ssp. <i>campestris</i> (L.) Clapham	+				Th	Mic	Dis	CU
175	<i>Brassica rapa</i> L. ssp. <i>rapa</i>	+				Th	Mes	Dis	CU
176	<i>Capsella bursa-pastoris</i> (L.) Medik.	+			+	Th	Mic	S	WP
177	<i>Cardamine flexuosa</i> With.	+	+		+	Th	N	S	D
178	<i>Cardamine macrophylla</i> Willd.	+	+			G	Mic	Comp	D
179	<i>Eruca sativa</i> Mill.	+	+			Th	Mic	Dis	WP
180	<i>Lepidium apetalum</i> Willd.	+	+			Th	N	S	WP
181	<i>Lepidium sativum</i> L.	+	+			Th	Mic	S	WP
182	<i>Nasturtium officinale</i> R. Br.	+	+		+	G	Mic	Comp	W
183	<i>Neslia apiculata</i> Fisch., CA.Mey. & Avec-Lall	+	+		+	Th	L	S	A
184	<i>Rorippa islandica</i> (Oed.) Borb.	+	+			Th	Mes	Dis	ST
185	<i>Sisymbrium irio</i> L.	+	+		+	Th	N	Dis	M
186	<i>Thlaspi andersonii</i> (Hk. f. & Thoms.) O.E. Schulz	+	+		+	Th	N	S	WP
187	<i>Thlaspi perfoliatum</i> L.	+	+		+	Th	Mic	S	WP
Buddlejaceae									
188	<i>Buddleja crispa</i> Bth.	+	+	+	+	Np	Mic	S	D
Buxaceae									
189	<i>Sarcococca saligna</i> (D. Don) Muell.Arg.	+	+	+	+	Np	Mic	S	D-F
Caesalpiniaceae									
190	<i>Caesalpinia decapetala</i> (Roth) Alston	+	+	+	+	Np	Mic	Comp	D
Campanulaceae									
191	<i>Campanula cashmeriana</i> Royle		+			Th	N	S	A
192	<i>Campanula pallida</i> Wall. var. <i>pallida</i>	+	+			H	Mes	S	A-D
193	<i>Campanula pallida</i> Wall. var. <i>tibetica</i> (Hk.f. et Thoms.) Hara		+			H	Mic	S	A-D
Cannabaceae									
194	<i>Cannabis sativa</i> L.	+	+			Th	Mic	S	WP
Cannaceae									
195	<i>Canna indica</i> L.	+	+			Ch	Meg	S	I
Caprifoliaceae									
196	<i>Lonicera asperifolia</i> (Decne.) Hk. f. & Thoms.	+	+	+	+	Np	N	S	D
197	<i>Lonicera caucasica</i> Pallas. ssp. <i>govianiana</i> (Wall. ex DC.) Hara	+	+	+	+	Np	Mes	S	D-F
198	<i>Lonicera obovata</i> Royle ex Hk. f. & Thoms.	+	+	+	+	Np	N	S	D-F
199	<i>Lonicera purpurascens</i> (Decne.) Walp.	+	+	+	+	Np	Mic	S	D-F

200	<i>Lonicera quinquelocularis</i> Hardw.	+	+	+	+	Np	N	S	D-R
201	<i>Viburnum cotinifolium</i> D. Don	+	+	+	+	Np	Mic	S	D
202	<i>Viburnum grandiflorum</i> Wall. ex DC.	+	+	+	+	Np	Mes	S	D
Caryophyllaceae									
203	<i>Arenaria serpyllifolia</i> L.		+	+		Th	L	S	M
204	<i>Cerastium dichotomum</i> L.	+	+			Th	N	S	M
205	<i>Cerastium fontanum</i> Baumg.	+			+	Th	N	S	R
206	<i>Dianthus orientalis</i> Adams.		+			Th	N	S	GY
207	<i>Silene conoidea</i> L.	+			+	Th	Mic	S	W
208	<i>Silene viscosa</i> (L.) Pers.	+	+			Th	Mic	S	W
209	<i>Silene vulgaris</i> (Moench) Garcke	+	+			Th	Mic	S	M
210	<i>Stellaria media</i> (L.) Vill.	+	+			Th	N	S	M
Celestraceae									
211	<i>Maytenus royleanus</i> (Wall. ex Lawson) Cuf.	+	+	+	+	Np	Mic	S	D
Chenopodiaceae									
212	<i>Chenopodium album</i> L.		+			Th	Mes	S	A
213	<i>Chenopodium ambrosioides</i> L.		+			Th	Mes	Dis	D
214	<i>Chenopodium botrys</i> L.	+	+			Th	Mic	Dis	A
Convolvulaceae									
215	<i>Convolvulus arvensis</i> L.	+			+	Th	Mes	S	F-A
216	<i>Evolvulus alsinoides</i> L.	+			+	Th	Mic	S	F
217	<i>Ipomoea eriocarpa</i> R. Br.		+	+		Th	Mic	S	A
218	<i>Ipomoea purpurea</i> (L.) Roth.		+	+		Th	Mes	S	A
Crassulaceae									
219	<i>Hylotelephium ewersii</i> (Ledeb.) H. Ohba		+			G	N	S	R
220	<i>Sedum hispanicum</i> L.		+			H	N	S	M
Cucurbitaceae									
221	<i>Cucumis melo</i> L. ssp. <i>agrestis</i> (Naud.) Grebensc. var. <i>agrestis</i> Naud		+	+		Th	Mac	S	CU
222	<i>Cucumis sativus</i> L.		+	+		Th	Mac	Dis	CU
223	<i>Cucurbita maxima</i> Duch. ex Lam.		+	+		Th	Mac	Dis	CU
224	<i>Lagenaria siceraria</i> (Molina) Standley	+				Th	Mac	Dis	A
225	<i>Luffa cylindrica</i> (L.) Roem.		+	+		Th	Mac	Dis	CU
226	<i>Solena amplexicaulis</i> (Lam.) Gandhi	+	+			G	Mic	S	D
Cuscutaceae									
227	<i>Cuscuta europaea</i> L.	+	+			P	Ap	Abs	Epi
228	<i>Cuscuta reflexa</i> Roxb.	+	+	+		P	Ap	Abs	Epi
Datisceae									
229	<i>Datisca cannabina</i> L.		+			Ch	Mic	Comp	WP
Dipsaceae									
230	<i>Scabiosa candolii</i> DC.	+	+			H	Mes	S	D
Ebenaceae									
231	<i>Diospyros kaki</i> L.	+	+	+	+	Megp	Mes	S	I
232	<i>Diospyros lotus</i> L.	+	+	+	+	Megp	Mes	S	D-F
Elaeagnaceae									
233	<i>Elaeagnus umbellata</i> Thunb.	+	+	+	+	Np	Mic	S	D-F
Euphorbiaceae									
234	<i>Andrachne cordifolia</i> (Wall. ex Dcne.) Muell. Arg.	+	+	+	+	Np	Mic	S	F-D
235	<i>Euphorbia helioscopia</i> L.		+			Th	N	S	A-D
236	<i>Euphorbia hispida</i> Boiss.		+	+		Th	N	S	A-D
237	<i>Euphorbia peplus</i> L.		+			Th	L	S	A-D
238	<i>Euphorbia prostrata</i> Ait.	+			+	Th	L	S	A-D
239	<i>Ricinus communis</i> L.	+	+	+	+	Np	Mac	S	A
Fagaceae									
240	<i>Quercus baloot</i> Griffith	+	+	+	+	Mesp	Mic	Sp	F-D

241	<i>Quercus dilatata</i> Royle	+	+	+	+	Mesp	Mic	S	F-D
242	<i>Quercus incana</i> Roxb.	+	+	+	+	Mesp	Mic	S	F-D
243	<i>Quercus semecarpifolia</i> Sm.	+	+	+	+	Mesp	Mic	S	F-D
Fumariaceae									
244	<i>Fumaria indica</i> (Hausskn.) Pugsley	+	+			Th	N	Dis	WP
Gentianaceae									
245	<i>Gentianodes argentea</i> (Royle ex D. Don) Omer, Ali & Qaiser	+	+			G	N	S	F
246	<i>Swertia ciliata</i> (G. Don) B. L. Burt			+	+	Th	Mes	S	D
247	<i>Swertia cordata</i> (G. Don) Clarke		+	+		Th	Mes	S	D-F
248	<i>Swertia paniculata</i> Wall.	+	+			Th	Mic	S	R
Geraniaceae									
249	<i>Erodium ciconium</i> (L.) L' Herit ex Aiton	+			+	Th	Mes	Comp	W
250	<i>Erodium cicutarium</i> (L.) L' Herit ex Aiton	+			+	Th	Mes	Comp	W
251	<i>Geranium himalayense</i> Klotzsch		+			Th	Mic	Dis	F
252	<i>Geranium rotundifolium</i> L.	+				Th	Mic	Dis	D
Grossulariaceae									
253	<i>Ribes himalense</i> Dcne.	+	+	+	+	Np	Mic	Dis	D
254	<i>Ribes orientale</i> Desf.	+	+	+	+	Np	Mic	Dis	D-F
Hamelidaceae									
255	<i>Parrotiopsis jacquemontiana</i> (Dcne.) Rehder	+	+	+	+	Np	Mes	S	D
Hippocastanaceae									
256	<i>Aesculus indica</i> (Wall. ex Camb.) Hk. f.	+	+	+	+	Megp	Mes	Dis	F
Hypericaceae									
257	<i>Hypericum oblongifolium</i> Choisy	+	+	+	+	Np	N	S	D
258	<i>Hypericum perforatum</i> L.		+			Ch	N	S	D
Juglandaceae									
259	<i>Juglans regia</i> L.	+	+	+	+	Mesp	Mic	Comp	D
Lamiaceae									
260	<i>Ajuga bracteosa</i> Wall. ex Bth.	+	+	+		H	Mic	S	D
261	<i>Ajuga parviflora</i> Bth.	+	+			Th	Mes	S	D
262	<i>Clinopodium umbrosum</i> (M. Bieb.) C. Koch.	+	+			Th	Mic	S	D
263	<i>Eremostachys superba</i> Royle ex Bth.	+	+			H	Mes	Dis	A
264	<i>Isodon rugosus</i> (Wall. ex Bth.) Codd	+	+	+	+	Np	Mes	S	D
265	<i>Lamium album</i> L.		+	+		Th	Mes	S	D
266	<i>Lamium amplexicaule</i> L.		+			Th	Mic	S	WP
267	<i>Leonurus cardiaca</i> L.		+			Th	Mes	Dis	W
268	<i>Leucas cephalotes</i> (Roth.) Spreng.	+	+			Th	Mic	S	D
269	<i>Marrubium vulgare</i> L.	+	+			Th	Mic	S	F
270	<i>Mentha arvensis</i> L.	+	+			G	N	S	W
271	<i>Mentha longifolia</i> (L.) L.	+	+			G	N	S	W
272	<i>Micromeria biflora</i> (Buch.-Ham. ex D. Don) Bth.		+			Th	L	S	WP
273	<i>Nepeta goviana</i> (Wall. ex Bth.) Bth.		+			Th	Mic	S	F
274	<i>Nepeta laevigata</i> (D. Don) Hand.-Mazz.		+			Th	Mic	S	F
275	<i>Origanum vulgare</i> L.		+	+		Ch	Mic	S	F
276	<i>Phlomis spectabilis</i> Falc. ex Bth	+	+	+	+	Np	Mic	S	D
277	<i>Prunella vulgaris</i> L.	+			+	H	Mes	S	W
278	<i>Rosmarinus officinalis</i> L.	+	+	+	+	Np	N	S	D
279	<i>Salvia lanata</i> Roxb.	+			+	Th	Mes	S	D
280	<i>Salvia moorcroftiana</i> Wall. ex Bth.	+			+	Th	Mac	S	D-A
281	<i>Salvia nubicola</i> Wall. ex Sweet		+	+	+	Th	Mes	S	D
282	<i>Salvia plebeia</i> R. Br.		+	+		H	Mes	S	D
283	<i>Stachys parviflora</i> Bth.		+			H	N	S	D

284	<i>Teucrium stocksianum</i> Boiss. var. <i>incanum</i> (Aitch. & Hemsley) Hedge & Lamon	+	+			H	Mic	S	D-W
285	<i>Thymus linearis</i> Bth. ssp. <i>linearis</i> Jalas		+			H	L	S	D
Linaceae									
286	<i>Linum corymbulosum</i> Reichenb.	+	+			Th	L	S	WP
287	<i>Reimwardtia trigyna</i> (Roxb.) Planch.	+	+	+	+	Np	N	S	D
Loranthaceae									
288	<i>Viscum album</i> L.	+	+	+	+	P	L	S	Epi
Malvaceae									
289	<i>Abelmoschus esculentus</i> (L.) Moench		+	+		Th	Mes	Sp	CU
290	<i>Malvastrum coromendelianum</i> L.		+			Th	N	Sp	A-WP
291	<i>Malva neglecta</i> Wall.	+	+			Th	Mes	S	A
292	<i>Malva sylvestris</i> L.	+				Th	Mes	S	A
Meliaceae									
293	<i>Cedrela serrata</i> Royle	+	+	+	+	Megp	Mic	Comp	D
294	<i>Melia azedarach</i> L.	+	+	+	+	Megp	N	Comp	GY
Moraceae									
295	<i>Ficus carica</i> L. ssp. <i>carica</i>	+	+	+	+	Megp	Mes	S	D
296	<i>Ficus palmata</i> Forssk.	+	+	+	+	Mesp	Mes	S	D
297	<i>Ficus sarmentosa</i> Buch.-Ham. ex J.E. Smith	+	+	+	+	Mesp	Mes	S	D
298	<i>Morus alba</i> L.	+	+	+	+	Megp	Mes	S	A
299	<i>Morus macroura</i> Miq. Syn. <i>M.</i> <i>laevigata</i>	+	+	+	+	Megp	Mes	S	A
300	<i>Morus nigra</i> L.	+	+	+	+	Megp	Mes	S	A
Myrsinaceae									
301	<i>Myrsine africana</i> L.	+	+	+	+	Np	N	S	D-F
Nyctaginaceae									
302	<i>Boerhavia procumbens</i> Banks ex Roxb.	+	+			H	N	S	W
303	<i>Mirabilis jalapa</i> L.	+	+	+	+	Np	Mes	S	GY
Oleaceae									
304	<i>Fraxinus hookeri</i> Wenzig	+	+	+	+	Micp	Mes	Comp	D
305	<i>Jasminum humile</i> L.	+	+	+	+	Np	Mic	Comp	D
306	<i>Jasminum officinale</i> L.	+	+	+	+	Np	Mic	Comp	D
307	<i>Olea ferruginea</i> Royle	+	+	+	+	Mesp	Mic	S	GY-D
Onagraceae									
308	<i>Circaea cordata</i> Royle		+			G	Mes	S	WP
309	<i>Epilobium hirsutum</i> L.	+	+	+	+	Np	N	S	W
310	<i>Epilobium parviflorum</i> Schreb.		+	+		H	N	S	W
311	<i>Oenothera rosea</i> L' Her. Ex Ait.		+	+		H	Mic	S	W
Oxalidaceae									
312	<i>Oxalis acetosella</i> L.	+	+			Th	N	Comp	M
313	<i>Oxalis corniculata</i> L.	+	+	+		Th	N	Comp	M-A
Paeoniaceae									
314	<i>Paeonia emodi</i> Wall. ex Royle	+	+		+	Ch	Mes	Dis	F
Papaveraceae									
315	<i>Papaver dubium</i> L.	+	+			Th	Mes	Dis	A-D
316	<i>Papaver somniferum</i> L.	+	+			Th	Mes	Dis	A-D
Papilionaceae									
317	<i>Argyrolobium roseum</i> (Camb.) Jaub. & Spach	+				H	N	Comp	D
318	<i>Aeschynomene indica</i> L.	+				H	N	Comp	F
319	<i>Astragalus graveolens</i> Buch.-Ham. ex Bth.	+	+	+	+	Np	N	Comp	D
320	<i>Astragalus psilocentros</i> Fisch.	+	+	+	+	Np	N	Comp	D
321	<i>Desmodium elegans</i> DC.	+	+	+	+	Np	Mes	Comp	D

322	<i>Indigofera heterantha</i> Wall. ex Brandis var. <i>gerardiana</i> (Wall. ex Baker) Ali	+	+	+	+	Np	L	Comp	F
323	<i>Indigofera heterantha</i> Wall. ex Brandis var. <i>heterantha</i>	+	+	+	+	Np	L	Comp	D-F
324	<i>Lathyrus aphaca</i> L.	+			+	Th	Mic	Comp	A
325	<i>Lathyrus pratensis</i> L.		+		+	Th	Mic	Comp	A
326	<i>Lathyrus sativus</i> L.	+	+			Th	N	Comp	A
327	<i>Lathyrus sphaericus</i> Retz.	+			+	Th	Mic	Comp	A
328	<i>Lespedeza juncea</i> (L. f.) Pers. var. <i>juncea</i>	+	+	+	+	Np	Mic	Comp	D
329	<i>Lotus corniculatus</i> L. var. <i>corniculatus</i>	+				H	Mic	Comp	A
330	<i>Medicago lupulina</i> L.	+	+			Th	N	Comp	D-A
331	<i>Medicago minima</i> (L.) Grubb.	+			+	Th	N	Comp	A
332	<i>Medicago polymorpha</i> L.	+			+	Th	N	Comp	A
333	<i>Melilotus indicus</i> (L.) All.	+			+	Th	Mic	S	D-A
334	<i>Phaseolus lunatus</i> L.	+				Ch	Mes	Comp	CU
335	<i>Pisum sativum</i> L. var. <i>sativum</i>	+				Th	Mic	Comp	CU
336	<i>Sophora mollis</i> (Royle) Baker ssp <i>mollis</i>	+	+	+	+	Np	Mic	Comp	D
337	<i>Trifolium repens</i> L.	+	+			H	N	Comp	A
338	<i>Trifolium resupinatum</i> L.	+	+			H	Mic	Comp	CU
339	<i>Trigonella emodi</i> Bth.		+	+		Th	N	Comp	A
340	<i>Vicia monantha</i> Retz.		+	+		Th	N	Comp	D
341	<i>Vicia sativa</i> L.	+			+	Th	N	Comp	A
Plantaginaceae									
342	<i>Plantago himalaica</i> Pilger		+			Th	Mic	S	D
343	<i>Plantago lanceolata</i> L.		+			Th	Mes	S	W
344	<i>Plantago major</i> L.		+	+		Th	Mes	S	w
Plantanaceae									
345	<i>Platanus orientalis</i> L.	+	+	+	+	Megp	Mes	Dis	F
Plumbaginaceae									
346	<i>Limonium cabulicum</i> (Boiss.) O. Kuntze	+	+	+	+	Np	Mes	S	D
347	<i>Limonium gilesii</i> (Hemsl.) Rech.f.& Koeie	+	+	+	+	Np	Mes	S	D
Podophyllaceae									
348	<i>Podophyllum emodi</i> Wall. ex Royle	+	+			H	Mic	Comp	F
Polygalaceae									
349	<i>Polygala abyssinica</i> R. Br. ex Fresen	+	+	+		Ch	N	S	F
Polygonaceae									
350	<i>Aconogonon alpinum</i> (All.) Schur		+	+		H	N	S	WP
351	<i>Bistorta amplexicaulis</i> (D. Don) Green		+	+		H	Mes	S	F
352	<i>Fallopia dumetorum</i> (L.) Holub		+	+		Th	Mic	S	F
353	<i>Persicaria glabra</i> (Willd.) M. Gomes		+	+		Th	Mes	S	W
354	<i>Polygonum aviculare</i> L.		+	+		Th	N	S	W
355	<i>Polygonum plebejum</i> R. Br.		+	+		Th	N	S	A
356	<i>Rumex dentatus</i> L.		+	+		Ch	Mes	S	W
357	<i>Rumex hastatus</i> D. Don		+	+	+	Ch	N	Dis	W
Portulacaceae									
358	<i>Portulaca oleracea</i> L.	+	+			Th	N	S	A
Primulaceae									
359	<i>Anagallis arvensis</i> L. var. <i>coerulea</i> (L.) Gouan.	+			+	Th	N	S	W-A
360	<i>Androsace rotundifolia</i> Hardwicke ssp. <i>landulosa</i> (Hk.f.) Y.Nasir		+			H	Mes	S	D
361	<i>Androsace foliosa</i> Dcne. ex Duby		+			H	Mes	S	D
362	<i>Androsace rotundifolia</i> Hardw. ssp. <i>Rotundifolia</i>	+	+			H	Mes	S	D

Th. 14837

363	<i>Cortusa brotheri</i> Pax ex Lipsky		+			H	Mes	S	D
364	<i>Primula denticulata</i> Sm.	+			+	G	Mes	S	F
365	<i>Primula rosea</i> Royle		+			G	Mic	S	F
Punicaceae									
366	<i>Punica granatum</i> L.	+	+	+	+	Micp	Mic	S	D
Ranunculaceae									
367	<i>Aconitum violaceum</i> Jacq. ex Stapf		+			G	N	Dis	D
368	<i>Anemone falconeri</i> Thoms.		+			H	Mic	Dis	GY
369	<i>Aquilegia pubiflora</i> Wall. ex Royle var. <i>pubiflora</i>		+			H	N	Comp	F
370	<i>Caltha alba</i> Camb. var. <i>alba</i>		+			H	N	S	W
371	<i>Ceratocephala falcata</i> (L.) Pers.		+			Th	L	Comp	D
372	<i>Clematis connata</i> DC.	+	+	+	+	Np	Mes	Comp	D
373	<i>Clematis grata</i> Wall.	+	+	+	+	Np	Mic	Comp	D-A
374	<i>Delpinium uncinatum</i> Hk. f. & T.		+			H	N	Dis	CU
375	<i>Ranunculus arvensis</i> L.	+				G	N	Dis	M
376	<i>Ranunculus laetus</i> Wall. ex Hk. f. & Thoms.		+			G	N	Dis	WP
377	<i>Ranunculus muricatus</i> L.	+	+			G	N	Dis	WP
378	<i>Ranunculus sceleratus</i> L.	+	+			G	N	Dis	WP
Rhamnaceae									
379	<i>Sageretia thea</i> (Osbeck) M.C. Johnston var. <i>thea</i>	+	+	+	+	Np	Mic	S	F
Rosaceae									
380	<i>Agrimonia eupatoria</i> L.		+			Ch	Mic	Comp	D
381	<i>Cotoneaster microphyllus</i> Wall. ex Lindl.	+	+	+	+	Np	L	S	F
382	<i>Cotoneaster nummularia</i> Fisch. & Mey.	+	+	+	+	Np	N	S	F
383	<i>Crataegus songarica</i> G. Koch.	+	+	+	+	Micp	Mes	Dis	F
384	<i>Duchesnea indica</i> (Andr.) Focke	+	+			H	Mic	Comp	D
385	<i>Fragaria vesca</i> L.	+	+			H	Mic	Comp	D
386	<i>Geum elatum</i> G. Don	+	+			H	Mes	Comp	F
387	<i>Geum urbanum</i> L.	+	+			G	Mes	Comp	F
388	<i>Malus pumila</i> Mill.	+	+	+	+	Np	Mes	S	CU
389	<i>Potentilla nepalensis</i> Hk. f.		+			G	N	Comp	D
390	<i>Potentilla reptans</i> L.	+	+			H	N	Comp	D
391	<i>Prunus armeniaca</i> L.	+	+	+	+	Micp	Mes	S	CU
392	<i>Prunus domestica</i> L.	+	+	+	+	Micp	Mes	S	CU
393	<i>Prunus persica</i> (L.) Batsch.	+	+	+	+	Micp	Mes	S	CU
394	<i>Pyrus pashia</i> Ham. ex D. Don	+	+	+	+	Micp	Mes	S	CU
395	<i>Pyrus pyrifolia</i> (Burm.) Nak.	+	+	+	+	Micp	Mes	S	D
396	<i>Rosa alba</i> L.	+	+	+	+	Np	N	Comp	CU
397	<i>Rosa brunonii</i> Lindl.	+	+	+	+	Np	N	Comp	F
398	<i>Rosa webbiana</i> Wall. ex Royle	+	+	+	+	Np	N	Comp	F
499	<i>Rubus ellipticus</i> Smith	+	+	+	+	Np	N	Comp	F
400	<i>Rubus fruticosus</i> L.	+	+	+	+	Np	Mes	Comp	F-D
401	<i>Rubus ulmifolius</i> Schott	+	+	+	+	Np	Mes	Comp	D
402	<i>Sanguisorba minor</i> Scop.		+			H	L	Comp	D
403	<i>Sibbaldia cuneata</i> Kuntze		+			H	Mic	Comp	WP
404	<i>Sorbaria tomentosa</i> (Lindl.) Rehd.	+	+	+	+	Np	Mic	Comp	WP
405	<i>Spiraea canescens</i> D. Don	+	+	+	+	Np	Mic	S	F
Rubiaceae									
406	<i>Galium aparine</i> L.	+	+			Th	N	S	WP-A
407	<i>Galium elegans</i> Wall.	+	+			Th	N	S	WP-A
408	<i>Galium tetraphyllum</i> Nazim. & Ehrend.		+			Th	N	S	A-D
409	<i>Himalrandia tetrasperma</i> (Roxb.)	+	+	+	+	Np	N	S	F

	Yamazaki								
410	<i>Rubia cordifolia</i> L.		+	+		H	Mic	S	D
411	<i>Rubia infundibularis</i> Hemsl. & Lace	+	+	+		H	Mes	S	R
Rutaceae									
412	<i>Skimmia laureola</i> (DC.) Sieb. & Zucc. ex Walp	+	+	+	+	Np	Mes	Comp	F
413	<i>Zanthoxylum armatum</i> DC.	+	+	+	+	Micp	Mes	Comp	D
Salicaceae									
414	<i>Populus alba</i> L.	+	+	+	+	Mesp	Mes	S	W
415	<i>Populus ciliata</i> Wall. ex Royle	+	+	+	+	Mesp	Mes	S	W
416	<i>Salix babylonica</i> L.	+	+	+	+	Mesp	Mes	S	W
417	<i>Salix denticulata</i> Anderson	+	+	+	+	Mesp	Mes	S	W
418	<i>Salix tetrasperma</i> Roxb.	+	+	+	+	Mesp	Mes	S	W
Sambucaceae									
419	<i>Sambucus wightiana</i> Wall. ex Wight & Arn.		+			Th	Mes	Comp	F
Sapotaceae									
420	<i>Saussurea albescens</i> (DC.) Sch. Bip.		+			H	Mes	S	D
Saxifragaceae									
421	<i>Bergenia ciliata</i> (Haw.) Sternb. var. <i>ciliata</i> Yeo	+	+			G	Mes	S	D
422	<i>Bergenia stracheyi</i> (Hk.f. & Thoms.) Engl.		+			G	Mes	S	D
423	<i>Saxifraga moorcroftiana</i> (Ser.) Sternb.		+	+		H	Mic	S	D
Scrophulariaceae									
424	<i>Kickxia ramosissima</i> (Wall.) Janchen	+			+	Th	Mes	S	R
425	<i>Picrorhiza kurroo</i> Royle ex Bth.		+			Th	Mes	S	F
426	<i>Scrophularia calycina</i> Bth.		+			Th	Mic	S	D
427	<i>Scrophularia scabiosifolia</i> Bth.		+			Th	N	S	D
428	<i>Verbascum thapsus</i> L.		+			Th	Meg	S	W
439	<i>Veronica biloba</i> L.	+			+	Th	N	Dis	W
440	<i>Veronica didyma</i> Tenore	+				Th	N	Dis	W
431	<i>Wulfenia amherstiana</i> Wall. ex Bth.		+			H	Mes	S	R
Simaroubaceae									
432	<i>Ailanthus altissima</i> (Mill.) Swingle	+	+	+	+	Megp	Mes	Comp	A-I
Smilacaceae									
433	<i>Smilax glaucophylla</i> Klotzsch	+	+	+	+	Np	Mes	S	F
434	<i>Smilax vaginata</i> Decne.	+	+	+	+	Np	Mic	S	F
Solanaceae									
435	<i>Atropa acuminata</i> Royle ex Miers		+			Th	Mes	S	D
436	<i>Capsicum annuum</i> L.		+	+		Th	Mic	S	CU
437	<i>Capsicum frutescens</i> L.	+	+	+	+	Np	Mes	S	GY
438	<i>Datura innoxia</i> Mill.		+	+		Th	Mes	S	D
439	<i>Datura stramonium</i> L.		+			Th	Mes	S	D-GY
440	<i>Hyoscyamus niger</i> L.	+				Th	Mes	S	A
441	<i>Lycopersicon esculentum</i> Miller	+	+	+	+	Th	Mes	S	CU
442	<i>Physalis divaricata</i> D. Don		+	+		Th	Mic	S	A
443	<i>Solanum nigrum</i> L. var. <i>nigrum</i>		+	+		Th	Mes	S	A-GY
444	<i>Solanum pseudo-capsicum</i> L.		+	+		Th	Mic	S	GY
445	<i>Solanum surattense</i> Burm. f.		+			H	Mes	S	GY
446	<i>Solanum tuberosum</i> L.		+			G	Mes	Comp	CU
447	<i>Withania somnifera</i> (L.) Dunal		+			Ch	Mac	S	A-GY
Thymelaeaceae									
448	<i>Daphne mucronata</i> Royle	+	+	+	+	Np	N	S	D-F
449	<i>Wikstroemia canescens</i> Meisn.	+	+	+	+	Np	N	S	F

Ulmaceae									
450	<i>Celtis caucasica</i> Willd.	+	+	+	+	Megp	Mic	S	D
451	<i>Celtis eriocarpa</i> Decne.	+	+	+	+	Mesp	Mic	S	D
Urticaceae									
452	<i>Debregeasia salicifolia</i> (D. Don) Rendle	+	+	+	+	Np	Mes	S	W
453	<i>Lecanthus peduncularis</i> (Royle) Wedd.	+	+			H	Mes	S	M
454	<i>Urtica dioica</i> L.	+	+			Th	Mic	S	M
Valerianaceae									
455	<i>Valeriana pyrolifolia</i> Decne.	+	+			G	N	S	M-W
456	<i>Valeriana jatamansi</i> Jones	+	+			G	Mic	S	M-W
Verbenaceae									
457	<i>Verbena officinalis</i> L.	+	+	+	+	Th	Mic	Dis	M-W
458	<i>Vitex negundo</i> L.	+	+	+	+	Np	Mes	Comp	D
Violaceae									
459	<i>Viola biflora</i> L.	+	+			Th	Mic	S	M
460	<i>Viola canescens</i> Wall. ex Roxb.	+				Th	Mic	S	R-M
Vitaceae									
461	<i>Vitis jacquemontii</i> Parker	+	+	+	+	Np	Mes	S	D
462	<i>Vitis vinifera</i> L.	+	+	+	+	Np	Mes	S	CU
Zygophyllaceae									
463	<i>Tribulus terrestris</i> L.		+			H	N	Comp	A-WP

Key to Abbreviations:

- (Life form) G-geophyte, Th-Therophyte, H-Hemicryptophyte, Ch-Chamaephyte, Np-Nanophanerophyte, Mip-Microphanerophyte, Mesp-Mesophanerophyte, Megp-Megaphanerophyte, P-Parasite
- (Leaf form) Ap-Aphyllous, L-Leptophyll, N-Nanophyll, Mic-Microphyll, Mes-Mesophyll, Mac-Macrophyll, Meg-Megaphyll
- (Lamina) A-Absent, S-Simple, Dis-Dissected, Comp-Compound, Sp-Spiny, N-Needle
- (Habitat) A-Agricultural fields, D-Dry slopes, W-Wet places, CU-Cultivated, GY-Graveyards, F-Forest, M- Moist shady places, R-Rock crevices, WP-Waste places, I-Introduced, Epi-Epiphyte

Table. 4.2 Ecological characters of Chail Valley Swat

S.No	Characterstics	No:	Percentage
1. Flora			
i	Families	104	-
ii	Genera	332	-
iii	Species	463	-
2. Life Form Spectra			
i	Geophytes	57	12.31%
ii	Therophytes	188	40.60%
iii	Hemicryptophytes	77	16.63%
iv	Chamaephytes	19	4.10%
v	Nanophanerophytes	71	15.33%
vi	Microphanerophytes	13	2.81%
vii	Mesophanerophytes	18	3.89%
viii	Megaphanerophytes	17	3.67%
ix	Parasites	3	0.65%
3. Leaf Size Spectra			
i	Aphyllous	2	0.43%
ii	Leptophyll	25	5.40%
iii	Nanophyll	136	29.37%
iv	Microphyll	140	30.24%
v	Mesophyll	147	31.75%
vi	Macrophyll	10	2.16%
vii	Megaphyll	3	0.65%
4. Lamina Shape			
i	Absent	3	0.65%
ii	Simple	305	65.87%
iii	Dissected	62	13.39%
iv	Compound	76	16.41%
v	Spiny	8	1.73%
vi	Needle	9	1.94%
5. Habitat			
i	Dry Mountain Sloop	175	37.79%
ii	Wet Soil	31	6.69%
iii	Cultivated	27	5.83%
iv	Forest	77	16.63%
v	Moist Shady Place	22	4.75%
vi	Rock Crevices	17	3.67%
vii	Waste Places	43	9.28%
viii	Graveyard	16	3.45%
ix	Introduced	5	1.07%
x	Epiphyte	3	0.64%
xi	Agricultural Fields	78	16.84%
6. Seasonality			
i	Spring	279	26.80%
ii	Summer	396	38.04%
iii	Autumn	193	18.54%
iv	Winter	173	16.62%

Table. 4.3 Life form and Leaf size spectra

S.No	Life Form	Spring	% Age	Summer	% Age	Autumn	% Age	Winter	% Age
1	Geophytes	29	10.39%	43	10.86%	1	0.52%	6	3.47%
2	Therophytes	92	32.97%	146	36.87%	47	24.35%	41	23.70%
3	Hemicryptophytes	29	10.39%	68	17.17%	19	9.84%	4	2.31%
4	Chamaephytes	7	2.51%	17	4.29%	5	2.59%	2	1.16%
5	Nanophanerophytes	71	25.45%	71	17.93%	71	36.79%	71	41.04%
6	Microphanerophytes	13	4.66%	13	3.28%	13	6.74%	13	7.51%
7	Mesophanerophytes	18	6.45%	18	4.55%	18	9.33%	18	10.40%
8	Megaphanerophytes	17	6.09%	17	4.29%	17	8.81%	17	9.83%
9	Parasites	3	1.08%	3	0.76%	2	1.04%	1	0.58%
		279	100 %	396	100 %	193	100 %	173	100 %
	Leaf Form	Spring	% Age	Summer	% Age	Autumn	% Age	Winter	% Age
1	Aphyllous	2	0.72%	2	0.51%	1	0.52%	0	0.00%
2	Leptophyll	16	5.73%	21	5.30%	9	4.66%	12	6.94%
3	Nanophyll	76	27.24%	119	30.05%	52	26.94%	46	26.59%
4	Microphyll	85	30.47%	117	29.55%	53	27.46%	48	27.75%
5	Mesophyll	93	33.33%	128	32.32%	72	37.31%	62	35.84%
6	Macrophyll	5	1.79%	7	1.77%	6	3.11%	4	2.31%
7	Megaphyll	2	0.72%	2	0.51%	0	0.00%	1	0.58%
		279	100 %	396	100 %	193	100 %	173	100 %

Fig 2. Life form spectra

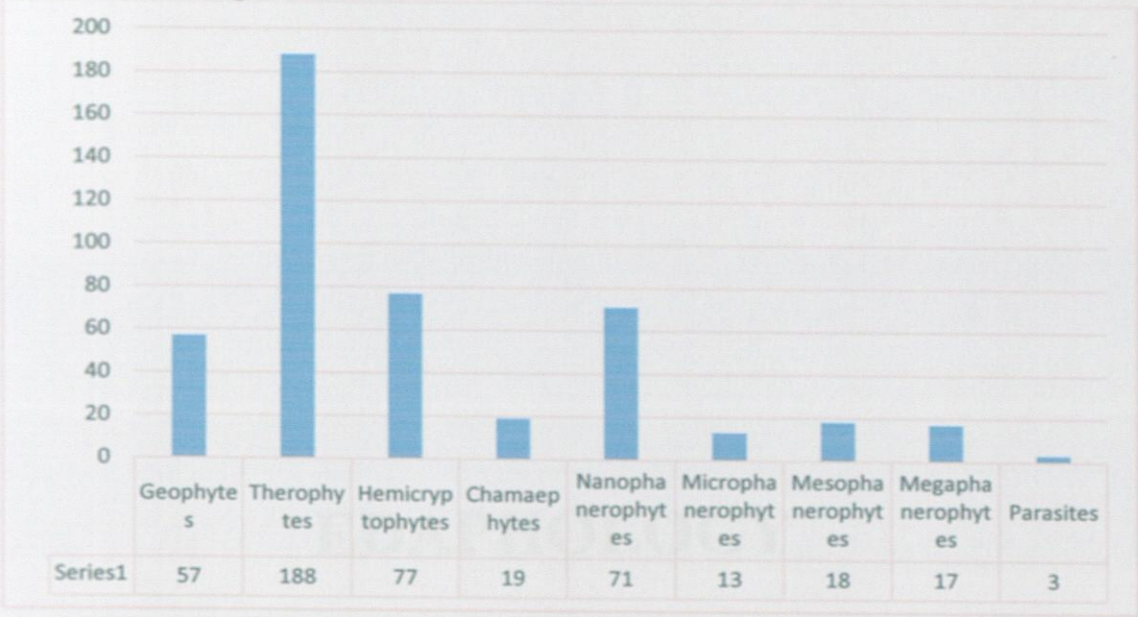
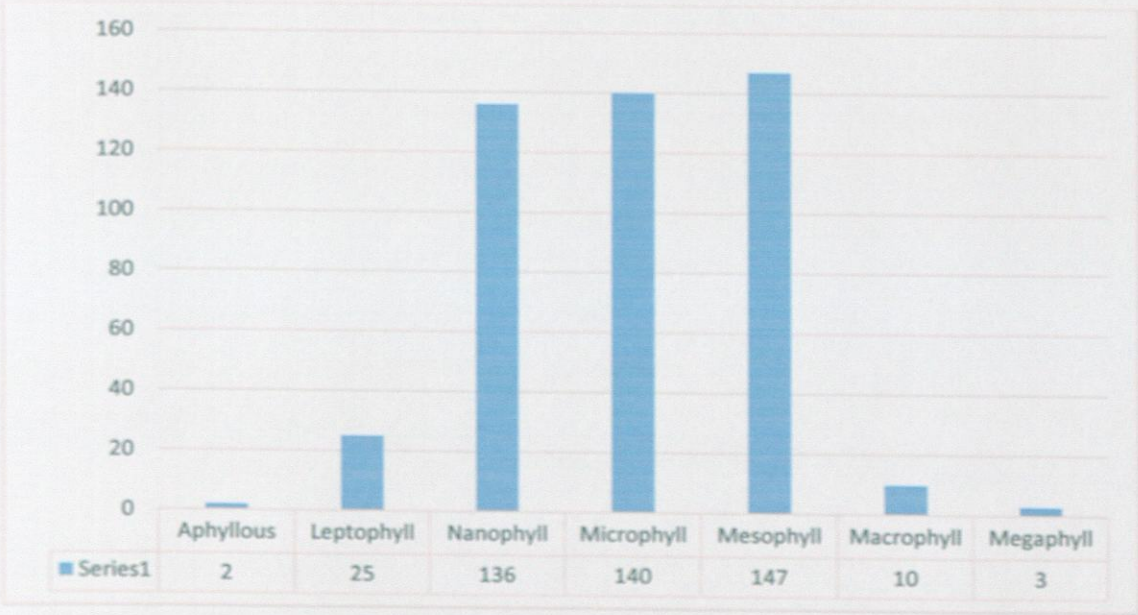


Fig 3. Leaf size spectra



EDAPHOLOGY

4.2 Edaphology

Soil is the superficial layer of earth's crust, originating from the parent material, which contains organic material, decaying products of living organisms as well as living organism. Any type of soil has four major components i.e. mineral matter, organic matter, soil air and soil water. Estimates show that in top soil mineral matter makes 45%, organic matter only 5% while pore space accounts for 50% (Bridges, 1978). Plants grow in soil as it is the major factor which controls the availability of water in terrestrial ecosystems. Soil is not just an abiotic component for plant life but it is home of a variety of living organisms including bacteria, algae, fungi and animals (Smith and Smith, 2012). The relative proportion of particles of various sizes in soil is termed as soil texture.

Rehman *et al.* (2015) enumerated soil pH, electrical conductivity and total dissolved solutes from soil and water of Gomai Zam Dam. The values obtained were in tolerable range. Aisha *et al.* (2015) studied the effect of Zn, Cu and B on the growth and yield of *Citrus reticulata*. Macro and micronutrient distribution in coniferous forests of Himalayan and Hindukush range was enumerated by Siddiqui *et al.* (2014). Vegetation dynamics was correlated with the soil texture, pH, electrical conductivity, total dissolved solutes and organic matter content (Noor and Khatoon, 2013). Dense vegetation patches were recorded from soils with high organic matter content. Arshad *et al.* (2011) studied the correlation between Cu and Zn availability with soil texture. Wu *et al.* (2011) enumerated soil salinity, soil moisture and soil pH. A positive correlation between altitude and vegetation while a negative correlation was observed with soil salinity and moisture. Lodhi *et al.* (2009) considered the impact of changes mineral contents of the soil in relation to salinity, moisture and temperature. Raza *et al.* (2005) studied the effects of sub-soil compaction on soil properties, nutrient uptake and yield of Maize. The correlation of the yield of Sugarcane with that of organic matter, pH, electrical conductivity, exchangeable Na and sodium absorption ratio were compared by Arain *et al.* (2000). The effect of soil pH on growth and rooting on *Camellia sinensis* was reported by Hamid *et al.* (2006).

Ahmad *et al.* (2012) estimated Fe and Zn where value of Fe appeared to be 3 mg/kg while that of Zn was 1 mg/kg. Chamizo *et al.* (2012) reported that biological soil crusts influence the water holding capacity, organic carbon, nitrogen content and soil aggregate stability. Shah *et al.* (2012) focused on estimation of Zn, Cu, Fe, Mn and B. Soil were found to be deficient in Zn, Fe and Mn while Cu and B were found

to be in adequate concentrations. Fardous *et al.* (2011) investigated the levels of Fe, Co and Mn in soils at a rural livestock farm in Sargodha. They also enumerated the same minerals in forage. In another study on seasonal variation of mineral, Ca and Cu contents were higher in winter season (Khan *et al.*, 2007). Khan *et al.* (2005) found that concentrations of Fe, Zn, Co and Se were higher in winter season than Cu and Mn. Co and Se concentrations were above critical value in all soil types. During the study of Ca, Mg, K and Na, in most of the samples Na was found to be deficient in soil as well as forage (Khan *et al.*, 2004).

Malik *et al.* (2010) estimated the Heavy metal contamination in soil from the industrial area and assessed the total contents of Pb, Cu, Zn, Co, Ni and Cr, of which Co levels were found to be high while those of Cu were the lowest. The accumulation of heavy metals in soils around a Salt lake, Turkey was estimated. These included Pb, Cr, Cu, Mn, Ni, Zn and Cd (Tug and Duman, 2010). Ashraf and Ali (2007) studied the effects of Ag, Zn and Pb on soil microorganisms and Been seed germination. Ag was found to be of highest toxic value as its minimum concentration appeared to inhibit the growth of soil microbes. Higher levels of Ag also delayed the seed germination. Similarly lead content was estimated from various localities of Rawalpindi (Lone *et al.*, 2006).

4.2.1 Soil texture

Texture of any soil is dependent upon parent material as well as the process of soil formation. These particles are classified into gravel, sand, silt and clay on the basis of their size. Pore space is dependent on soil texture. Course textured or light soils have large pore space and hence soil has less water holding capacity while fine textured or heavy soils have comparatively small pore space and are poorly aerated (Smith and Smith, 2012). Soil from Chail village area was found to be loamy sand with 9.2% clay, 53.2% silt and 37.6% sand particles. Soil was silty loam in Chail valley floor. It was composed of 5.2% clay, 47.2% silt and 47.6% sand particles. Silt particles dominated with 65.2% while clay and sand particles were represented by 7.25 and 27.6% in Shinku site respectively. Soil was loamy sand in Bishigram area with 9.2% clay, 37.2% silt and 53.6% sand particles. In Dabargai soil was loamy in texture, with 7.2% clay, 49.2% silt and 43.6% sand. Water holding capacity was slightly lower in soils from Bishigram, Dabargai and Chail valley floor because of relative abundance of sand particles. Soils were a heavy textured in Shinku and Chail village. Our findings are in line with the work of Nafees *et al.* (2008) on soil texture

of river Swat catchment area. They also noticed the soil erosion as major soil polluting factor (Table. 4.4; Fig. 4).

4.2.2 Physicochemical characteristics

Soil pH has a strong influence on availability of soil nutrients, cation exchange capacity of soil as well as solubility of toxic nutrients in soil (Estefan *et al.*, 2013). As major portion of study area falls under the moist temperate region hence soils have a mild acidic nature because of considerable amount of rainfall throughout the year. Soils were mildly acidic in reaction throughout the study area. Soil samples from Chail village had a pH value of 5.2, Chail valley floor and Shinku with 5.4 respectively and Dabargai with 5.8. Soil pH was recorded as 6.0 from Bishigram area (Table. 4.5).

Soil organic matter has strong impact on soil aggregation, soil nutrients and their availability, water holding capacity as well as net biological activity. It represents the plant and animal remains, products of soil microbes and various stages of their decomposition and synthesis. Soils in cultivated temperate regions have 3-4% of soil organic matter while in semi-arid regions its amount is usually less than 1.5% (Estefan *et al.*, 2013). Results of this study are in accordance with this pattern as organic matter in the soil ranged between 1.38 to 2.76% in the study area. This is due to the mild acidic nature of the soils, which show a slight degree of podzolization. Soil samples from Chail village were found to have 2.07% organic matter while in Chail valley floor it was recorded as 2.76%. Shinku displayed 1.38% organic matter while in Bishigram and Dabargai it was found to be 2.48% and 2.08% respectively. Soils in temperate regions are not calcareous unlike the semi-arid regions. In present study CaCO_3 content was slightly higher in samples from Bishigram with a value of 10%. Chail valley floor recorded 7.5% CaCO_3 , while in Shinku it was recorded as 3%. Chail village and Dabargai contained less amount of CaCO_3 .

Concentration of soluble inorganic salts is reflected in salinity and measured by electrical conductivity. Hence it affects the soil characteristics which influence the crop yield, soil texture, soil organic matter, salinity and cation exchange capacity. Soils with relative abundance of sand particles have low electrical conductivity and it increases with increase in proportion of finer particles in soils. Present study is right in line with this principle as Chail village soil had EC value of 0.043 dsm^{-1} with 9.2% clay, 53.2% silt and 37.6% sand elements. The EC value at Chail valley floor was found to be 0.08 dsm^{-1} with 5.2% clay, 47.2% silt and 47.6% sand particles, while

0.026 dsm^{-1} was recorded from Shinku having 7.2% clay, 65.2% silt and 27.6% sand particles. The electrical conductivity of 0.023 dsm^{-1} with 9.2% clay, 37.2% silt and 53.6% sand particles was recorded in Bishigram. Soils from Dabargai area had 0.03 dsm^{-1} with 7.2% clay, 49.2% silt and 43.65 sand particles (Table. 4.5). Total dissolved solids and electrical conductivity are both indicators of soil salinity. Chail valley floor had 51 ppm TDS which was the highest recorded value in the study area. It was followed by 28 ppm at Chail village, 20 ppm at Dabargai, 17 ppm at Shinku and 16 ppm at Bishigram.

Elemental sulphur in soil gets oxidized to SO_4 under aerobic conditions while in anaerobic conditions elemental Sulphur is reduced to SO_3 by soil microorganisms. Sulphate content is usually low in soils of humid regions (Estefan *et al.*, 2013). Our findings are in accordance with this as study area is mostly moist temperate region. Soils in Chail village had 516 $\mu\text{g/g}$ of Sulfates. Sulphate content of soil samples from Chail valley floor was 556 $\mu\text{g/g}$ while in Shinku it was 450 $\mu\text{g/g}$. It was higher in soils of Bishigram with a value of 661 $\mu\text{g/g}$ while 496 $\mu\text{g/g}$ were found in soils of Dabargai. Soil water is the most important ecological factor as all plant life depends on available moisture in any soil sample. Available water in soil depends upon soil texture, organic matter, slope and amount of precipitation. Biological activity and nutrient transformations in soil are also influenced by available water in the soil. A more or less uniform pattern of soil moisture was observed. The availability of water was 0.16% in Chail village while Chail valley floor and Dabargai each had 0.15% available water. Soil samples from Shinku had 0.18% available water while lowest percentage of soil water (0.12%) was recorded from Bishigram (Table. 4.5).

Soil sodicity is often measured in terms of sodium absorption ratio in milliequivalents per liter (millieq/L). SAR expresses the proportion of sodium to calcium and magnesium in soil solutions. Soils was non sodic, hence smaller SAR values were recorded during the study. Lesser SAR values indicate the capacity of soil to form aggregates, good aeration and fitness for agricultural practices (Horneck *et al.*, 2007). SAR was found to be 0.52 millieq/L in soils of Chail village. Chail valley floor presented 0.2 millieq/L SAR as compared to 0.3 millieq/L in Shinku. Soils from Bishigram and Dabargai had 0.21 and 0.13 millieq/L SAR respectively. Findings of this study are in line with the results presented in their respective works by Urooj *et al.* (2016) Aisha *et al.* (2015); Ali *et al.* (2015); Anyasi and Atagana (2014); Noor and Khatoon (2013); Altay *et al.* (2013); Arshad *et al.* (2011); Shirazi *et al.* (2011); Wu *et*

al. (2011); Shah *et al.* (2010) and Arain *et al.* (2000) while in disagreement with results of Rehman *et al.* (2015), which described these parameters from a different ecological zone.

4.2.3 Macronutrients

Nitrogen is one of the most important macronutrient in soil which influences the plant life directly. Requirement of nitrogen by plants for vegetative growth is vital. Soils deficient in nitrogen content show low yield and poor plant growth. Nitrogen is an important component of organic biomolecules like proteins, nucleic acids, ATP and vitamins. Plants growing on nitrogen deficient soils develop chlorotic patches on leaves and herbaceous stems. In soils nitrogen may occur in either organic or inorganic forms. More than 95% of the nitrogen content in soil comes from organic fraction (Estefan *et al.*, 2013). Inorganic nitrogen content of the soil comprises of ammonium (NH_4), nitrate (NO_3) and to a lesser extent nitrite (NO_2) forms. Nitrogen is the most abundant gas in atmosphere which is fixed in many ways and in turn utilized by plants. Apart from atmospheric nitrogen fixation, biological nitrogen fixation accounts for most of the nitrogen content in soils. Biological nitrogen fixation is due to symbiotic bacteria such as *Rhizobium* while a number of soil inhabiting anaerobic bacteria such as *Clostridium* can also fix nitrogen. Being an important mineral required for vegetative growth, a considerable amount of nitrogen is removed from soil after every crop removal. Runoff water and soil erosion also contribute to the process of nitrogen loss from soils. Soil of Chail village and Chail valley floor had respectively 0.1035 % and 0.138% nitrogen while Shinku exhibited 0.069% nitrogen content. Similarly Bishigram and Dabargai soils had 0.1242% and 0.1104% nitrogen respectively (Table. 4.6).

Phosphorous is usually present in low concentrations and mostly depends upon type of parent material, extent of weathering, soil erosion and climatic conditions. Organic phosphorous comes mainly from plant residue, microbes and manure while inorganic form from apatite, phosphorous adsorbed into clay micelles and phosphates of aluminum and iron. Phosphorous is an integral component of nucleic acids and ATP which influences the root formation, stem elongation, crop maturity and resistance to diseases in plants. Soil from Chail village showed 470 $\mu\text{g/g}$ of phosphorous as compared to Chail valley floor which displayed 430 $\mu\text{g/g}$. Shinku, Bishigram and Dabargai had 494 $\mu\text{g/g}$, 475 $\mu\text{g/g}$ and 385 $\mu\text{g/g}$ of phosphorous in

order. An overall uniform pattern of phosphorous content was observed in soil samples from different localities of the study area.

Potassium is of vital importance for plant's vegetative and reproductive growth. Potassium deficiency in soils results in poor root growth, lesser cellulose content, chlorosis, decreased enzymatic activity and decreased protein content. Role of potassium in translocation of carbohydrates within plants is well established. Being highly mobile element potassium moves easily to younger plant parts from older parts hence its deficiency symptoms are observed first at lower leaves which later progress to higher plant parts with the passage of time. Plants growing on potassium deficient soils show low resistance to drought and pests. Potassium concentration in Chail village was found to be 6398 $\mu\text{g/g}$. Whereas Chail valley floor showed 10634 $\mu\text{g/g}$ potassium content. Soils of Shinku area had 8925 $\mu\text{g/g}$ of potassium. Potassium content was relatively higher in soils of Bishigram area (13059 $\mu\text{g/g}$) while lowest at Dabargai area (4162 $\mu\text{g/g}$).

Calcium is required by various enzymes to activate their function as well as in plant cell walls as calcium pectate. Plants growing in soils with adequate concentrations of calcium show diseased resistance. It also improves the absorption of other nutrients by roots as well as their translocation within the plants. Symbiotic bacteria which fix nitrogen require calcium to form nodules on the roots of leguminous plants. During this study 34448 $\mu\text{g/g}$ of calcium was found in soil from Chail village, 16722 $\mu\text{g/g}$ from Chail valley floor, 24148 $\mu\text{g/g}$ from Shinku, 14568 $\mu\text{g/g}$ from Bishigram and 39159 $\mu\text{g/g}$ from Dabargai area (Table. 4.6).

Magnesium is an essential component of chlorophyll hence plants growing in magnesium deficient soils show chlorosis quite early. Magnesium also determines the uptake of phosphorous by plants, and vice versa. Magnesium is required as an activator for enzymes in plants. Magnesium uptake decreases with low soil pH. Soils of Chail village had 22188 $\mu\text{g/g}$ of magnesium. Magnesium content in Chail valley floor and Shinku were 15433 $\mu\text{g/g}$, and 17056 $\mu\text{g/g}$ respectively. In soil samples collected from Shinku area 17056 $\mu\text{g/g}$ of magnesium was estimated while soils of Bishigram and Dabargai had 13738 $\mu\text{g/g}$ and 25127 $\mu\text{g/g}$ magnesium.

Sulfur is an important soil nutrient required for the synthesis of amino acids such as cysteine and methionine. Sulfur is also needed for nitrate-reductase process which transforms nitrates to amino acids. In soils sulfur is locked up in organic matter and is converted into SO_4 to be utilized by plants, by the process of mineralization.

Results of this study revealed the presence of 172 $\mu\text{g/g}$ of sulfur in soils of Chail village. Soils from Chail valley floor had 185 $\mu\text{g/g}$ of sulfur while Shinku, Bishigram and Dabargai had 150 $\mu\text{g/g}$, 220 $\mu\text{g/g}$ and 165 $\mu\text{g/g}$ respectively (Table. 4.6). Results presented here for macronutrients are backed by earlier studies in their respective study areas by Siddiqui *et al.* (2014); Fardous *et al.* (2010); Khan *et al.* (2004) and Arain *et al.* (2000).

4.2.4 Micronutrients

Main sources of sodium content in soil are fertilizers, pesticides and breakdown of minerals during the process of soil formation. Sodium levels were not alarmingly high in the soils of study area but results clearly indicate that frequent use of pesticides and fertilizers is building up sodium levels in the study area which may lead to sodium toxicity in years to come. Poor plant growth is the outcome of raised sodium levels in soil. During present study, soil samples collected from Chail village had 13289 $\mu\text{g/g}$ of sodium followed by 9302 $\mu\text{g/g}$, 12072 $\mu\text{g/g}$, 9109 $\mu\text{g/g}$ and 16161 $\mu\text{g/g}$ of sodium in soils of Chail valley floor, Shinku, Bishigram and Dabargai respectively (Table. 4.7).

Cation balance and cation transport within plant is dependent upon soil chlorides. Chloride is highly soluble in soil water and it competes with nitrate uptake. In present study, the soils were found to have considerably lesser doses of chloride because of relatively higher rainfall throughout the year. Runoff water removes much of the chlorides from the top soil. Abundance of chloride in soil results in raised toxicity levels which often result in scorched leaf margins and excessive abscission. Chloride toxicity also results in reduced leaf and leaflet size. None of such symptoms were observed in study area. Chail village soils possessed 32 mg/gm of chloride. Chloride content was found to be 38 mg/gm in soils of Chail valley floor. In Shinku area 27 mg/gm of chloride was estimated while in soil samples collected from Bishigram and Dabargai area the chloride concentrations were 34 mg/gm and 42 mg/gm respectively.

Iron content of the soils were found to be adequate because of their mild acidic nature. Calcareous soils are often deficient in iron. Poorly aerated soils are also iron deficient. Iron plays an important role in the process of chlorophyll production hence iron deficient soils will develop chlorotic plants. Lignin content of plants is also dependent on iron levels in soil. In Chail village 46845 $\mu\text{g/g}$ of iron was recorded while it was 39143 $\mu\text{g/g}$ in soils of Chail valley floor. In Shinku, Bishigram and

Dabargai showed 40590 $\mu\text{g/g}$, 35852 $\mu\text{g/g}$ and 46067 $\mu\text{g/g}$ iron content respectively (Table. 4.7).

Cobalt is not a common mineral in soil but it contributes a lot in plant performance and lives of soil organisms. Cobalt is precursor of many enzymes and acts as a bio-stimulant. It is required by nitrogen fixing bacteria which form root nodules in leguminous plants. Being vital for nitrogen fixation, cobalt deficiency leads to nitrogen deficiency in the soil. In present study cobalt levels appeared as 25.1 ppm in Chail village, 20.1 ppm in Chail valley floor, 36.6 ppm in Shinku, 22.45 ppm in Bishigram and 30.15 ppm in Dabargai. Cobalt levels were adequate because the nitrogen content was sufficiently available in soil samples across the study area.

Manganese functions in enzyme systems, chlorophyll synthesis and enhances the germination. In soil plants take up manganese as Mn^{2+} . Manganese deficiency is accompanied by yellowing of leaf veins and delayed maturity in plants. In acidic soils manganese deficiency is often observed but in present study comparatively moderate manganese levels were observed throughout the study area. The soil of Chail village possessed 891 $\mu\text{g/g}$ of manganese, followed by 722 $\mu\text{g/g}$ in Chail valley floor, Shinku 805 $\mu\text{g/g}$, Bishigram 708 $\mu\text{g/g}$ while Dabargai shared 815 $\mu\text{g/g}$.

Copper is also an important micronutrient which is required as an activator for several plant enzymes. Its presence is also important for successful protein synthesis. It is required for chlorophyll synthesis as well. Some other nutrients such as iron, manganese and aluminum interfere with the availability of copper to plants. Results of present study revealed 37 $\mu\text{g/g}$ copper in soils of Chail village, 40 $\mu\text{g/g}$ each in Chail valley floor and Shinku while soils of Bishigram and Dabargai possessed 29 $\mu\text{g/g}$ and 27 $\mu\text{g/g}$ of copper (Table 4.7).

Zinc is required in very minute amounts but it has a major role in determining the overall vegetation yield. Zinc is important for the process of protein synthesis and growth regulation. Plant growing in soils with zinc deficiency often develop short internodes and leaves of smaller size. Zinc deficiency also leads to delayed maturity in plants. This study revealed that 82 $\mu\text{g/g}$ of zinc was found in soil samples collected from Chail village. Zinc levels were comparatively low in soil of Chail valley floor and Dabargai viz. 76 $\mu\text{g/g}$ and 77 $\mu\text{g/g}$ respectively. In soil samples of Shinku zinc levels were found to be 97 $\mu\text{g/g}$ while it was 80 $\mu\text{g/g}$ in.

Barium, usually considered less important for plant life and is found in soil at concentrations about 15 to 3500 ppm. Recent studies conducted by Abreu *et al.*

(2012) indicated that barium accumulation in high concentration may result in barium toxicity in plants. In our study barium levels were found to be 150 $\mu\text{g/g}$, 107 $\mu\text{g/g}$, 217 $\mu\text{g/g}$, 296 $\mu\text{g/g}$ and 106 $\mu\text{g/g}$ in soils of Chail village, Chail valley floor, Shinku, Bishigram and Dabargai respectively. The barium content was well below the critical range so no barium toxicity was observed throughout the study area (Table. 4.7).

Aluminum is not included in the category of essential elements for plant growth but it is an abundant mineral in earth's crust. Raised aluminum levels may cause stunted roots and may interfere with the uptake of phosphorous and sulfur. Excess of aluminum may reduce availability of other cations in the soil. It may become a problem for plant growth in soils with acidic reaction (Delhaize and Ryan, 1995). Though soils in the study area showed an acidic nature, aluminum levels were not alarmingly high. Aluminum levels were recorded as 60326 $\mu\text{g/g}$ in soils of Chail village followed by 49339 $\mu\text{g/g}$ in Chail valley floor and 51933 $\mu\text{g/g}$, 50175 $\mu\text{g/g}$ and 60088 $\mu\text{g/g}$ in Shinku, Bishigram and Dabargai respectively. Results presented here for micronutrients are supported by the works of Ahmad *et al.* (2012); Shah *et al.* (2012); Arshad *et al.* (2011); Fardous *et al.* (2011, 2010); Khan *et al.* (2009, 2007) and Khan *et al.* (2005).

4.2.5 Heavy metals

Titanium is present in soils in high concentrations but it is usually less available for plants (Dumon and Ernst, 1988). Its role in enhancing yield of certain crops is already established (Pais, 1983; Balik *et al.*, 1989; Carvajal and Alcaraz, 1998). Highest titanium values (Table. 4.8) were observed at Shinku area i.e. 1708 $\mu\text{g/g}$ followed by Chail village (1588 $\mu\text{g/g}$), Bishigram (1494 $\mu\text{g/g}$) and Dabargai (1465 $\mu\text{g/g}$). Lowest titanium content was recorded from Chail valley floor (1438 $\mu\text{g/g}$).

Vanadium is more or less evenly distributed in lithosphere (Salminen *et al.*, 2005). Anthropogenic factor such as burning of fossil fuels may build up raised vanadium levels (Baes and Mesmer, 1976). In soil of Chail village 208 $\mu\text{g/g}$ of vanadium was found which was followed by 163 $\mu\text{g/g}$ in Chail valley floor, 190 $\mu\text{g/g}$ in Shinku, 141 $\mu\text{g/g}$ in Bishigram and 217 $\mu\text{g/g}$ in soils of Dabargai area. Vanadium levels were low in soil samples of study area hence no vanadium toxicity in soils was observed. (Table. 4.8).

Chromium toxicity due to its raised levels in soil may result in stunted growth, decreased seed germination, low yield, decreased rates of photosynthesis and

inhibition of enzymatic activity (Olivera, 2012). Chromium levels were considerably low in the soil of study area. Highest levels of chromium were found in soils of Chail village (94 $\mu\text{g/g}$) while lowest chromium levels were observed in soils of Shinku (64 $\mu\text{g/g}$). Chail valley floor, Bishigram and Dabargai had 81 $\mu\text{g/g}$, 79 $\mu\text{g/g}$ and 82 $\mu\text{g/g}$ of chromium.

Deficiency of nickel may lead to leaf curling and stunted growth. Moreover, it is an important component of urease enzyme which is of vital value in nitrogen metabolism. Nickel contents were found to be well above critical value (0.1 ppm) throughout the study area. Nickel content was 51 $\mu\text{g/g}$ each in Chail village and Chail valley floor. Shinku, Bishigram and Dabargai, demonstrated 57 $\mu\text{g/g}$, 53 $\mu\text{g/g}$ and 46 $\mu\text{g/g}$ nickel content respectively.

Lead is found in soils in low concentrations unless the soil is polluted. Normal lead content in soils are considered as less than 299 ppm. Anthropogenic activities contribute to increased lead levels in soil. Present study revealed that there was no lead toxicity in soils of the area as lead was recorded well below the critical value. Soil samples from Chail village had 65.4 ppm of lead, followed by 62.5 ppm in soils of Chail valley floor, 64.7 ppm in Shinku, 89 ppm in Bishigram and 63.5 ppm of lead in Dabargai.

Silver is a naturally occurring rare element. Usually it is found in combined form as nitrates or oxides. Biogeochemical cycles are the main source along with anthropogenic activities which contribute to silver content in soil, water and air (ATSDR, 1990). Silver is reported to have an inhibitory effect on enzymes involved in phosphorous, sulfur and nitrogen cycles when its levels range from 540 to 2700 mg/kg in soils (Domsch, 1984). Silver levels were well below this range so no silver toxicity was observed throughout the study area. Soil of Chail village was found to have 1.6 ppm of silver which was followed by Chail valley floor with 3.2 ppm of silver, Shinku with 2.75 ppm of silver and Dabargai with 3.65 ppm of silver in soil. Comparatively higher silver levels were recorded from soils of Bishigram area (5.1 ppm).

Natural as well as anthropogenic sources contribute to the addition of cadmium into the soil. Usual range of cadmium content in soil is reported to be 0.1 to 0.5 ppm but slight fluctuation in these values is also observed depending upon multiple factors (Cook and Morrow, 1995). High levels of cadmium in soil result in cadmium toxicity which lead to growth inhibition in plants as well as poor root

development, leaf rolling and chlorosis (Krantev *et al.*, 2008; Yadav, 2010; Rascio and Navari-Izzo, 2011). Cadmium levels were a bit high in soil samples collected from Chail valley floor and Bishigram viz. 1.1 ppm and 1.5 ppm respectively. Chail village had 0.65 ppm of cadmium while Shinku and Dabargai soils had 0.25 and 0.45 ppm of cadmium (Table. 4.8). These findings are in line with the works of Ahmad *et al.* (2014); Malik *et al.* (2010); Tug and Duman (2010); Iram *et al.* (2009); Ashraf and Ali (2007) and Lone *et al.* (2006).

Analysis of variance (ANOVA) is a statistical tool to test the hypothesis that means of two or more samples are equal. It analyzes the significance of one or more parameters by comparing the response variable means at different factor levels. When ANOVA was applied to 30 edaphic variables for five monitoring sites the variance among all parameters was found to be 865573761.005 (*MSB* value) and variance within these parameters was calculated as 7033062.2 (*MSW* value). This gave the *F* calculated value as 123.0721 which is greater than *F-crit* value (1.562071), hence the results clearly indicate that means of all 30 parameters are significantly different from each other (Table. 4.9 & 4.10).

Table.4.4 Soil Texture

S. No	Locality	Clay	Silt	Sand	Texture
1	Chail	9.2	53.2	37.6	Loamy sand
2	Chail Valley Floor	5.2	47.2	47.6	Silt loam
3	Shinku	7.2	65.2	27.6	Silt loam
4	Dabargai	7.2	49.2	43.6	Loam
5	Bishigram	9.2	37.2	53.6	Loamy sand

Table. 4.5 Physicochemical characteristics

S. No	Locality	pH	% Organic matter	% Lime (CaCO ₃)	EC dsm-1	TDS ppm	Sulphates µg/g	% Available Water	SAR millieq/L
1	Chail	5.2	2.07	2.5	0.043	28	516	0.16	0.52
2	Chail Valley Floor	5.4	2.76	7.5	0.08	51	556	0.15	0.2
3	Shinku	5.4	1.38	3	0.026	17	450	0.18	0.3
4	Dabargai	5.8	2.08	2.5	0.03	20	496	0.15	0.13
5	Bishigram	6	2.48	10	0.023	16	661	0.12	0.21
	Average	5.56	2.154	5.1	0.0404	26.4	535.8	0.152	0.272

Table. 4.6 Macronutrients in soil

S. No	Locality	% N ₂	P µg/g	K µg/g	Ca µg/g	Mg µg/g	S µg/g
1	Chail	0.1035	470	6398	34448	22188	172
2	Chail Valley Floor	0.138	430	10634	16722	15433	185
3	Shinku	0.069	494	8925	24148	17056	150
4	Dabargai	0.1104	385	4162	39159	25127	165
5	Bishigram	0.1242	475	13059	14568	13738	220
	Average	0.10902	450.8	8635.6	25809	18708.4	178.4

Table. 4.7 Micronutrients in soil

S.No	Locality	Na $\mu\text{g/g}$	Cl mg/g	Fe $\mu\text{g/g}$	Co ppm	Mn $\mu\text{g/g}$	Cu $\mu\text{g/g}$	Zn $\mu\text{g/g}$	Al $\mu\text{g/g}$	Ba $\mu\text{g/g}$
1	Chail	13289	32	46845	25.1	891	37	82	60326	150
2	Chail Valley Floor	9302	38	39143	20.1	722	40	76	49339	107
3	Shinku	12072	30	40590	36.6	805	40	97	51933	217
4	Dabargai	16161	42	46067	30.15	815	27	77	60088	106
5	Bishigram	9109	34	35852	22.45	708	29	80	50175	296
	Average	11986.6	35.2	41699.4	26.88	788.2	34.6	82.4	54372.2	175.2

Table. 4.8 Heavy metals in soil

S. No	Locality	Ti $\mu\text{g/g}$	V $\mu\text{g/g}$	Cr $\mu\text{g/g}$	Ni $\mu\text{g/g}$	Pb ppm	Ag ppm	Cd ppm
1	Chail	1588	208	94	51	65.4	1.6	0.65
2	Chail Valley Floor	1438	163	81	51	62.5	3.2	1.1
3	Shinku	1708	190	64	57	64.7	2.75	0.25
4	Bishigram	1494	141	79	53	89	5.1	1.5
5	Dabargai	1465	217	82	46	63.5	3.65	0.45
	Average	1538.6	183.8	80	51.6	69.02	3.26	0.79

Table. 4.9 Summary of ANOVA for edaphic variables

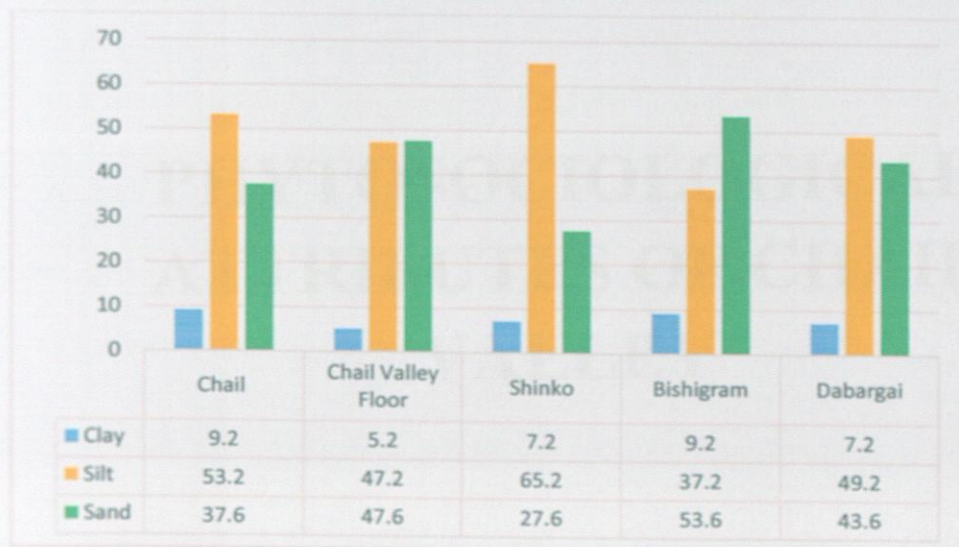
S. No	Groups	Sum	Average	Variance
1	pH	27.8	5.56	0.108
2	% Organic matter	10.77	2.154	0.27128
3	% CaCO ₃	25.5	5.1	11.925
4	Electrical conductivity	0.202	0.0404	0.000548
5	TDS	132	26.4	211.3
6	SO ₄	2679	535.8	6355.2
7	Available water	0.76	0.152	0.00047
8	Sodium absorption ratio	1.36	0.272	0.02287
9	Nitrogen	0.5451	0.10902	0.000676
10	Phosphorous	2254	450.8	1895.7
11	Potassium	43178	8635.6	12165943
12	Calcium	129045	25809	116136848
13	Magnesium	93542	18708.4	22867397
14	Sulphur	892	178.4	700.3
15	Sodium	59940	11988	8654512
16	Chloride	176	35.2	23.2
17	Iron	208497	41699.4	21877791
18	Cobalt	134.4	26.88	43.48325
19	Manganese	3941	788.2	5595.7
20	Copper	173	34.6	38.3
21	Zinc	412	82.4	72.3
22	Aluminum	271861	54372.2	29254348
23	Barium	876	175.2	6603.7
24	Titanium	7693	1538.6	12165.8
25	Vanadium	919	183.8	997.7
26	Chromium	400	80	114.5
27	Nickle	258	51.6	15.8
28	Lead	335.1	67.02	178.587
29	Silver	16.3	3.26	1.63925
30	Cadmium	3.95	0.79	0.25675

Source of variation	SS	df	MS	F	P-value	F-crit
BG	25101639069.15	29	865573761.005	123.0721	7.00856	1.562071
WG	843967461.58	120	7033062.2			
Total	25945606530.73	149				

Table. 4.10 Results of ANOVA for edaphic variables

BG-Between groups WG-Within groups

Fig. 4 Soil texture



4.3 Phytosociological attributes of Chail valley

Phytosociology deals with all the characteristics of vegetation structure, composition, function, dynamics and on the basis of such characteristics plant communities are established (Ahmad and Shaukat, 2012). Phytosociology may be referred to study of plant communities and their classification (Mishra, 2012). Such studies lead to help in understanding the multilateral relations of plants to one another as well as with the environment. Phytosociology discloses many characteristics of plants communities such as quantitative, qualitative and synthetic characteristics. This discipline also determines the relationship of plant species to each other as well as ecological characteristics (Becking, 1957). Plant community is the spatial and temporal association of functional unit of species and generally these associations can be separated into groups for the provision of bases for the vegetation sciences (Magurran, 1988). Plant community classification mainly depends upon the presence of indicator species and floristic composition though, due the rapid increase in human population and settlement in new land are the main factors responsible for the exploitation of plants communities (Badshah *et al.*, 2016; Ali *et al.*, 2015).

Present study was conducted in Hindukush range of District Swat, Pakistan during 2012-2015. Five monitoring sites were established viz. Chail village, Chail valley floor, Shinku, Dabargai and Bishigram (Fig. 5). The study area displays a unique floristic and vegetation structure. A total of 202 species were recorded in sampling unit, of which trees were represented by 33 species, shrubs by 36 species and herbs by 133 species. On the basis of IVI three communities respectively of tree, shrub and herb layer were established at each monitoring site. This approach of classifying vegetation into tree, shrub and herbaceous communities is in agreement with the work of Ahmad *et al.* (2016), Dad (2016), Ali *et al.* (2015), Saurav and Das (2014), Sharma *et al.* (2014) Saglam (2013), Ahmad *et al.* (2010), Digiovinazzo *et al.* (2010), Hussain *et al.* (2010), Mohler *et al.* (2006) Munhoz *et al.* (2006) and Padalia *et al.* (2004).

Tree communities comprised of 16 families, with Pinnaceae as the leading family with an FIV of 190.85 followed by Fagaceae (64.97), Juglandaceae (45.51), Ebenaceae (38.54), Moraceae (31.64), Rosaceae (30.41), Simoroubaceae (22.36) and Salicaceae with 19.86. Oleaceae, Taxaceae, Punicaceae, Meliaceae and Ulmaceae had importance values ranging from 16.8 to 5.82.

Shrubby vegetation was represented by 21 families, dominated by Rosaceae, with highest FVI value of 101.44. It was followed by Papilionaceae (59.27), Hammelidaceae (41.62), Berberidaceae (33.47), Thymelaceae (33.44), Oleaceae (31.91), Buxaceae (30.21), Myrsinaceae (27.14), Lamiaceae (26.16) and Caprifoliaceae (23.43). Similarly, Buddlejaceae, Euphorbiaceae, Elaeagnaceae, Grossulariaceae, Rhamnaceae, Acanthaceae, Urticaceae, Rutaceae and Plumbaginaceae were the associated families having FVI ranging from 16.98 to 4.96.

Herbaceous layers were represented by 47 families with Poaceae as the leading family with FVI value of 182.15. Asteraceae (43.06), Lamiaceae (27.55), Papilionaceae (24.06), Polygonaceae (23.15), Saxifragaceae (17.4), Brassicaceae (14.24), Euphorbiaceae (14.09), Rosaceae (13.82) and Apiaceae (12.35) were the sub dominant families. Other important families of herbaceous layer included Plantaginaceae, Ranunculaceae, Caryophyllaceae, Sapotaceae, Solanaceae, Amaryllidaceae, Scrophulariaceae, Urticaceae and Oxalidaceae (Table 4.11).

4.3.1 Chail Village (Stand I)

Plant communities at this site were established at Southern and South-Eastern aspects at an elevation of 1390 meters up to 1480 meters. Soil at this locality was loamy-sand, with 9.2% clay particles, 53.2% silt and 37.6% sand particles. Nitrogen content of the soil was estimated to be 0.1035 %, phosphorous 470 µg/g, potassium 6398 µg/g, calcium 34448 µg/g and magnesium 22188 µg/g. Sodium absorption ratio (SAR) of the soil was 0.52 millieq/L while sulphates were found to be 516 µg/g. Soil pH at this monitoring site was recorded as 5.2 which reflected the podzolic nature of the soil. Organic matter was found to be 2.07 % which is typical to the podzolic soils. Due to steep slope water content was low, i.e. 0.16 % (Table. 4.12).

1. *Pinus- Diospyros- Quercus* community

This plant community was recorded from South facing slope at an elevation of 1480 meters. *Pinus wallichiana* was the dominant species with IVI of 25.39. Distribution showing clumping rather than a uniform pattern of distribution due to lavish wood cutting in the area. Second dominant was found to be *Diospyros lotus* with an IVI of 23.38, forming a close association with *Pinus wallichiana* at lower

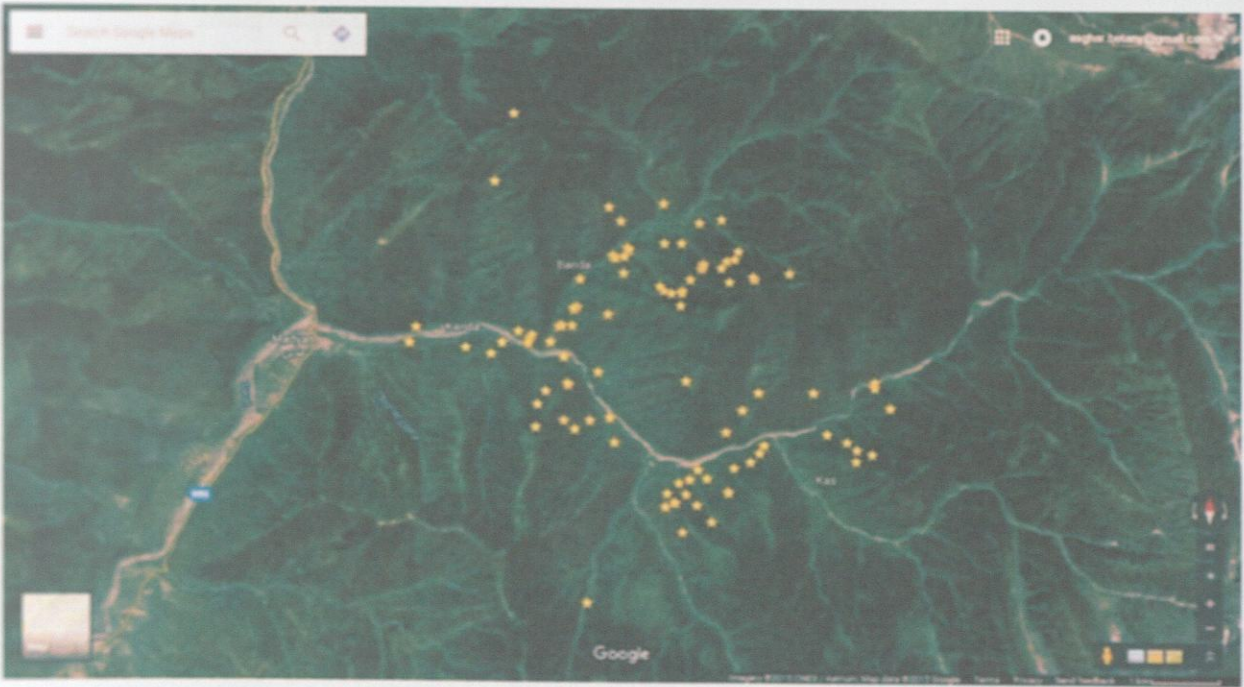


Fig. 5 Map of the monitoring sites showing all the quadrates

parts of the slopes. As the plant yield edible fruits with medicinal value the population density of the *Diospyros lotus* was high with a considerably uniform dispersion. *Quercus dilatata* with an IVI of 15.62, mostly dispersed among *Pinus wallichiana* members as higher altitudes. Findings of the present study are also backed by the works of Ilyas *et al.* (2015); Shaheen *et al.* (2011); Ahmad *et al.* (2010) and Hussain *et al.* (2010). Other prominent members of this community included *Juglans rigia* (12.93 IVI), *Ailanthus altissima* (9.21 IVI), *Ficus carica* (8.94 IVI) and *Crataegus songarica* (4.49 IVI). Common herbs growing around this community included *Rumex hastatus*, *Solidago virga-aurea*, *Fragaria vesica*, *Plantago himalayica*, *Medicago polymorpha*, *Sonchus asper*, *Cuscuta europaea* and *Salvia moorcroftiana* were the common herbs growing around this community.

2. *Indigofera-Cotoneaster-Jasminum* community

On South facing slope this shrubby community was recorded. Scanty trees and comparatively thick shrub cover near the foothills indicated the disturbed nature of habitat which is under tremendous biotic stress. Dominant species was *Indigofera heterantha* var. *gerardiana* with an IVI value of 13.36 followed by *Cotoneaster nummularia* with an IVI value of 13.25. These shrubs made thick randomly dispersed patches on mostly tree-less aspect of the cliffs. Co-dominant was found to be *Jasminum humile* with an IVI value of 10.23. Similar shrub communities were reported by Haq *et al.* (2015) and Ilyas *et al.* (2015). The rest of the shrubs included *Spiraea canescens* (10.01 IVI), *Buddleja crispa* (9.6 IVI), *Myrsine Africana* (7.34 IVI), *Rubus fruticosus* (7.23 IVI) and *Daphne mucronata* (6.84 IVI). Other members of the shrub layer in this locality were *Rubus ellipticus*, *Elaeagnus umbellata*, *Viburnum cotinifolium* and *Sageretia thea*.

3. *Apluda-Cynodon-Heteropogon* community

This community was recorded from South-eastern aspect at an elevation of 1390 meters. In Chail village area therophytes dominate the landscape. This community was dominated by *Apluda mutica* with an IVI value of 14.57, almost uniformly distributed in the locality making strong association with the second dominant *Cynodon dactylon* with an IVI value of 13.35. Just around the shrubby vegetation *Apluda mutica* was forming mixed patches with third dominant *Heteropogon contortis* with an IVI value of 6.64. The other associated species were *Fragaria vesca* (5.82 IVI), *Bergenia ciliata* (5.07 IVI), *Artemisia vulgaris* (4.93 IVI) and *Origanum vulgare* (4.3 IVI). Remaining species such as *Arthraxon prionodes*,

Bistorta amplexicaulis, *Buplerum falcatum*, *Cichorium intybus*, *Clematis grata*, *Clinopodium umbrosum*, *Cuscuta europa*, *Euphorbia prostrata*, *Medicago polymorpha*, *Pennistum orientale*, *Plantago himalaica*, *Rumex hastatus* and *Salvia moorcroftiana* had IVI values ranging between (1.32 to 3.92). Results of similar nature are reported by Ahmad *et al.* (2016); Urooj *et al.* (2016); Haq *et al.* (2015); Ilyas *et al.* (2015); Dad (2016); Ahmad *et al.* (2010); Ahmad (2009); Jabeen and Ahmad (2009).

4.3.2 Chail valley floor (Stand II)

Plant communities established at this monitoring site were found on an elevation of 1620 meters. Soil analysis displayed a contrasting picture with reference to adjoining Chail village. Soil was silt-loam at this site with 5.2% clay particles, 47.2% silt and 47.6% sand particles. Soil reaction was mildly acidic with a soil pH of 5.4. Organic matter content was estimated as 2.76% which was well within normal range. Water content in soil was found to be 0.15 %. Nitrogen content was 0.138% followed by phosphorous 430 µg/g, potassium 10634 µg/g, calcium 16722 µg/g and magnesium 15433 µg/g. Sodium absorption ratio of the soil was estimated as 0.2 millieq/L and sulphate content was recorded as 556 µg/g. Floods of recent past have eroded soil in the valley floor to a huge extent and main water tributary of the valley Chail stream is still a big threat to remaining vegetation cover in the valley floor (Table. 4.12)

1. *Pinus-Quercus-Juglans* community

This community was recorded at an elevation of 1620 meters, *Pinus wallichiana* was found to be dominated with an IVI value of 18.06. This was associated with *Quercus baloot* having an IVI value of 15.52. They showed a clumped dispersion pattern throughout the valley floor. Third dominant was *Juglans regia* with an IVI value of 13.36. Results presented here are supported by the works of Khan *et al.* (2016); Akhtar and Bergmeier (2015); Shaheen *et al.* (2015); Sharma *et al.* (2014); Hussain *et al.* (2010) and Khan *et al.* (2010). These were followed by *Olea ferruginea* (8.42 IVI), *Salix denticulata* (6.66 IVI), *Alanthus altissima* (6.42) and *Punica granatum* (5.91 IVI). In addition to this *Ficus carica*, *Populus alba*, *Prunus persica*, *Morus nigra*, *Malus pumiula*, *Crataegus songarica* and *Diospyros lotus* had IVI values ranging between 4.32 to 2.87. *Phalaris minor*, *Achillea millefolium*, *Cannabis sativa*, *Viola canescens*, *Fumaria indica*, *Urtica dioica*, *Capsella bursa-*

pastoris, *Chenopodium album* and *Plantago major* were the common herbaceous flora intermingled with trees.

2. *Rubus-Isodon-Ricinus* community

Rubus ulmifolius with an IVI value of 15.92 dominated this community with uniform distribution throughout the valley floor. It had thick patches of *Isodon rugosus* as second dominant with an IVI value of 13.67. But on low elevation *Ricinus communis* associated forming randomly dispersed clumps with an IVI value of 11.67. Ilyas *et al.* (2015) also reported these shrubs as dominants his work. These dominant forms were followed by *Mrsine Africana* (8.9 IVI), *Sarcococca saligna* (8 IVI), *Indigofera heterantha* var. *gerardiana* (7.31 IVI), *Jasminum humile* (6.94 IVI) and *Debergeasia salicifolia* (6.21 IVI). Other shrubby members of this community such as *Daphne mucronata*, *Justicia adhatoda*, *Lespedeza juncea*, *Berberis lyceum* and *Lonicera asperifolia* had IVI values ranging between 5.49 and 3.62.

3. *Apluda-Heteropogon-Poa* community

This community of Chail valley floor was dominated by *Apluda mutica* with an IVI value of 9.81. Though herbs were not forming a uniform cover due to severe soil erosion by Chail stream in past few years but still thick patches of herbs were recorded in the valley floor and banks of Chail stream. Second dominant plant species was *Heteropogon contortis* with an IVI value of 8.34 which formed association with *Poa annua* having an IVI value of 7.92. These dominants were followed by *Phalaris minor* (6.54 IVI), *Artemisia scoparia* (5.19 IVI), *Urtica dioca* (3.81 IVI), *Verbascum thapsus* (3.71 IVI), *Plantago major* (2.89 IVI) and *Chenopodium album* (2.83 IVI). These results are in line with the work of Ahmad *et al.* (2016) and Dad (2016).

4.3.3 Shinku (Stand III)

Plant communities at this site were established at elevation of 2150 meters on Northern and North-Western slopes. Soil analyses indicated that soils at this site are silt-loam with 7.2% clay particles, 65.2% silt particles and 27.6% sand particles. Soil pH was recorded as 5.4 and organic matter was estimated as 1.38%. Acidic soils show a slow rate of humification which is the reason behind low organic matter in the soil. Due to lesser proportion of sand particles the water holding capacity was good and there was 0.18% available water in the collected samples. Nitrogen content was low i.e. 0.069%. Phosphorous was estimated as 494 µg/g while potassium was found to be 8925 µg/g. Calcium content was a bit higher i.e. 24148 µg/g and magnesium was 17056 µg/g in the soils of this locality. Sodium absorption ratio was also a little low in

comparison with Chail village and Chail valley floor i.e. 0.3 millieq/L. Sulphates were estimated as 450 µg/g (Table. 4.12).

1. *Quercus-Abies-Pinus* community

Quercus-Abies-Pinus community of trees was recorded at an elevation of 1495 meters up to 1680 meters on Northern and North-Western slopes in Shinku area. This area had a uniformly spread thick Oak forest mixed with conifers. Deforestation was also not that alarming as that of Chail village and Chail valley floor. On higher elevations the forest was almost undisturbed but the habitat will face biotic stress, especially the anthropogenic pressure from increasing population in the low laying villages, in next few years. In this community the dominant was *Quercus incana* with an IVI value of 18.91. Second dominant was *Abies pindrow* with an IVI of 18.6, making strong association with *Quercus incana* on North-Western aspect and *Pinus wallichiana* with IVI of 12.56. Our results are in line with the works of Bokhari *et al.* (2016); Ali *et al.* (2015); Ilyas *et al.* (2015); Shaheen *et al.* (2015); Siddique *et al.* (2015) and Ahmad *et al.* (2010). The other important contributors to this community were *Juglans regia* (11.59 IVI), *Taxus fauna* (8.88 IVI), *Pyrus pashia* (4.16 IVI) and *Cedrus deodara* (4.02 IVI). *Taxus fauna* was more abundant on North-Western aspect than on Northern aspect. On lower elevations mixed patches of *Diospyros kaki* (3.64 IVI), *Crataegus songarica* (2.04 IVI) and *Ailanthus altissima* (1.89 IVI) were recorded. Some notable herbaceous members found within this community were *Oxalis corniculata*, *Euphorbia prostrata*, *Anagallis arvensis*, *Scandix pecten-veneris*, *Avena fatua*, *Taraxacum officinale*, *Stellaria media*, *Silene conoidea*, *Hypericum perforatum*, *Poa annua* and *Clematis grata*.

2. *Sarcococca-Daphne-Berberis* community

Shrubby layer was much prominent making thick strips from Northern to North-Western aspect. This community was found at an elevation of 1491 meters up to 1516 meters. The first dominant in this community was found to be *Sarcococca saligna* with an IVI value of 19.01 making thick uniformly dispersed clumps with second dominant *Daphne mucronata* with an IVI value of 17.29. *Berberis lyceum* with an IVI value of 13.6, was common to Northern slopes. Our findings are supported by the work of Ali *et al.* (2015) and Ilyas *et al.* (2015). Other important members of this community included *Indigifera heterantha* var. *heterantha* (10.24 IVI), *Cotoneaster nummularia* (7.3 IVI), *Myrsine africana* (6.62 IVI) and *Buddleja*

crispa (6.05 IVI). *Rosa webbiana* was randomly distributed at higher elevations with an IVI of 3.51.

3. *Cynodon-Apluda-Bergenia* community

Herbaceous community was found at elevation of 1490 to 1610 meters. *Cynodon dactylon* appeared to be the dominant with an IVI value of 13.97, followed by *Apluda mutica* with an IVI value of 12.47 as co-dominant. *Apluda mutica* was observed to form randomly dispersed thick patches all along the Northern slope. *Bergenia ciliata* appeared as the next dominant with an IVI of 6.88 near small water falls on both aspects. Similar results are present in the works of Ahmad *et al.* (2015); Dad (2016); Ilyas *et al.* (2015) and Ahmad (2009). This community also included *Fragaria vesca* (6.74 IVI), *Artemisia vulgaris* (6.46 IVI), *Rumex hastatus* (4.63 IVI), *Poa annua* (4.22 IVI), *Sassurea albescense* (4.11 IVI), *Avena fatua* (3.53 IVI) and *Nacrissus tazetta* (3.16 IVI).

4.3.4 Dabargai (Stand IV)

Plant communities at this site were established at an elevation of 2371 meters on North-Eastern and Southern aspects. Soil was loam with 7.2% clay particles, 49.2% silt particles and 43.6% sand particles. Soil pH was recorded as 5.8 and it was evident from a higher degree of podzolization in the soils of the study area with considerably low organic content i.e. 2.08%. Water content of the soil was estimated as 0.15%. Nitrogen content was estimated as 0.1104 %. Phosphorous and potassium were recorded as 385 µg/g and 4162 µg/g respectively. Calcium content was found to be 39159 µg/g while magnesium content was 25127 µg/g. Sodium absorption ratio was 0.13 millieq/L and sulphates were only 496 µg/g (Table. 4.12).

1. *Cedrus-Abies-Pinus* community

This tree community was found between elevation ranges of 1935 to 12371 meters. *Cedrus deodara* with an IVI value of 22.07 was the abundantly growing tree. *Abies pindrow* and *Pinus wallichiana* with an IVI value of 16.01 and 13.38 respectively were the second and third dominants. *Cedrus-Abies* forest was much thicker on North-Eastern aspect and showed degradation on Southern slope. Results of this study are in line with the works of Bokhari *et al.* (2016); Khan *et al.* (2016); Akhtar and Bergemeier (2015); Sharma *et al.* (2014); Ahmad *et al.* (2010). In addition to these dominant forms other important members of this community included *Olea ferruginea* (5.53 IVI), *Ficus carica* (4.41 IVI), *Taxus fauna* (4.06 IVI), *Quercus baloot* (3.88 IVI), *Juglans regia* (3.27 IVI), *Moras alba* (3.02 IVI) and *Cedrela*

serrata (2.91 IVI). Notable herbaceous elements of this community were *Thymus linearis*, *Ammi visnaga*, *Apluda mutica*, *Dactylis glomerata*, *Centaurea iberica*, *Notholirion thomsonianum*, *Dioscorea deltoidea*, *Amaranthus viridis*, *Verbascum thapsus*, *Gagea elegans*, *Micromeria biflora* and *Sisymbrium irio*.

2. *Parrotiopsis-Viburnum-Berberis* community

Shrubby layer was randomly dispersed on North-Eastern and Southern slopes. *Parrotiopsis jacquemontiana* was dominant with an IVI value of 25.51 making randomly dispersed thick patches mostly on North-Eastern aspect. *Viburnum grandiflorum* was second dominant with an IVI value of 13.08 making continuous strips with *Berberis lyceum* (IVI 12.26). Ali *et al.* (2015), Ilyas *et al.* (2015) and Hussain *et al.* (2010) also have reported similar results in their studies respectively. Some other important contributors to this community included *Indigifera heterantha* var. *gerardiana* (7.08 IVI), *Maytenus royleanus* (4.63 IVI), *Myrsine Africana* (4.28 IVI), *Ribes himalense* (4.05 IVI), *Isodon rugosus* (3.86 IVI) and *Jasminum humile* (3.46 IVI).

3. *Chrysopogon-Themeda-Cynodon* community

This community is dominated by *Chrysopogon fulvus* with an IVI value of 10.89. It had a rather uniform dispersion on North-Eastern aspect than on Southern slopes. *Themeda anathera* with an IVI value of 9.33 was more common to Southern aspect on lower elevations. These results are supported by the works of Ahmad *et al.* (2016); Dad (2016); Shaheen *et al.* (2015); Ahmad (2009) and Jabeen and Ahmad (2009). *Cynodon dactylon* with an IVI value to 8.64 was declared as next dominant. Some other important members of this community included *Avenia fetua* (3.58 IVI), *Bergenia ciliata* and *Verbascum thapsus* both with IVI values of 3.09, *Salvia moorcroftiana* (3.04 IVI), *Sisymbrium irio* (2.46 IVI), *Cannabis sativa* (2.39 IVI) and *Artemisia absinthium* (2.36 IVI).

4.3.5 Bishigram (Stand V)

Plant communities at this sampling site were established at an elevation of 2698 meters on Northern and Southern aspects. Soils in the area were loamy-sand in texture with 9.2% clay particles, 37.2% silt particles and 53.6% sand particles. Soil pH was 6 and organic matter content was estimated as 2.48 %. Due to relative abundance of sand particles water content in the soil was low i.e. 0.12%. Nitrogen content was 0.1242% which was better than Chail village, Chail valley floor and Shinku areas displaying a healthy rate of saprophytic activity in the soils.

Phosphorous content was 475 µg/g, potassium 13059 µg/g and calcium 14568 µg/g. Magnesium was recorded as 13738 µg/g. Sodium absorption ratio was low i.e. 0.21 millieq/L and sulphates were abundant i.e. 661 µg/g (Table. 4.12).

1. *Picea-Pinus-Abies* community

This tree community was found at an elevation range of 2475 to 2698 meters on both aspects. Forest was found in good health with the exception on Northern slopes where deforestation was quite evident due to fuel wood extraction by locals. *Picea smithiana* with an IVI value of 22.07 followed by *Pinus wallichiana* with an IVI value of 14.54 were the leading trees in this community. On higher elevations *Picea smithiana* formed association with *Abies pindrow* with an IVI value of 12.36. These results are in line with the works of Khan *et al.* (2016); Bokhari *et al.* (2016); Akhtar and Bergemeier (2015); Sharma *et al.* (2014); Ahmad *et al.* (2010) and Hussain *et al.* (2010). Other notable contributors were *Juglans rigia* (4.36 IVI), *Diospyros lotus* (4.12 IVI) and *Ficus carica* (3.6 IVI). On Southern aspect there was a mixed patch of *Platanus orientalis* (3.6 IVI), *Acer cappadocicum* and *Pinus roxbergii* both having IVI values of 3.07. In addition to this *Cedrus deodara* made randomly dispersed clumps on Northern aspect with IVI values of 2.92. On higher elevations at Northern aspect *Quercus dilatata* and *Taxus fauna* were found with an IVI value of 2.79 each, delimiting a thin strip of *Quercus semicarpifolia* with an IVI value of 2.76. At this monitoring site the common herbs included *Arenaria serpyllifolia*, *Brachiaria reptans*, *Eryngium coeruleum*, *Pseudognaphalium affine*, *Eragrostis minor*, *Angelica glauca*, *Calanthe tricarinata*, *Portulaca oleracea*, *Apluda mutica* and *Podophyllum emodi*.

2. *Parrotiopsis-Cotoneaster-Indigofera* community

Parrotiopsis jacuemontiana with an IVI value of 16.11 making a very prominent stretched patch on Northern slopes and clumped pattern on Southern aspect. It was accompanied by *Cotoneaster nummularia* with an IVI value of 14.82. *Indigofera heterantha* var. *heterantha* was the companion shrub with an IVI value of 11.95. It was more common to Southern aspect than to Northern slopes. *Cotoneaster nummularia* rather displayed a uniformed dispersion on both slopes. Akhtar and Bergmeier (2015), Haq *et al.* (2015), Hussain *et al.* (2010) and Ahmad *et al.* (2006) also reported similar results in their studies. Other important contributors to this community were *Limonium cabulicum* (4.96 IVI), *Rubus fruticosus* (4.84 IVI), *Jasminum humile* (4.6 IVI), *Ribes orientale* (4.54 IVI), *Spiraea canescens* (4.47 IVI)

and *Berberis lyceum* (3.94 IVI). Notable shrubs but with lesser IVI values included *Isodon rugosus*, *Lespedeza juncea*, *Phlomis spectabilis*, *Andrachne cordifolia*, *Sarcococca saligna*, *Skimmia laureola* and *Himalrandia tetrasperma*.

3. *Cenchrus-Medicago-Rumex* community

Herbaceous community was found to have rich diversity with a dominant being the *Cenchrus pennisetiformis* having an IVI value of 18.92 with uniform strips on both slopes. It was found making good association with *Medicago lupulina* with an IVI value of 11.87. While on lower elevations *Rumex hastatus* with an IVI value of 8.97 was dominating both the aspects. Similar results were communicated by Ahmad *et al.* (2016) and Khan *et al.* (2012). This community also had *Poa annua* (3.8 IVI), *Cyanodon dactylon* (3.4 IVI), *Aristida cyanantha* (3.12 IVI), and *Sisymbrium irio* (2.83 IVI).

4.3.6 Maturity index

Maturity index was calculated according to Pichi-Sermolli (1948). At Chail village, tree community had 48.57 maturity index, shrubs had 31.66 and herbaceous community had a 28.61 maturity index. The mean value for the site was 36.28. At Chail valley floor, tree community showed a maturity index of 34.28, followed by shrubby layer with a value of 23.07 and herb layer having 16.06. The mean value for these three communities was 24.47. In Shinku, tree community had a maturity index of 44. Shrub community with a maturity index value of 27.27 while herb community had only 19.62. Mean value for maturity index at this site was 19.62. Maturity index for tree community at Dabargai area was found to be 28.88 followed by 16.31 value of shrub community and 12.73 value for herbaceous community. Mean value for the maturity index at this site was 19.30. At Bishigram, tree community had a maturity index of 27. At this site shrub had a maturity index of 20 followed by herb layer having a maturity index of 10.86. Mean value of maturity index at this site was 19.28 (Table. 4.13).

4.3.7 Index of similarity

1. Tree communities

According to Motyka's index of similarity (Motyka *et al.*, 1950), PDQ tree community of Chail village was found to be 16.09 % similar to PQJ community of Chail valley floor. The similarity between PDQ community and QAP community at Shinku was found to be 10.56 %. The analysis showed that similarity between PDQ community and that of CAP community at Dabargai area was 10.63 %. Lowest value

of similarity was observed between PDQ community and PPA community of Bishigram, i.e. 10.54 %. Similarity between PQJ tree community of Chail valley floor and that of QAP community at Shinku was 11.96 %. PQJ community was 12.61 % similar to tree community CAP at Dabargai area. Only 11.09 % similarity was observed between PQJ community and PPA community of Bishigram area. QAP tree community at Shinku area showed more similarity with CAP tree community of Dabargai area i.e. 16.42 %. QAP community was 16.04 % similar to PPA community at Bishigram. CAP tree community at Dabargai area showed maximum similarity with PPA tree community at Bishigram i.e. 18.11 % (Table. 4.14).

2. Shrub communities

Shrubby vegetation showed little similarities among communities on the basis of Motyka's index. ICJ community at Chail village site was 6.71 % similar to RIR community at Chail valley floor. ICJ shrub community was found 10.45 % similar to SDB shrub community at Shinku. Similarity between ICJ community and PVB community at Dabargai area was 7.07 %. The ICJ community was least similar to PCI community at Bishigram i.e. 5.31 %. Shrub community at Chail valley floor i.e. RIR was 10.36 % similar to SDB shrub community at Shinku. Same RIR community was 6.95 % similar to PVB community of shrubs at Dabargai. A 5.17 % similarity was observed between RIR community and PCI shrub community at Bishigram. Comparison of shrub community at Shinku area i.e. SDB community and PVB community at Dabargai showed 11.81 % similarity while between SDB community and PCI community at Bishigram 9.73 % similarity was observed. Shrub communities at Dabargai i.e. PVB and that of Bishigram i.e. PCI community showed maximum similarity i.e. 14.6 % (Table. 4.15).

3. Herbaceous communities

Among herbaceous communities, ACH community at Chail village was 7.06 % similar to AHP herb community at Chail valley floor. The ACH community was found to be 19.64 % similar to CAB community at Shinku while its similarity with CTC community at Dabargai site was 8.27 %. The herb community ACH was least similar to Bishigram herb community with a similarity index of just 3.03 %. The herb community of Chail valley floor i.e. AHP was 4.57 % similar to Cab herb community at Shinku, 6.13 % similar to CTC community at Dabargai and 5.87 % similar to CMR community at Bishigram. The CAB herb community of Shinku was 10.68 % similar to CTC community at Dabargai and 6.40 % similar to CMR community at Bishigram.

Similarity between CTC community at Dabargai and CMR community at Bishigram was found to be 6.88 % (Table 4.16).

The study area represented a collage of thick forests to open canopy woodlands, thick bushy patches sprawling northern slopes and partly making random patches on southern slopes, rocky vegetation to small and medium sized meadows. The vegetation structure is mainly regulated by several factors, such as, soil pH, soil salinity, electrical conductivity, climate and anthropogenic factors (Pausas and Austin, 2001). Vegetation is also influenced by soil moisture, atmospheric humidity, aspect and grazing intensity (Ahmad *et al.*, 2016; Dad, 2016; Shaheen and Qureshi, 2011). Anthropogenic pressure is an eminent threat to vegetation structure of the study area. Harsh winters compel the local population to obtain fuel wood from the forest resulting in deforestation. At many places in the study area land sliding was noticed, which is the immediate outcome of deforestation. Similar threats to montane vegetation types in Pakistan are also reported by Siddiqui *et al.* (2015, 2013) and Ahmad *et al.* (2010, 2006).

This study is the first report on the vegetation structure of the study area hence it will provide the baseline for the future studies of similar nature. Pakistan is divided into four phytogeographic regions and Swat falls in the Sino-Japanese region. Findings of this study are supported strongly by the works of notable workers of the field, *Acer cappadocicum*, *Diospyros lotus*, *Juglans regia*, *Olea ferruginea*, *Picea smithiana*, *Pinus roxburghii*, *Pinus wallichiana*, *Quercus baloot*, *Quercus incana*, *Quercus semecarpifolia*, *Salix denticulate* and *Taxus fauna* are important tree species of this region. Common shrubs of this phytogeographic region are *Andrachne cordifolia*, *Berberis lyceum*, *Daphne mucronata*, *Indigofera heterantha*, *Isodon rugosus*, *Parrotiopsis jacquemontiana*, *Buddleja crispa* and *Sageretia thea*. Herbaceous vegetation of this region has *Achyranthes aspera*, *Agrostis viridis*, *Apluda mutica*, *Bergenia ciliata*, *Euphorbia heliscopia*, *Fumaria indica*, *Hypericum perforatum*, *Medicago lupine*, *Oxalis acetosella*, *Poa annua*, *Rumex hastatus* and *Themeda anathera* (Ahmad and Shaukat, 2012; Nasir and Rafiq, 1995; Ali and Qaiser, 1986). Species distribution is also determined by soil nutrients and moisture (Phillips, 2003). Schuur and Matson (2001) reported that thick vegetation cover is due to relative abundance of clay particles and soil nutrients. Species richness was higher at higher altitudes than the foothills and low laying areas. Thick forest and well developed herbaceous cover was observed at higher altitudes (Nogues *et al.*, 2008).

According to the classification of Champion *et al.* (1965) the study area includes elements of Subtropical Pine forests, Himalayan sub-tropical scrub, Lower West Himalayan temperate forests, Oak forest, Moist temperate deciduous forest and Himalayan moist temperate scrub, which further support the findings of present study. Deforestation is a big threat to vegetation structure in the study area. It is resulting in habitat destruction and converting thick forests into ones with much open canopy. Slash and burn practice for converting the mountain slopes into agricultural land is seen throughout the valley. Some very common animal species of the yesteryears are now on the brink, facing a threat of extinction, one of such examples is *Pteropus sp.* (Flying fox) which once was common to the study area is seen very rarely these days. Soil in the area is also becoming drier due to less vegetation cover. Forests in the study area appear to be diminishing gradually. Natural factors, such as land sliding, floods and earthquakes are putting tremendous pressure on vegetation in the area. Biota and anthropogenic stress are in conflict throughout the valley. Reforestation can ensure the continuity of ecosystem components coupled with establishment of protected areas. Deforestation can also be checked by providing alternative sources of energy to the people of study area. Lack of awareness about the floristic wealth can be overcome by starting capacity building programs and Governmental as well as NGOs can play a constructive role in this regard. Similar recommendations were proposed by Khan *et al.* (2012); Shaheen *et al.* (2012) and Tarrason (2010) for their research areas.

Table. 4.11 FIV data for the families

	TREES	
	Family	IVI
1	Pinaceae	190.85
2	Fagaceae	64.97
3	Juglandaceae	45.51
4	Ebenaceae	38.54
5	Moraceae	31.64
6	Rosaceae	30.41
7	Simaroubaceae	22.36
8	Salicaceae	19.86
9	Oleaceae	16.8
10	Taxaceae	15.73
11	Punicaceae	5.91
12	Meliaceae	5.82
13	Ulmaceae	5.13
14	Plantanaceae	3.6
15	Aceraceae	3.07
16	Anacardiaceae	2.39
	SHRUBS	
1	Rosaceae	101.44
2	Papilionaceae	59.27
3	Hamelidaceae	41.62
4	Berberidaceae	33.47
5	Thymelaceae	33.44
6	Oleaceae	31.91
7	Buxaceae	30.21
8	Myrsinaceae	27.14
9	Lamiaceae	26.16
10	Caprifoliaceae	23.43
11	Euphorbiaceae	16.98
12	Buddlejaceae	15.65
13	Elaeagnaceae	12.16
14	Grossulariaceae	8.59
15	Rhamnaceae	7.6
16	Acanthaceae	7.09
17	Urticaceae	6.21
18	Rutaceae	5.75
19	Plumbaginaceae	4.96
20	Celastraceae	4.63
21	Rubiaceae	1.89
	HERBS	
1	Poaceae	182.15
2	Asteraceae	43.06
3	Lamiaceae	27.55
4	Papilionaceae	24.06

5	Polygonaceae	23.15
6	Saxifragaceae	17.4
7	Brassicaceae	14.24
8	Euphorbiaceae	14.09
9	Rosaceae	13.82
10	Apiaceae	12.35
11	Plantaginaceae	9.95
12	Ranunculaceae	9.88
13	Caryophyllaceae	9.43
14	Sapotaceae	8.54
15	Solanaceae	8.01
16	Amaryllidaceae	7.62
17	Scrophulariaceae	6.8
18	Urticaceae	5.99
19	Oxalidaceae	5.97
20	Cannabaceae	5.54
21	Gentianaceae	5.5
22	Colchicaceae	4.38
23	Chenopodiaceae	3.67
24	Rubiaceae	3.39
25	Amaranthaceae	3.14
26	Covolvulaceae	3.13
27	Malvaceae	2.82
28	Cucutaceae	2.68
29	Primulaceae	2.35
30	Papaveraceae	2.16
31	Iridaceae	2.08
32	Campanulaceae	1.79
33	Liliaceae	1.7
34	Podophyllaceae	1.66
35	Boraginaceae	1.62
36	Hypericaceae	1.53
37	Fumariaceae	1.02
38	Violaceae	0.92

39	Crassulaceae	0.78
40	Valerianaceae	0.78
41	Verbenaceae	0.78
42	Portulacaceae	0.7
43	Zygophyllaceae	0.51
44	Orchidaceae	0.5
45	Dioscoraceae	0.46
46	Geraniaceae	0.42
47	Paeoniaceae	0.42

Table 4.12 IV1 data for Plant communities of Chail valley

		Chail village	Chail valley floor	Shanku	Dabargai	Bishigram
	Trees	PDQ	PQJ	QAP	CAP	PPA
1	<i>Abies pindrow</i> Royle.	-	-	18.6	16.01	12.36
2	<i>Acer cappadocicum</i> Gled.	-	-	-	-	3.07
3	<i>Atlantus altissima</i> (Mill.) Swingle	9.21	6.42	1.89	2.37	2.47
4	<i>Cedrela serrata</i> Royle	-	-	-	2.91	-
5	<i>Cedrus deodara</i> (Roxb. ex Lamb.) G. Don	-	-	4.02	22.07	2.92
6	<i>Celtis caucasica</i> Willd.	-	-	-	2.62	2.51
7	<i>Crataegus songarica</i> G. Koch.	4.49	3.21	2.04	2.47	-
8	<i>Diospyros kaki</i> L.	-	-	3.64	-	-
9	<i>Diospyros lotus</i> L.	23.38	2.87	1.86	2.71	4.12
10	<i>Ficus carica</i> L. ssp <i>carica</i>	8.94	4.23	1.76	4.41	3.6
11	<i>Juglans regia</i> L.	12.93	13.36	11.59	3.27	4.36
12	<i>Malus pumila</i> Mill.	-	3.54	-	-	-
13	<i>Melia azedarach</i> L.	-	-	-	2.91	-
14	<i>Morus alba</i> L.	-	-	1.81	3.02	-
15	<i>Morus nigra</i> L.	-	3.87	-	-	-
16	<i>Olea ferruginea</i> Royle	-	8.42	-	5.53	2.85
17	<i>Picea smithiana</i> (Wall.) Boiss.	-	-	-	2.8	22.07
18	<i>Pinus roxburghii</i> Sargent	-	-	-	-	3.07

19	<i>Pinus wallichiana</i> A.B. Jackson	25.39	18.06	12.56	13.38	14.54
20	<i>Pistacia chinensis</i> Bunge ssp. <i>integerrima</i>	-	-	-	-	2.39
21	<i>Platanus orientalis</i> L.	-	-	-	-	3.60
22	<i>Populus alba</i> L.	-	3.93	-	-	-
23	<i>Prunus persica</i> (L.) Batsch.	-	3.93	-	-	-
24	<i>Punica granatum</i> L.	-	5.91	-	-	-
25	<i>Pyrus pashia</i> Ham. ex D. Don	-	-	4.16	-	-
26	<i>Pyrus pyrifolia</i> (Burm.) Nak.	-	-	4.01	-	2.56
27	<i>Quercus baloot</i> Griffith	-	15.52	-	3.88	-
28	<i>Quercus dilatata</i> Royle	15.62	-	-	3.02	2.79
29	<i>Quercus incana</i> Roxb.	-	-	18.91	-	2.47
30	<i>Quercus semecarpifolia</i> Sm.	-	-	-	-	2.76
31	<i>Salix babylonica</i> L.	-	-	-	2.47	-
32	<i>Salix denticulata</i> Anderson	-	6.66	4.19	-	2.61
33	<i>Taxus fauana</i> (Zucc.) Pilger	-	-	8.88	4.06	2.79
	Shrubs	ICJ	RIR	SDB	PVB	PCI
1	<i>Andrachne cordifolia</i> (Wall.ex Dcne.) Muell. Arg.	-	-	-	2.1	3.25
2	<i>Berberis lycium</i> Royle		3.67	13.6	12.26	3.94
3	<i>Buddleja crispa</i> Bth.	9.6	-	6.05	-	-
4	<i>Cotoneaster nummularia</i> Fisch. & Mey.	13.25		7.3	2.47	14.82

5	<i>Daphne mucronata</i> Royle	6.84	5.49	17.29	1.96	1.86
6	<i>Debregeasia salicifolia</i> (D. Don) Rendle	-	6.21	-	-	-
7	<i>Elaeagnus umbellata</i> Thunb.	6.31	-	3.93	-	1.92
8	<i>Himalrandia tetrasperma</i> (Roxb.) Yamazaki	-	-	-	-	1.89
9	<i>Indigofera heterantha</i> Wall. Ex Brandis var. <i>gerardiana</i>	13.36	7.31	-	7.08	-
10	<i>Indigofera heterantha</i> Wall. ex Brandis var. <i>heterantha</i>	-	-	10.24	2.1	11.95
11	<i>Isodon rugosus</i> (Wall. ex Bth.) Codd	-	13.67	-	3.86	3.44
12	<i>Jasminum humile</i> L.	10.23	-	6.68	3.46	4.6
13	<i>Jasminum officinale</i> L.	-	6.94	-	-	-
14	<i>Justicia adhatoda</i> L.	-	4.68	-	-	-
15	<i>Lespedeza juncea</i> (L. f.) Pers. var. <i>juncea</i>	-	3.89	-	-	3.34
16	<i>Limonium cabulicum</i> (Boiss.) O. Kuntze	-	-	-	-	4.96
17	<i>Lonicera asperifolia</i> (Decne.)	-	3.62	-	-	-
18	<i>Lonicera obovata</i> Royle ex Hk. f. & Thoms.	-	-	-	1.92	-
19	<i>Maytenus royleanus</i> (Wall. ex Lawson) Cuf.	-	-	-	4.63	-
20	<i>Myrsine africana</i> L.	7.34	8.9	6.62	4.28	-
21	<i>Parrotiopsis jacquemontiana</i> (Decne.) Rehder	-	-	-	25.51	16.11
22	<i>Phlomis spectabilis</i> Falc. ex Bth	-	-	-	1.93	3.26

23	<i>Ribes himalense</i> Dene.	-	-	-	-	4.05	-	-
24	<i>Ribes orientale</i> Desf.	-	-	-	-	-	4.54	-
25	<i>Ricinus communis</i> L.	-	-	11.63	-	-	-	-
26	<i>Rosa webbiana</i> Wall. ex Royle	-	-	-	3.51	1.96	1.55	-
27	<i>Rubus ellipticus</i> Smith	6.43	-	-	-	-	-	-
28	<i>Rubus fruticosus</i> L.	7.23	-	-	5.71	1.97	4.84	-
29	<i>Rubus ulmifolius</i> Schott	-	-	15.92	-	-	-	-
30	<i>Sageretia thea</i> (Osbeck) M.C. Johnston var. <i>thea</i>	4.52	-	-	-	-	3.08	-
31	<i>Sarcococca saligna</i> (D. Don) Muell.Arg.	-	-	8	19.01	-	3.2	-
32	<i>Skimmia laureola</i> (DC.) Sieb. & Zucc. ex Walp	-	-	-	-	2.88	2.87	-
33	<i>Spiraea canescens</i> D. Don	10.01	-	-	-	-	4.47	-
34	<i>Strobilanthes urticifolia</i> Wall. ex Kuntze	-	-	-	-	2.41	-	-
35	<i>Viburnum cotinifolium</i> D. Don	4.81	-	-	-	-	-	-
36	<i>Viburnum grandiflorum</i> Wall. ex DC.	-	-	-	-	13.08	-	-
	Herbs	ACH	AHP	CAB	CTC	CMR		
1	<i>Achillea millefolium</i> L.	-	1.09	-	-	-	-	-
2	<i>Achyranthes aspera</i> L. var. <i>pubescens</i> (Moq.) C.C. Townsend	-	-	-	0.42	-	-	-
3	<i>Agrimonia eupatoria</i> L.	-	-	-	-	-	0.42	-

4	<i>Agrostis viridis</i> Gouan	-	-	-	-	1.99	0.5
5	<i>Ajuga bracteosa</i> Wall. ex Bth.	-	-	-	-	1.08	-
6	<i>Ajuga parviflora</i> Bth.	-	-	-	-	-	0.74
7	<i>Amaranthus viridis</i> L.	-	-	1.69	-	1.03	-
8	<i>Ammi visnaga</i> (L.) Lam.	-	-	-	-	0.51	-
9	<i>Anagallis arvensis</i> L. var. <i>coerulea</i> (L.) Gouan.	-	-	-	1.31	0.42	0.63
10	<i>Angelica glauca</i> Edgew.	-	-	-	-	-	1.19
11	<i>Arthraxon prionodes</i> (Steud.) Dandy	3.61	-	-	-	-	-
12	<i>Apluda mutica</i> L.	14.57	9.81	12.47	-	1.85	0.54
13	<i>Arenaria serpyllifolia</i> L.	-	-	-	-	-	1.07
14	<i>Aristida cyanantha</i> Nees ex Steud.	-	-	-	-	-	3.12
15	<i>Artemisia absinthium</i> L.	-	-	-	-	2.36	-
16	<i>Artemisia scoparia</i> Waldst. & Kit.	-	5.19	-	-	-	-
17	<i>Artemisia vulgaris</i> L.	4.93	-	6.46	-	-	-
18	<i>Avena fatua</i> L.	-	-	3.53	-	3.58	-
19	<i>Bergenia ciliata</i> (Haw.) Sternb. var. <i>ciliata</i> Yeo	5.07	-	6.88	-	3.09	1.29
20	<i>Bistoria amplexicaulis</i> (D. Don) Green	2.54	-	-	-	0.93	-
21	<i>Brachiaria reptans</i> (L.) Gardner & Hubbard	-	-	-	-	-	0.42
22	<i>Brassica rapa</i> L. ssp. <i>Campestris</i>	-	2.09	-	-	-	-
23	<i>Buplerum falcatum</i> L.	2.2	-	2.03	-	-	-

24	<i>Bupleurum longicaule</i> Wall. ex DC. var. <i>ramosum</i> Nasir	-	-	-	-	0.98	-
25	<i>Calanthe tricarinata</i> Lindl.	-	-	-	-	-	0.5
26	<i>Caltha alba</i> Camb. var. <i>alba</i>	-	-	-	0.66	2.11	-
27	<i>Campanula pallida</i> Wall. var. <i>pallida</i>	-	-	1.79	-	-	-
28	<i>Cannabis sativa</i> L.	-	-	1.78	-	2.39	1.37
29	<i>Capsella bursa-pastoris</i> (L.) Medik.	-	-	1.67	-	1.67	1.44
30	<i>Cenchrus pennisetiformis</i> Hochst. & Steud. Ex Steud.	-	-	-	-	-	18.92
31	<i>Centaurea iberica</i> Trev. ex Spreng.	-	-	-	-	0.42	-
32	<i>Ceratocephala falcata</i> (L.) Pers.	-	-	-	-	-	0.42
33	<i>Chenopodium album</i> L.	-	-	2.83	-	0.84	-
34	<i>Chrysopogon fulvus</i> (Spreng.) Chiov.	-	-	-	-	10.89	-
35	<i>Chrysopogon serrulatus</i> Trin.	-	-	-	-	-	0.42
36	<i>Cichorium intybus</i> L.	1.32	-	-	1.12	0.88	-
37	<i>Clematis grata</i> Wall.	2.53	-	-	2.21	-	-
38	<i>Clinopodium umbrosum</i> (M. Bieb.) C. Koch.	3.68	-	-	-	0.55	-
39	<i>Colchicum luteum</i> Baker	-	-	1.94	-	1.37	1.07
40	<i>Convolvulus arvensis</i> L.	-	-	1.42	-	0.93	0.78
41	<i>Conyza Canadensis</i> (L.) Cronquist	-	-	1.02	-	0.93	-
42	<i>Cuscuta europaea</i> L.	1.39	-	-	0.42	-	-
43	<i>Cuscuta reflexa</i> Roxb.	-	-	0.87	-	-	-

44	<i>Cynodon dactylon</i> (L.) Pers.	13.35	-	13.97	8.64	3.4
45	<i>Dactylis glomerata</i> L.	-	-	-	0.42	0.42
46	<i>Datura innoxia</i> Mill.	-	1.63	-	-	-
47	<i>Dicanthium annulatum</i> (Forssk.) Stapf	-	-	-	0.46	-
48	<i>Dioscorea deltoidea</i> Wall. ex Kunth	-	-	-	0.46	-
49	<i>Eragrostis minor</i> Host	-	-	-	-	1.31
50	<i>Erodium ciconium</i> (L.) L' Herit ex Aiton	-	-	-	-	0.42
51	<i>Eryngium coeruleum</i> M-Bieb.	-	1.74	-	-	1.33
52	<i>Euphorbia helioscopia</i> L.	-	-	1.59	-	0.78
53	<i>Euphorbia peplus</i> L.	-	1.81	-	2.18	0.46
54	<i>Euphorbia prostrata</i> Ait.	2.75	-	1.44	0.79	-
55	<i>Foeniculum vulgare</i> Mill.	-	0.47	-	-	-
56	<i>Fragaria vesca</i> L.	5.82	-	6.74	0.42	-
57	<i>Fumaria indica</i> (Hausskn.) Pugsley	-	0.47	-	0.55	-
58	<i>Gagea elegans</i> Wall. ex Royle	-	-	-	0.42	-
59	<i>Galium aparine</i> L.	-	2.61	-	-	0.78
60	<i>Heliotropium strigosum</i> Willd. ssp. <i>brevifolium</i> (Wall.) Kazmi	-	-	-	-	0.74
61	<i>Heteropogon contortis</i> L.	6.64	8.34	-	-	-
62	<i>Hypericum oblongifolium</i> Choisy	-	-	0.23	-	-
63	<i>Hypericum perforatum</i> L.	-	-	0.42	0.88	-
64	<i>Iris germanica</i> L.	-	-	-	-	1.11

65	<i>Iris hookeriana</i> Foster	-	-	-	-	0.97	-
66	<i>Lactuca orientalis</i> Boiss.	-	-	-	-	0.46	-
67	<i>Lepidium apetalum</i> Willd.	-	-	-	-	-	1.03
68	<i>Lepidium sativum</i> L.	-	-	-	-	0.42	-
69	<i>Lolium temulentum</i> L.	-	-	-	-	1.3	-
70	<i>Notholirion thomsonianum</i> (Royle) Stapf	-	-	-	-	0.46	-
71	<i>Malva neglecta</i> Wall.	-	-	-	-	-	0.74
72	<i>Malvastrum coromandelianum</i> L.	-	-	-	0.42	0.42	1.24
73	<i>Medicago lupulina</i> L.	-	-	-	-	-	11.87
74	<i>Medicago minima</i> (L.) Grufb.	-	-	2.51	-	0.69	-
75	<i>Medicago polymorpha</i> L.	2.92	-	1.79	0.66	-	0.99
76	<i>Mentha longifolia</i> (L.) L.	-	-	2.34	-	-	-
77	<i>Micromeria biflora</i> (Buch-Ham.ex D. Don) Bth.	-	-	-	-	0.46	-
78	<i>Myosotis alpestris</i> F. W. Schmidt var. <i>albicans</i> (H. Riedl) Y. Nasir	-	-	-	-	-	0.46
79	<i>Narcissus tazetta</i> L.	-	-	2.56	3.16	1.12	0.78
80	<i>Oenanthе javanica</i> (Blume) DC.	-	-	-	-	0.42	-
81	<i>Onosma hispida</i> Wall. ex G. Don	-	-	-	-	0.42	-
82	<i>Origanum vulgare</i> L.	4.3	-	-	-	-	-
83	<i>Oxalis acetosella</i> L.	-	-	1.09	-	0.74	0.91
84	<i>Oxalis corniculata</i> L.	-	-	-	2.41	-	0.82

83	<i>Paeonia emodi</i> Wall. ex Royle	-	-	-	-	0.42	-
86	<i>Papaver dubium</i> L.	-	-	-	-	-	1.19
87	<i>Papaver somniferum</i> L.	-	-	0.97	-	-	-
88	<i>Pennisetum orientale</i> L.C. Rich.	1.96	-	2.62	-	-	-
89	<i>Phalaris minor</i> Retz.	-	-	6.54	-	2.13	-
90	<i>Plantago lanceolata</i> L.	-	-	0.42	-	1.3	1.81
91	<i>Plantago himalaica</i> Pilger	2.37	-	-	-	0.46	0.7
92	<i>Plantago major</i> L.	-	-	2.89	-	-	-
93	<i>Poa annua</i> L.	-	-	7.92	4.22	-	3.8
4	<i>Podophyllum emodi</i> Wall. ex Royle	-	-	-	-	-	1.66
95	<i>Portulaca oleracea</i> L.	-	-	-	-	-	0.7
96	<i>Pseudognaphalium affine</i> (D. Don.) Anderb.	-	-	-	-	-	0.46
97	<i>Ranunculus laetus</i> Wall. ex Hk. f. & Thoms.	-	-	1.44	-	-	-
98	<i>Ranunculus sceleratus</i> L.	-	-	-	-	-	0.78
99	<i>Rumex dentatus</i> L.	-	-	-	0.84	1.11	-
100	<i>Rumex hastatus</i> D. Don	2.45	-	-	4.63	1.68	8.97
101	<i>Salvia lanata</i> Roxb.	-	-	1.74	-	0.51	-
102	<i>Salvia moorcraftiana</i> Wall. Ex Bth.	3.32	-	-	2.43	3.04	-
103	<i>Sanguisorba minor</i> Scop.	-	-	-	-	0.42	-
104	<i>Saussurea albescens</i> (DC.) Sch. Bip.	3.92	-	-	4.11	0.51	-
105	<i>Saxifraga moorcroftiana</i> (Ser.) Sternb.	-	-	-	-	-	1.07
106	<i>Scandix pecten-veneris</i> L.	-	-	-	1.48	-	-

107	<i>Sedum hispanicum</i> L.	-	-	-	-	-	0.78
108	<i>Silene conoidea</i> L.	-	-	2.05	-	-	-
109	<i>Silene viscosa</i> (L.) Pers.	-	-	-	0.93	0.46	-
110	<i>Silene vulgaris</i> (Moench) Garcke	-	1.49	-	-	-	-
111	<i>Sisymbrium irio</i> L.	-	-	-	2.46	2.83	-
112	<i>Solanum nigrum</i> L. var. <i>nigrum</i>	-	1.42	0.7	0.88	1.98	-
113	<i>Solanum pseudocapricum</i> L.	-	-	0.66	-	-	-
114	<i>Solidago virga-aurea</i> L.	2.13	-	2.99	0.55	-	-
115	<i>Sonchus asper</i> (L.) Hill	2.62	-	3.03	0.93	0.42	-
116	<i>Stellaria media</i> (L.) Vill.	-	-	1.03	1.9	0.5	-
117	<i>Swertia ciliata</i> (G. Don) B. L. Burtt	3.54	0.99	-	-	-	-
118	<i>Swertia cordata</i> (G. Don) Clarke	-	-	-	0.97	-	-
119	<i>Taraxacum officinale</i> Wigg.	-	-	2.03	0.84	0.46	-
120	<i>Teucrium stocksianum</i> Boiss. var. <i>incanum</i> (Aitch. & Hemsley) Hedge & Lamon	-	2.81	-	-	-	-
121	<i>Themeda anathera</i> (Nees ex Steud.) Hack.	-	-	-	9.33	-	-
122	<i>Thymus linearis</i> Bth. ssp. <i>linearis</i> Jalas	-	-	-	0.55	-	-
123	<i>Tragopogon gracilis</i> D. Don	-	-	-	-	0.42	-
124	<i>Tribulus terrestris</i> L.	-	-	-	0.51	-	-
125	<i>Trigonella emodi</i> Bth.	-	-	-	-	0.46	-
126	<i>Tulipa stellata</i> Hk. f.	-	-	-	-	0.82	-
127	<i>Urtica dioica</i> L.	-	3.81	-	-	2.18	-

128	<i>Valeriana jatamansi</i> Jones	-	-	-	-	-	0.78
129	<i>Verbascum thapsus</i> L.	-	3.71	-	-	3.09	-
130	<i>Verbena officinalis</i> L.	-	-	-	-	-	0.78
131	<i>Vicia monantha</i> Retz.	-	-	1.33	-	0.42	0.42
132	<i>Viola canescens</i> Wall. ex Roxb.	-	0.92	-	-	-	-
133	<i>Withania somnifera</i> (L.) Dunal	-	-	-	-	-	0.74

Key to the abbreviations used in the table:

PDQ - Pinus-Diospyros-Quercus community
 ICJ - Indigofera-Cotoneaster-Jasminum community
 ACH - Apluda-Cynodon-Heteropogon community
 PQJ - Pinus-Quercus-Juglans community
 RIR - Rubus-Isodon-Ricinus community
 AHP - Apluda-Heteropogon-Poa community
 QAP - Quercus-Abies-Pinus community
 SDB - Sarcococca-Daphne-Berberis community
 CAB - Cynodon-Apluda-Bergenian community
 PPA - Picea-Pinus-Abies community
 PCI - Parrotiopsis-Cotoneaster-Indigofera community
 CMR - Cenchrus-Medicago-Rumex community
 CAP - Cedrus-Abies-Pinus community
 PVB - Parrotiopsis-Viburnum-Berberis community
 CTC - Chrysopogon-Thymus-Cynodon community

Table. 4.13 Maturity index

	Chail village	Chail valley floor	Shinku	Dabargai	Bishigram
Trees	48.57	34.28	44	28.88	27
Shrubs	31.66	23.07	27.27	16.31	20
Herbs	28.61	16.06	19.62	12.73	10.86
Mean	36.28	24.47	30.29	19.30	19.28

Table. 4.14 Similarity index of tree communities

PDQ	PQJ	QAP	CAP	PPA
X	X	X	X	X
16.09	X	X	X	X
10.56	11.96	X	X	X
10.62	12.61	16.42	X	X
10.54	11.09	16.04	18.11	X

Table. 4.15 Similarity index of shrubby communities

ICJ	RIR	SDB	PVB	PC1
X	X	X	X	X
6.71	X	X	X	X
10.45	10.36	X	X	X
7.07	6.95	11.81	X	X
5.31	5.17	9.73	14.6	X

Table 4.16 Similarity index of herbaceous communities

ACH	AHP	CAB	CTC	CMR
X	X	X	X	X
7.06	X	X	X	X
19.64	4.57	X	X	X
8.27	6.13	10.68	X	X
3.03	5.87	6.40	6.88	X

4.3.8 PC-Ord Analysis

4.3.8a Ward's cluster analysis for trees

Ward's cluster analysis classified the vegetation data of 33 tree species into three groups. Two-way cluster dendrogram showed these groups from five monitoring sites as well as presence-absence of tree species. These communities were established on the basis of quantitative values of tree species in different groups as described below:

Cluster I. *Pinus wallichiana*- *Diospyros lotus* community

This represented a single site i.e. Chail village with a total of seven tree species. *Pinus wallichiana* appeared to be the dominant tree species in this locality with mean IVI value of 25.40% followed by *Diospyros lotus* as co-dominant with mean value of 23.39%. *Quercus dilatata*, *Juglans regia*, *Ailanthus altissima* and *Ficus carica* with mean values 15.63%, 12.94%, 9.22% and 8.94% respectively were the others tree members of this community. Lowest IVI mean value of 4.49% was recorded for *Crataegus songarica* (Table. 4.17).

Results of edaphic variables and soil nutrient content showed that soil in this association is loamy with a pH of 5.2 which was found to be lowest in comparison to other monitoring sites. Organic matter content was 2.07% which was low as compared to the second association but higher than that of third association. Lime content was 2.5 % which was lower than other groups, while electrical conductivity ds/m was 0.043, which was lower than second group but higher than the third group. TDS value was recorded as 28 ppm which is lower than cluster II but higher than III. Sodium absorption ratio was 0.52 millieq/L, which was found to be highest among all clusters. Sulphate content was 516 µg/g which was lower than other groups. Nitrogen content (0.1035%) and phosphorous (470 µg/g) were also high to rest of the communities. Potassium (6398 µg/g) was low while aluminum (60326 µg/g) was higher than other groups. Other soil nutrients included barium was estimated as 150 µg/g, calcium 34448 µg/g, magnesium 22188 µg/g, sodium 13289 µg/g, sulphur 172 µg/g, titanium 1588 µg/g, vanadium 208 µg/g, chromium 94 µg/g and iron 46845 µg/g in this group. Cobalt (25.1 ppm), zinc (82 µg/g) and lead (65.4 ppm) were high as compared to cluster II but lower than III. Magnesium content was high while silver and cadmium were low. Nickel content was similar to

cluster II but lower than III however copper content was higher than cluster III but lower than II (Table. 4.18).

Cluster II. *Pinus wallichiana*- *Quercus baloot* community

This association made an isolated stand in Chail valley floor, comprising of a total of 14 trees. Species richness was higher in this stand as compared to cluster I. *Pinus wallichiana* in combination with *Quercus baloot* dominated this association. These tree species had mean IVI values of 18.07% and 15.53% respectively. Other important members of this community were *Juglans regia* (13.36 IVI), *Olea ferruginea* (8.43 IVI), *Salix denticulate* (6.66% IVI), *Ailanthus altissima* (6.42 % IVI), *Punica granatum* (5.91 IVI) and *Ficus carica* (4.24 IVI). *Populus alba*, *Prunus persica*, *Morus nigra*, *Malus pumila*, *Craegus songarica* and *Diospyros lotus* were the remaining components of this association (Table. 4.17).

Edaphic variables displayed a different picture from cluster I. Soil was found as silty-loam with an acidic reaction (pH 5.4). Organic matter content, lime content, electrical conductivity and sodium absorption ratio were 2.76 %, 7.5%, dsm^{-1} and 0.2 millieq/L respectively. Mean values of other soil nutrients i.e. sulphates (556 $\mu\text{g/g}$), nitrogen (0.138%), phosphorous (430 $\mu\text{g/g}$), potassium (10634 $\mu\text{g/g}$), aluminum (49339 $\mu\text{g/g}$), barium (107 $\mu\text{g/g}$), calcium (16722 $\mu\text{g/g}$), magnesium (15433 $\mu\text{g/g}$), sodium (9302 $\mu\text{g/g}$), sulphur (185 $\mu\text{g/g}$), titanium (1438 $\mu\text{g/g}$), vanadium (163 $\mu\text{g/g}$), chromium (81 $\mu\text{g/g}$) and iron (39143 $\mu\text{g/g}$). Similarly, cobalt content, manganese, nickel, copper, zinc, lead and silver respectively were 20.1 ppm, 722 $\mu\text{g/g}$, 51 ppm, 40 $\mu\text{g/g}$, 76 $\mu\text{g/g}$, 62.5 ppm, and 3.2 ppm while cadmium contents was just 1.1 $\mu\text{g/g}$ respectively (Table. 4.18).

Cluster III. *Abies pindrow*- *Pinus wallichiana* community

This association was established at Shanku, Dabargai and Bishigram area. *Abies pindrow* with an IVI mean value of 15.66 % appeared dominant followed by *Pinus wallichiana* with mean IVI value of 13.50 % as co-dominant. These were followed by *Cedrus deodara* (9.68 IVI), *Picea smithiana* (8.29 IVI), *Quercus incana* (7.13 IVI), *Juglans regia* (6.41 IVI), *Taxus fauana* (5.25 IVI) and *Ficus carica* (3.26 IVI). This cluster comprised of 28 tree including *Diospyros lotus*, *Olea ferruginea*, *Salix denticulata*, *Ailanthus altissima* and *Pyrus pyrolifolia* with IVI values ranging from 2.90 % to 2.19 %. Remaining species such as *Quercus dilatata*, *Celtis caucasica*, *Morus alba*,

Crataegus songarica, *Pyrus pashia*, *Quercus baloot*, *Diospyros kaki*, *Platanus orientalis*, *Acer cappadocicum*, *Pinus roxburghii*, *Cedrela serrata*, *Melia azedarach*, *Quercus semecarpifolia*, *Salix babylonica* and *Pistacia chinensis* having less mean values (Table. 4.17).

Soil was silt-loam with a pH value of 5.73. Organic content was 1.98 % which was lower than other clusters and lime content was 5.73 % which was lower than cluster II but higher than cluster III. Electrical conductivity of soil was 0.03 dsm^{-1} , which is lower than both of the earlier association while sodium absorption ratio was 0.21 millieq/L. Nutrient analyses displayed a different picture than the previous association where sulphates estimated as $535.67 \text{ } \mu\text{g/g}$ which was highest among all the associations. Nitrogen content was 0.10 % which is more or less similar to cluster I but lower than II. Phosphorous was found to be $451.33 \text{ } \mu\text{g/g}$. Other nutrients included aluminum ($54065.33 \text{ } \mu\text{g/g}$), barium ($206.33 \text{ } \mu\text{g/g}$), calcium ($25958.33 \text{ } \mu\text{g/g}$), magnesium ($18640.33 \text{ } \mu\text{g/g}$), sodium ($12447.33 \text{ } \mu\text{g/g}$), sulphur ($178.33 \text{ } \mu\text{g/g}$), titanium ($1555.67 \text{ } \mu\text{g/g}$), vanadium ($182.67 \text{ } \mu\text{g/g}$), chromium ($75.00 \text{ } \mu\text{g/g}$) and iron is ($40836.33 \text{ } \mu\text{g/g}$). The remaining nutrients estimated were cobalt, manganese, nickel, copper, zinc, lead, silver and cadmium (Table. 4.18).

Table. 4.17 Clusters of trees vegetation obtained through Wards cluster analysis

	I	II	III
Tree species	IVI	IVI	IVI
<i>Abies pindrow</i>	0	0	15.66
<i>Acer cappadocicum</i>	0	0	1.02
<i>Ailanthus altissima</i>	9.22	6.42	2.24
<i>Cedrela serrata</i>	0	0	0.97
<i>Cedrus deodara</i>	0	0	9.68
<i>Celtis caucasica</i>	0	0	1.71
<i>Crataegus songarica</i>	4.49	3.22	1.51
<i>Diospyros kaki</i>	0	0	1.22
<i>Diospyros lotus</i>	23.39	2.88	2.90
<i>Ficus carica</i> ssp. <i>carica</i>	8.94	4.24	3.26
<i>Juglans regia</i>	12.94	13.36	6.41
<i>Malus pumila</i>	0	3.54	0
<i>Melia azedarach</i>	0	0	0.97
<i>Morus alba</i>	0	0	1.61
<i>Morus nigra</i>	0	3.87	0
<i>Olea ferruginea</i>	0	8.43	2.80
<i>Picea smithiana</i>	0	0	8.29
<i>Pinus roxburghii</i>	0	0	1.02
<i>Pinus wallichiana</i>	25.40	18.07	13.50
<i>Pistacia chinensis</i> ssp. <i>Integerrima</i>	0	0	0.80
<i>Platanus orientalis</i>	0	0	1.20
<i>Populus alba</i>	0	3.94	0
<i>Prunus persica</i>	0	3.94	0
<i>Punica granatum</i>	0	5.91	0
<i>Pyrus pashia</i>	0	0	1.39
<i>Pyrus pyrolifolia</i>	0	0	2.19
<i>Quercus baloot</i>	0	15.53	1.29
<i>Quercus dilatata</i>	15.63	0	1.94
<i>Quercus incana</i>	0	0	7.13
<i>Quercus semecarpifolia</i>	0	0	0.92
<i>Salix babylonica</i>	0	0	0.82
<i>Salix denticulata</i>	0	6.66	2.27
<i>Taxus fauana</i>	0	0	5.25

Table. 4.18 Edaphic variables and soil nutrients associated with different associations of trees.

	I	II	III
Edaphic Variables			
	Mean	Mean	Mean
pH	5.2	5.4	5.73
% Organic matter	2.07	2.76	1.98
% CaCO ₃	2.5	7.5	5.17
ECdsm ⁻¹	0.043	0.08	0.03
TDS ppm	28	51	17.67
SAR millieq/L	0.52	0.2	0.21
Soil nutrients			
Sulphates µg/g	516	556	535.67
Nitrogen-N %	0.1035	0.138	0.10
Phosphorous µg/g	470	430	451.33
Potassium µg/g	6398	10634	8715.33
Aluminum µg/g	60326	49339	54065.33
Barium µg/g	150	107	206.33
Calcium µg/g	34448	16722	25958.33
Magnesium µg/g	22188	15433	18640.33
Sodium µg/g	13289	9302	12447.33
Sulphur µg/g	172	185	178.33
Titanium µg/g	1588	1438	1555.67
Vanadium µg/g	208	163	182.67
Chromium µg/g	94	81	75.00
Iron µg/g	46845	39143	40836.33
Cobalt ppm	25.1	20.1	29.73
Manganese µg/g	891	722	776.00
Nickel µg/g	51	51	52.00
Copper µg/g	37	40	32.00
Zinc µg/g	82	76	84.67
Lead ppm	65.4	62.5	72.40
Silver ppm	1.6	3.2	3.83
Cadmium ppm	0.65	1.1	0.73

4.3.8b Ward's Cluster Analysis for Understory Vegetation

Cluster analysis was done on the basis of IVI of the understory vegetation as well as edaphic attributes and soil nutrients. The Ward's cluster analysis split the IVI data for understory plants into four prominent groups in five monitoring sites. Two way cluster analysis showing vegetation groups as well as presence and absence of species in these monitoring sites is given in Table. 4.19.

Group I. *Cynodon dactylon* - *Apluda mutica* community

This community was established at Chail village and Shanku, comprising of 58 species including 42 herbs and 18 shrubs. *Cynodon dactylon* with an IVI mean value of 13.67 appeared to be dominated followed by *Apluda mutica* with an IVI score of 13.52. These were followed by *Daphne mucronata* (12.07 IVI), *Indigofera heterantha* (11.81 IVI), *Cotoneaster nummularia* (10.28 IVI) *Sarcococca saligna* (9.51 IVI), *Jasminum humile* (8.46 IVI), *Myrsine africana* (6.98 IVI), *Berberis lycium* (6.8 IVI) and *Rubus fruticosus* (6.47 IVI). Remaining contributors included *Fragaria vesica* (6.28 IVI), *Bergenia ciliata* (5.98 IVI), *Artemisia vulgaris* (5.7 IVI), *Elaeagnus umbellata* (5.13 IVI), *Spiraea canescens* (5.01 IVI), *Rhus semialata* (4.8 IVI), *Saussurea albescens* (4.02 IVI), *Rumex hystrix* (3.54 IVI), *Heteropogon contortus* (3.32 IVI), *Rubus ellipticus* (3.22 IVI) and *Buddleja crispa* (3.03 IVI). *Salvia moorcroftiana*, *Sonchus asper*, *Solidago virgaurea*, *Viburnum regosum*, *Clematis grata*, *Origanum vulgare*, *Bupleurum falcatum*, *Poa annua* and *Euphorbia prostrata* were the companion species with least values. This association also included *Clinopodium umbrosum*, *Anthrox prononoides*, *Medicago polymorpha*, *Avena fatua*, *Swertia paniculata*, *Rosa webbiana*, *Narcissus tazetta* and *Bistorta amplexicaulis* as scattered flora.

Soil texture supporting this association was loamy sand to silt loam. Soil reaction was acidic (pH 5.3) and soil pH was lowest among all the understory groups. The organic matter (1.725 %) of the soil is also low as to other groups while the lime content of this community is high than group II but lower than the soil of the remaining understory vegetation. Among the remaining three edaphic variables. The mean value of EC was 0.0345 dsm^{-1} and sodium absorption ratio was noted as 0.41 millieq/L, while TDS was 22.5 ppm (Table. 4.20). Among the soil nutrient contents the mean value of nitrogen was 0.08625 %, phosphorous 482 $\mu\text{g/g}$, potassium 7661.5 $\mu\text{g/g}$, aluminum 56129.5 $\mu\text{g/g}$.

barium 183.5 µg/g, calcium 29298 µg/g, magnesium 19622 µg/g, sodium 12680.5 µg/g, sulphur 161 µg/g, sulphates 483 µg/g, titanium 1648 µg/g, vanadium 199 µg/g, chromium 79 µg/g, iron 43717.5 µg/g, cobalt 30.85 ppm, manganese 848 µg/g, nickel 54 µg/g, copper 38.5 µg/g, zinc 89.5 µg/g, lead 65.05 ppm, silver 2.175 ppm and cadmium 0.45 ppm.

Group II: *Parrotiopsis jacquemontiana*-*Viburnum grandiflorum* community

This community included 85 species represented by 66 herbs and 19 shrubs. On the basis of IVI data, the leading members were *Parrotiopsis jacquemontiana*, *Viburnum grandiflorum* and *Berberis lyceum* with IVI mean values of 25.52, 13.09 and 12.26 respectively. These were followed by *Chrysopogon fulvus* (110.89 IVI), *Themeda anathera* (9.34 IVI) and *Cynodon dactylon* (8.65 IVI). The other associated shrub members were *Indigofera heterantha* (7.08 IVI), *Maytenus royleanus* (4.63 IVI), *Myrsine africana* (4.29 IVI), *Ribes himalense* (4.06 IVI), *Isodon rugosus* (3.86 IVI), *Jasminum humile* (3.46 IVI), *Skimmia laureola* (2.89 IVI), *Cotoneaster nummularia* (2.47 IVI), and *Strobilanthes urticifolia* (2.41 IVI). The remaining 52 species were herbaceous flora in which four species shared 3.59- 3.05 IVI, six had 2.46-2.12 while the IVI of twelve species was in the range of 1.99 to 1.04%. The remaining species of this community shared less than 1% IVI (Table 4.19).

Soil was loamy and soil reaction was acidic with pH 5.8. Organic matter was recorded as 2.8 % which was higher than group I but was lower than others. Lime content was estimated as 2.5 % at this site while sodium absorption ratio was found to be 0.13 millieq/L, which was lower than all other groups. Electrical conductivity was 0.03 dms⁻¹ and TDS was recorded as 20 ppm which was more than group III but lesser than remaining groups (Table. 4.20). Soil contained nitrogen (0.1104 %), phosphorous (385 µg/g), potassium (4162 µg/g), aluminum (60088 µg/g), barium (106 µg/g), calcium (39159 µg/g), magnesium (25127 µg/g) and sodium (16161 µg/g). The other 14 nutrient elements sulphur (165 µg/g) and sulphate content (496 µg/g) were greater than the mean values of the soil of association group I, but lower than groups III and group IV. The mean values of vanadium (217 µg/g), chromium (82 µg/g) and iron (46067 µg/g) in the soil were higher as compared to the soil of other groups while titanium (1465 µg/g) was sporadically distributed. Rest of the soil minerals showed manganese (815 µg/g) and

cobalt (30.15 ppm) which were less than cluster I but higher than the remaining associations. Similarly, Nickel (46 µg/g) and copper (27 µg/g) were found to be less concentrated as compared to other groups. The mean values of zinc, lead, silver and cadmium were 77 µg/g, 63.5 ppm, 3.65 ppm and 0.45 ppm respectively.

Group III: *Cenchrus pennisetiformis*-*Cotoneaster nummularia* community

This community was established at Bishigram and appeared to be second most diverse community, represented by 78 species in total including 18 shrubs and 60 herbaceous species. The leading species was *Cenchrus pennisetiformis* with IVI value of 18.93 followed by *Cotoneaster nummularia* with 14.82. These were followed by *Indigofera heterantha* (11.96 IVI), *Medicago lupulina* (11.88 IVI), *Rumex hystrix* (8.98 IVI), *Rubus fruticosus* (4.84 IVI), *Jasminum humile* (4.6 IVI), *Ribes orientale* (4.54 IVI), *Spiraea canescens* (4.48 IVI), *Berberis lycium* (3.95 IVI), *Poa annua* (3.81 IVI), *Isodon rugosus* (3.44 IVI), *Cynodon dactylon* (3.4 IVI), *Lespedeza juncea* (3.35 IVI), *Phlomis spectabilis* (3.27 IVI), *Andrachne cordifolia* (3.25 IVI), *Sarcococca saligna* (3.21 IVI), *Aristida cyanantha* (3.13 IVI) and *Sageretia thea* (3.09 IVI). The IVI of *Skimmia laureola*, *Sisymbrium irio*, and *Urtica dioica* ranged from 2.87 to 2.18%. The remaining members possessed either 2% or fewer IVI values as shown in Table. 4.19.

The soil texture was loamy with pH 6, showing mildly acidic nature. Organic matter was 2.76 % which was higher than the previous clusters but lower than IV. Lime content was 10 % which was higher than all other groups. Electrical conductivity was 0.023 dsm⁻¹ and TDS 16 ppm which were lower than other associations while sodium absorption ratio 0.21 millieq/L was lower than I, but higher than group II. Nitrogen concentration was 0.1242 %, phosphorous 475 µg/g, potassium 13059 µg/g, aluminum 50175 µg/g, barium 296 µg/g, calcium 14568 µg/g, magnesium 13738 µg/g, sodium 9109 µg/g, sulphur 220 µg/g and sulphates 661 µg/g. The other nutrients included titanium (1494 µg/g) which was lower than the soil of group I but higher than other groups while the mean value of vanadium was 141 µg/g, which appeared to be lower than the soil of other groups. The soil contained same amount of chromium (79 µg/g) to group I, but lower than the soil of other groups. Iron content (35852 µg/g) was lower than the soils of all other groups. Remaining nutrients included cobalt (22.45 ppm), manganese (708

µg/g), nickel (53 µg/g), copper (29 µg/g), zinc (80 µg/g), lead (89 ppm), silver (5.1 ppm) and cadmium (1.5 ppm).

Group IV: *Rubus ulmifolius*- *Isodon rugosus*-community

This relatively less diverse community was established at Chail valley floor, comprising of 52 species represented by 13 species of shrubs and 39 species of herb. *Rubus ulmifolius* with an IVI of 15.92 and *Isodon rugosus* with an IVI of 13.67 respectively dominated the community, followed by *Ricinus communis* having an IVI of 11.64. Other prominent members of this community included *Apluda mutica* (9.82 IVI), *Myrsine Africana* (8.91 IVI), *Heteropogon contortus* (8.34 IVI), *Sarcococca saligna* (8.01 IVI), *Poa annua* (7.93 IVI), *Indigofera heterantha* (7.31 IVI), *Jasminum officinale* (6.94 IVI), *Phalaris minor* (6.55 IVI), *Debregeasia salicifolia* (6.21 IVI), *Daphne mucronata* (5.49 IVI), *Artemesia scoparia* (5.19 IVI) and *Justicia adhatoda* (4.69 IVI) while the remaining species had less than 4 % mean IVI as displayed in Table. 4.19.

This association had a loamy sand soil with pH value of 5.4 showing an acidic nature. Organic matter was 2.76 % which was higher than the soils of other groups. Lime content was 7.5 % which was higher than soils of all other groups except group III. Electrical conductivity was 0.08 dsm⁻¹, TDS was 51 ppm while sodium absorption ratio was 0.2 millieq/L (Table. 4.20). Soil nutrient profile at this site was also diverse, nitrogen content was 0.138 % which was higher than other groups. Other nutrients included phosphorous (430 µg/g), potassium (10634 µg/g), aluminum (49339 µg/g), barium (107 µg/g), calcium (16722 µg/g), magnesium (15433 µg/g), sodium (9302 µg/g), sulphur (185 µg/g), sulphates (556 µg/g), titanium (1438 µg/g), vanadium (163 µg/g), chromium (81 µg/g), iron (39143 µg/g), cobalt (20.1 ppm), manganese (722 µg/g), nickel (51 µg/g), copper (40 µg/g), zinc (76 µg/g), lead (62.5 ppm), silver (3.2 ppm) and cadmium (1.1 ppm).

Table. 4.19 Associations of understory vegetation obtained through Wards cluster analysis

	I	II	III	IV
Herbs	IVI	IVI	IVI	IVI
<i>Achillea millefolium</i>	0	0	0	1.10
<i>Achyranthes aspera</i> var. <i>pubescens</i>	0	0.42	0	0
<i>Agrimonia eupatoria</i>	0	0	0.43	0
<i>Agrostis viridis</i>	0	1.99	0.51	0
<i>Ajuga bracteosa</i>	0	1.08	0	0
<i>Ajuga parviflora</i>	0	0	0.75	0
<i>Amaranthus viridis</i>	0	1.04	0	1.69
<i>Ammi visnaga</i>	0	0.51	0	0
<i>Anagallis arvensis</i> var. <i>coerulea</i>	0.66	0.42	0.63	0
<i>Angelica glauca</i>	0	0	1.20	0
<i>Arthraxon prionodes</i>	1.81	0	0	0
<i>Apluda mutica</i>	13.52	1.86	1.81	9.82
<i>Arenaria serpyllifolia</i>	0	0	1.08	0
<i>Aristida cyanantha</i>	0	0	3.13	0
<i>Artemisia absinthium</i>	0	2.37	0	0
<i>Artemisia scoparia</i>	0	0	0	5.19
<i>Artemisia vulgaris</i>	5.70	0	0	0
<i>Avena fatua</i>	1.77	3.59	0	0
<i>Bergenia ciliata</i> var. <i>ciliata</i>	5.98	3.09	1.29	0
<i>Bistorta amplexicaulis</i>	1.27	0.93	0	0
<i>Brachiaria reptans</i>	0	0	0.43	0
<i>Brassica rapa</i> ssp. <i>campestris</i>	0	0	0	2.09
<i>Bupleurum falcatum</i>	2.12	0	0	0
<i>Bupleurum longicaule</i> var. <i>ramosum</i>	0	0.99	0	0
<i>Calanthe tricarinata</i>	0	0	0.51	0
<i>Caltha alba</i> var. <i>alba</i>	0.33	2.12	0	0
<i>Campanula pallida</i> var. <i>pallida</i>	0	0	0	1.79
<i>Cannabis sativa</i>	0	2.39	1.37	1.78
<i>Capsella bursa-pastoris</i>	0	1.67	1.44	1.67
<i>Cenchrus pennisetiformis</i>	0	0	18.93	0
<i>Centaurea iberica</i>	0	0.42	0	0
<i>Ceratocephala falcata</i>	0	0	0.43	0
<i>Chenopodium album</i>	0	0.84	0	2.83
<i>Chrysopogon fulvus</i>	0	10.89	0	0
<i>Chrysopogon serrulatus</i>	0	0	0.43	0
<i>Cichorium intybus</i>	1.22	0.89	0	0

<i>Clematis grata</i>	2.37	0	0	0
<i>Clinopodium umbrosum</i>	1.84	0.56	0	0
<i>Colchicum luteum</i>	0	1.38	1.08	1.95
<i>Convolvulus arvensis</i>	0	0.93	0.79	1.42
<i>Conyza Canadensis</i>	0	0.93	0	1.02
<i>Cuscuta europaea</i>	0.91	0	0	0
<i>Cuscuta reflexa</i>	0	0	0	0.87
<i>Cynodon dactylon</i>	13.67	8.65	3.40	0
<i>Dactylis glomerata</i>	0	0.42	0.43	0
<i>Datura innoxia</i>	0	0	0	1.63
<i>Dicanthium annulatum</i>	0	0.47	0	0
<i>Dioscorea deltoidea</i>	0	0.47	0	0
<i>Eragrostis minor</i>	0	0	1.32	0
<i>Erodium ciconium</i>	0	0	0.43	0
<i>Eryngium coeruleum</i>	0	0	1.33	1.74
<i>Euphorbia helioscopia</i>	0.80	0	0.79	0
<i>Euphorbia peplus</i>	0	2.19	0.47	1.82
<i>Euphorbia prostrata</i>	2.10	0.79	0	0
<i>Foeniculum vulgare</i>	0	0	0	0.47
<i>Fragaria vesical</i>	6.28	0.42	0	0
<i>Fumaria indica</i>	0	0.56	0	0.47
<i>Gagea elegans</i>	0	0.42	0	0
<i>Galium aparine</i>	0	0	0.79	2.62
<i>Heliotropium strigosum ssp. brevifolium</i>	0	0	0.75	0
<i>Heteropogon contortus</i>	3.32	0	0	8.34
<i>Hypericum perforatum</i>	0.21	0.89	0	0
<i>Iris germanica</i>	0	0	1.12	0
<i>Iris hookeriana</i>	0	0.98	0	0
<i>Lactuca orientalis</i>	0	0.47	0	0
<i>Lepidium apetalum</i>	0	0	1.03	0
<i>Lepidium sativum</i>	0	0.42	0	0
<i>Lolium temulentum</i>	0	1.30	0	0
<i>Lonicera obovata</i>	0	0.47	0	0
<i>Malva neglecta</i>	0	0	0.75	0
<i>Malvastrum coromendelianum</i>	0	0.42	1.24	0
<i>Malvestrum coramendalianum</i>	0.21	0	0	0
<i>Medicago lupulina</i>	0	0	11.88	0
<i>Medicago minima</i>	0	0.70	0	2.52
<i>Medicago polymorpha</i>	1.79	0	0.99	1.79

<i>Mentha longifolia</i>	0	0	0	2.34
<i>Micromeria biflora</i>	0	0.47	0	0
<i>Myosotis alpestris</i>	0	0	0.47	0
<i>Narcissus tazetta</i>	1.58	1.13	0.79	2.57
<i>Notholirion thomsonianum</i>	0	0.47	0	0
<i>Oenanthe javanica</i>	0	0.42	0	0
<i>Onosma hispida</i>	0	0.42	0	0
<i>Origanum vulgare</i>	2.15	0	0	0
<i>Oxalis acetosella</i>	0	0.74	0.91	1.10
<i>Oxalis corniculata</i>	1.21	0	0.83	0
<i>Paeonia emodi</i>	0	0.42	0	0
<i>Papaver dubium</i>	0	0	1.20	0
<i>Papaver somniferum</i>	0	0	0	0.97
<i>Pennisetum orientale</i>	0.98	0	0	2.62
<i>Phalaris minor</i>	0	2.14	0	6.55
<i>Plantago himalayica</i>	1.19	0	0	0
<i>Plantago lanceolata</i>	0.21	1.31	0	0
<i>Plantago major</i>	0	0	0	2.89
<i>Poa annua</i>	2.11	0	3.81	7.93
<i>Podophyllum emodi</i>	0	0	1.66	0
<i>Portulaca oleracea</i>	0	0	0.71	0
<i>Pseudognaphalium affine</i>	0	0	0.47	0
<i>Ranunculus laetus</i>	0	0	0	1.45
<i>Ranunculus sceleratus</i>	0	0	0.79	0
<i>Rumex dentatus</i>	0.42	1.12	0	0
<i>Rumex hestatus</i>	3.54	1.68	8.98	0
<i>Salvia lanata</i>	0	0.51	0	1.74
<i>Salvia moorcroftiana</i>	2.88	3.05	0	0
<i>Sanguisorba minor</i>	0	0.42	0	0
<i>Saussurea albescens</i>	4.02	0.51	0	0
<i>Saxifraga moorcroftiana</i>	0	0	1.08	0
<i>Scandix pecten-veneris</i>	0.74	0	0	0
<i>Sedum hispanicum</i>	0	0	0.79	0
<i>Silene conoidea</i>	1.03	0	0	0
<i>Silene viscosa</i>	0	0.93	0.47	0
<i>Silene vulgaris</i>	0	0	0	1.50
<i>Sisymbrium irio</i>	0	2.46	2.83	0
<i>Solanum nigrum</i> var. <i>nigrum</i>	0.35	0.89	1.99	1.42
<i>Solanum pseudocapicum</i>	0.33	0	0	0

<i>Solidago virga-aurea</i>	2.57	0.56	0	0
<i>Sonchus asper</i>	2.83	0.93	0.43	0
<i>Stellaria media</i>	0.52	1.91	0.51	0
<i>Swertia ciliata</i>	0	0	0	1.00
<i>Swertia cordata</i>	0	0.98	0	0
<i>Swertia paniculata</i>	1.77	0	0	0
<i>Taraxacum officinale</i>	1.02	0.84	0.47	0
<i>Teucrium stocksianum</i>	0	0	0	2.82
<i>Themeda anathera</i>	0	9.34	0	0
<i>Thymus linearis ssp. linearis</i>	0	0.56	0	0
<i>Tragopogon gracilis</i>	0	0	0.43	0
<i>Tribulus terrestris</i>	0	0.51	0	0
<i>Trigonella emodi</i>	0	0	0.47	0
<i>Tulipa stellate</i>	0	0	0.83	0
<i>Urtica dioica</i>	0	0	2.18	3.81
<i>Valeriana jatamansi</i>	0	0	0.79	0
<i>Verbascum thapsus</i>	0	3.09	0	3.71
<i>Verbena officinalis</i>	0	0	0.79	0
<i>Vicia monantha</i>	0.67	0.42	0.43	0
<i>Viola canescens</i>	0	0	0	0.93
<i>Withania somnifera</i>	0	0	0.75	0
Shrubs				
<i>Andrachne cordifolia</i>	0	2.10	3.25	0
<i>Berberis lycium</i>	6.80	12.26	3.95	3.68
<i>Buddleja crispa</i>	3.03	0	0	0
<i>Cotoneaster nummularia</i>	10.28	2.47	14.82	0
<i>Daphne mucronata</i>	12.07	1.97	1.87	5.49
<i>Debregeasia salicifolia</i>	0	0	0	6.21
<i>Elaeagnus umbellata</i>	5.13	0	1.92	0
<i>Himalrandia tetrasperma</i>	0	0	1.89	0
<i>Indigofera heterantha var. gerardiana</i>	11.81	7.08	0	7.31
<i>Indigofera heterantha var. heterantha</i>	0	2.10	11.96	0
<i>Isodon rugosus</i>	0	3.86	3.44	13.67
<i>Jasminum humile</i>	8.46	3.46	4.60	0
<i>Jasminum officinale</i>	0	0	0	6.94
<i>Justicia adhatoda</i>	0	0	0	4.69
<i>Lespedeza juncea var. juncea</i>	0	0	3.35	3.90
<i>Lonicera asperifolia</i>	0	0	0	3.63
<i>Lonicera obovata</i>	0	1.92	0	0

<i>Maytenus royleanus</i>	0	4.63	0	0
<i>Myrsine africana</i>	6.98	4.29	0	8.91
<i>Parrotiopsis jacquemontiana</i>	0	25.52	0	0
<i>Phlomis spectabilis</i>	0	1.94	3.27	0
<i>Rhus semialata</i>	4.80	0	0	0
<i>Ribes himalense</i>	0	4.06	0	0
<i>Ribes orientale</i>	0	0	4.54	0
<i>Ricinus communis</i>	0	0	0	11.64
<i>Rosa webbiana</i>	1.76	1.97	1.55	0
<i>Rubus ellipticus</i>	3.22	0	0	0
<i>Rubus fruticosus</i>	6.47	1.98	4.84	0
<i>Rubus ulmifolius</i>	0	0	0	15.92
<i>Sageretia thea</i> var. <i>thea</i>	2.26	0	3.09	0
<i>Sarcococca saligna</i>	9.51	0	3.21	8.01
<i>Skimmia laureola</i>	0	2.89	2.87	0
<i>Spiraea canescens</i>	0	0	4.48	0
<i>Strobilanthes urticifolia</i>	0	2.41	0	0
<i>Viburnum grandiflorum</i>	0	13.09	0	0
<i>Viburnum regosum</i>	2.41	0	0	0

Table. 4.20 Edaphic Variables and soil nutrients associated with groups of understory vegetation

	I	II	III	IV
Edaphic variables				
Parameters	Mean	Mean	Mean	Mean
pH	5.3	5.8	6	5.4
% Organic matter	1.725	2.08	2.48	2.76
% Lime (CaCO ₃)	2.75	2.5	10	7.5
EC 1:5 ms/cm	0.0345	0.03	0.023	0.08
TDS ppm	22.5	20	16	51
SAR millieq/L	0.41	0.13	0.21	0.2
Soil nutrients				
Nitrogen-N %	0.08625	0.1104	0.1242	0.138
Phosphorous µg/g	482	385	475	430
Potassium µg/g	7661.5	4162	13059	10634
Aluminum µg/g	56129.5	60088	50175	49339
Barium µg/g	183.5	106	296	107
Calcium µg/g	29298	39159	14568	16722
Magnesium µg/g	19622	25127	13738	15433
Sodium µg/g	12680.5	16161	9109	9302
Sulphur µg/g	161	165	220	185
Sulphates µg/g	483	496	661	556
Titanium µg/g	1648	1465	1494	1438
Vanadium µg/g	199	217	141	163
Chromium µg/g	79	82	79	81
Iron µg/g	43717.5	46067	35852	39143
Cobalt ppm	30.85	30.15	22.45	20.1
Manganese µg/g	848	815	708	722
Nickel µg/g	54	46	53	51
Copper µg/g	38.5	27	29	40
Zinc µg/g	89.5	77	80	76
Lead ppm	65.05	63.5	89	62.5
Silver ppm	2.175	3.65	5.1	3.2
Cadmium ppm	0.45	0.45	1.5	1.1

4.3.9a Principle Component Analysis for Trees

Principal component analysis of trees is shown in Figures 6, 7 and 8 representing Axis 1-2, 1-3 and 2-3 of PCA ordination plane using the IVI data of trees and associated 29 parameters of edaphic variables and nutrients elements of the studied sites. The groups obtained through Ward's Cluster analysis are superimposed on the PCA ordination axis 1-2, 1-3 and 2-3. In the Plane of PCA ordination axis 1-2 group 1, of trees species is situated almost in the middle, while group 2 (Chail valley floor) is situated in the right corner. Group 3 of trees species which comprises of three stands is situated in the left corner. The two stands of this group (Shinko and Dabargai) are situated in the lower left corner near axis 1 while Bishigram site is located in the upper left corner of axis 2. The rotation of the stand between axis 1-3 is anti-clockwise in which group 1 is located in the lower middle portion of axis 1(right side), group 2 at the left upper corner between axis 1-3, while group 3 is located in the upper portion of axis 3 (right corner). The ordination plan of axis 2-3 of PCA shows that the rotation of stands is irregular. Group 1 is located at axis two in lower mid portion, Group 2, in the upper middle portion, while the stands of group 3 are parallel to axis 1(two stands toward axis 3, and one in the right side between the two axis (1-3).

Correlation of PCA Ordination Axis of trees vegetation with edaphic variables and soil nutrients

Table 4.21 shows the correlation of edaphic parameters and soil nutrients with PCA Ordination Axis of trees vegetation data. The results reveal that among the edaphic parameters only EC and TDS are found in significant relation with Axis 1 of PCA ordination ($P < 0.01$), pH is found in significant correlation with Axis 3 ($P < 0.01$), % Lime (CaCO_3) is significantly correlated with Axis 2 at the given probability level, ($P < 0.05$). Among the soil nutrients Potassium, Sodium, Vanadium and Lead are found in significant correlation with PCA Axis 2 at $P < 0.05$. Sulphur, Sulphates and Cadmium are also significantly correlated with Axis 2 at a probability level ($P < 0.01$). Similarly, only Copper is found in significant correlation with Axis 3.

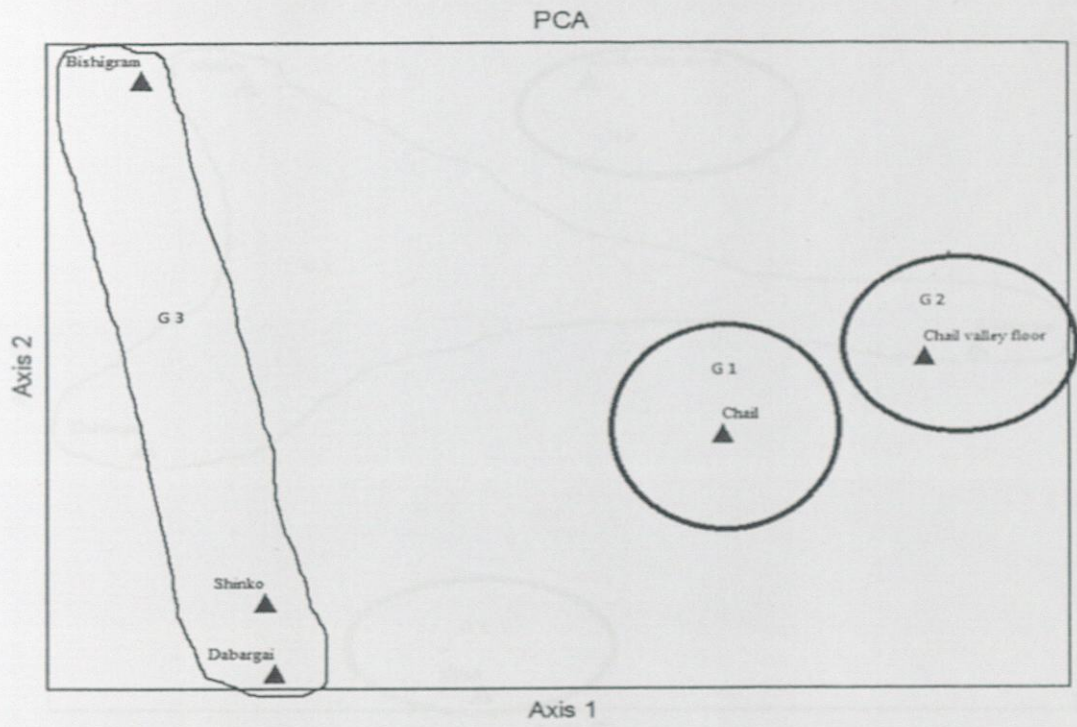


Fig: 6. PCA ordination Axis 1, 2 of stands of tree species in relation to edaphic variables and nutrients

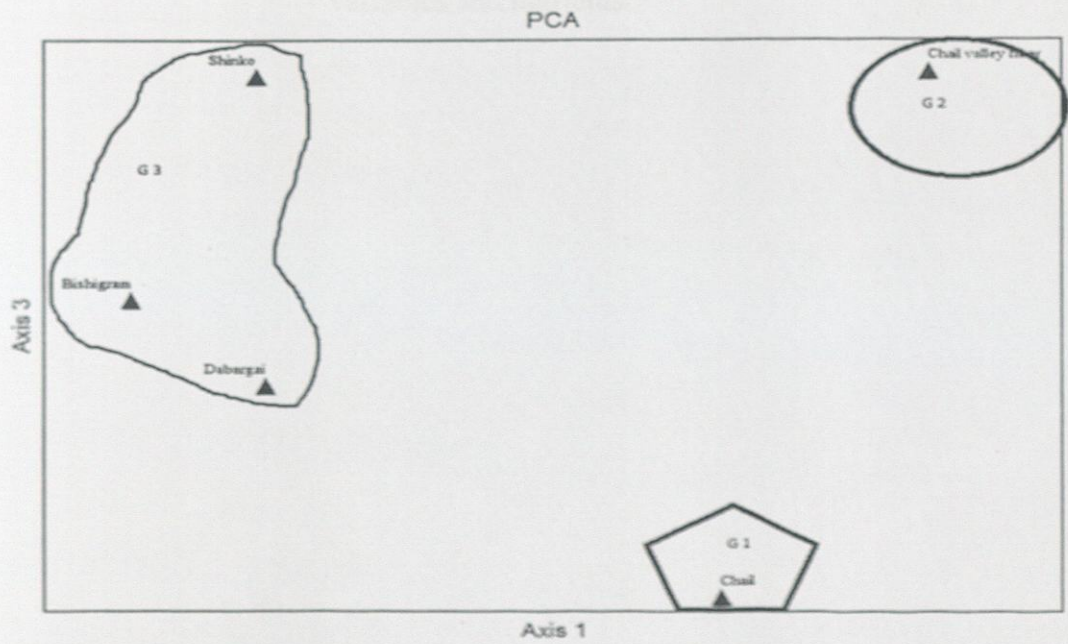


Fig: 7. PCA ordination Axis 1, 3 of stands of tree species in relation to edaphic variables and nutrients

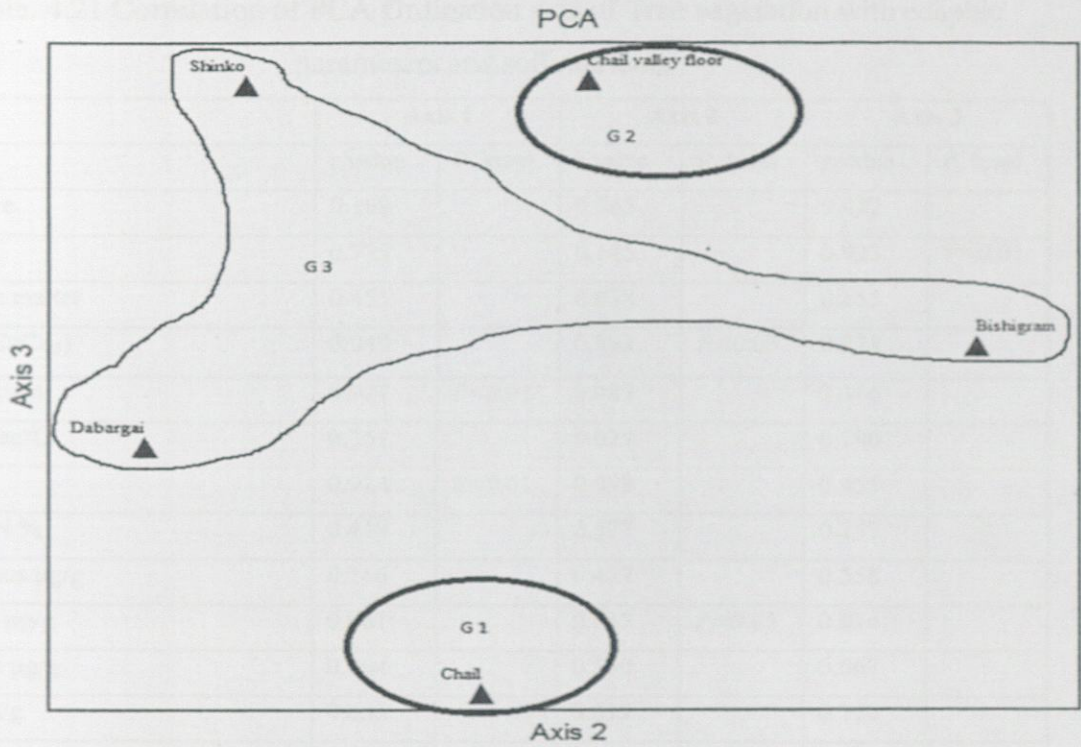


Fig: 8. PCA ordination Axis 2, 3 of stands of tree species in relation to edaphic variables and nutrients

Table. 4.21 Correlation of PCA Ordination axis of Tree vegetation with edaphic parameters and soil nutrients

Parameter	Axis 1		Axis 2		Axis 3	
	r value	P. level	r value	P. level	r value	P. level
Soil texture	0.109		0.765		0.472	
pH	0.723		0.145		0.923	$P<0.01$
% Organic matter	0.455		0.638		0.155	
% Lime (CaCO_3)	0.049		0.893	$P<0.05$	0.228	
EC 1:5 ms/cm	0.927	$P<0.01$	0.083		0.466	
SAR millieq/L	0.351		0.029		0.790	
TDS ppm	0.924	$P<0.01$	0.098		0.455	
Nitrogen-N %	0.419		0.577		0.237	
Phosphorous $\mu\text{g/g}$	0.146		0.477		0.558	
Potassium $\mu\text{g/g}$	0.061		0.837	$P<0.05$	0.074	
Aluminum $\mu\text{g/g}$	0.004		0.550		0.067	
Barium $\mu\text{g/g}$	0.655		0.619		0.150	
Calcium $\mu\text{g/g}$	0.037		0.748		0.105	
Magnesium $\mu\text{g/g}$	0.016		0.727		0.162	
Sodium $\mu\text{g/g}$	0.197		0.812	$P<0.05$	0.260	
Sulphur $\mu\text{g/g}$	0.106		0.940	$P<0.01$	0.315	
Sulphates $\mu\text{g/g}$	0.106		0.939	$P<0.01$	0.319	
Titanium $\mu\text{g/g}$	0.262		0.331		0.489	
Vanadium $\mu\text{g/g}$	0.068		0.867	$P<0.05$	0.076	
Chromium $\mu\text{g/g}$	0.497		0.208		0.139	
Iron $\mu\text{g/g}$	0.225		0.706		0.144	
Cobalt ppm	0.528		0.737		0.051	
Manganese $\mu\text{g/g}$	0.132		0.600		0.382	
Nickel $\mu\text{g/g}$	0.167		0.163		0.494	
Copper $\mu\text{g/g}$	0.630		0.111		0.904	$P<0.05$
Zinc $\mu\text{g/g}$	0.362		0.317		0.364	
Lead ppm	0.557		0.822	$P<0.05$	0.406	
Silver ppm	0.588		0.524		0.791	
Cadmium ppm	0.073		0.946	$P<0.01$	0.189	

4.3.9b Principle Component Analysis for understory vegetation

The PCA ordination of understory vegetation is represented in Figures 9 and 10. As shown in the figures, four groups of understory vegetation obtained through Ward's Cluster analysis were superimposed on the PCA ordination axis 1-2, 1-3 and 2-3. In the Plane of PCA ordination axis 1, 2 of understory vegetation groups 1 (Chail and Shinko) is located in the left side upper corner of Axis 2, while group 2 and group 4 are located in the lower left side of Axis 1 toward Axis 2. Group 3 is separated toward the right side, so there is no overlapping among the stands and the rotation in the ordination plane is seems to be almost anti-clockwise. As shown in figure 10 the rotation of stands between Axis 1, Axis 3 is anti-clockwise. The stands are located in the corners of Axis 1 and Axis 3. Same is the case for PCA ordination Axis 2, 3 but stand 4 is located in the upper corner toward axis 3 (left side) of ordination plane.

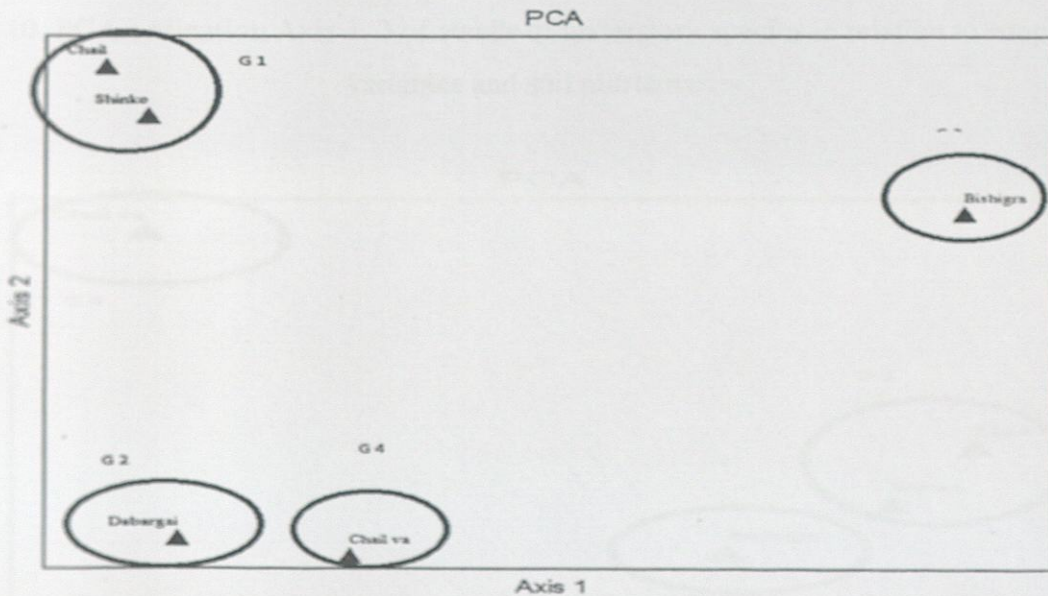


Fig. 9. PCA ordination Axis 1, 2 of stands of understory species in relation to edaphic variables and soil nutrients

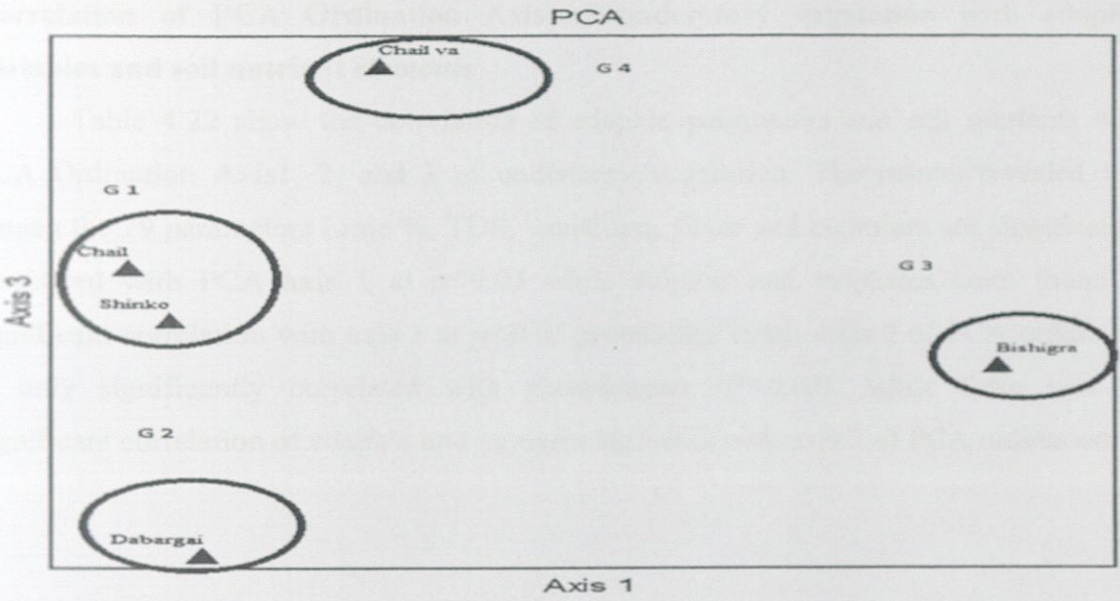


Fig. 10. PCA ordination Axis 1, 3 of stands of understory species in relation to edaphic variables and soil nutrients

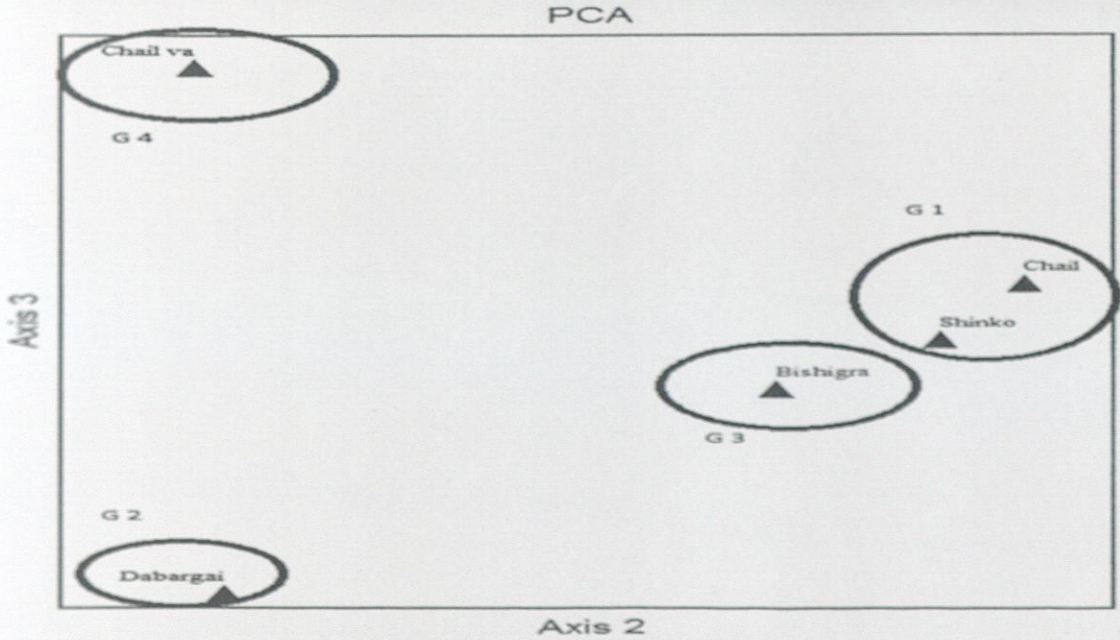


Fig: 11. PCA ordination Axis 2, 3 of stands of understory species in relation to edaphic variables and soil nutrients

Correlation of PCA Ordination Axis of understory vegetation with edaphic variables and soil nutrient elements

Table 4.22 show the correlation of edaphic parameters and soil nutrients with PCA Ordination Axis1, 2, and 3 of understory vegetation. The results revealed that among the 29 parameters Lime %, TDS, vanadium, silver and cadmium are significantly correlated with PCA axis 1 at $p<0.05$ while sulphur and sulphates were found in significant correlation with axis 1 at $p<0.05$ probability level. Axis 2 of PCA ordination is only significantly correlated with phosphorous ($P<0.05$), while there was no significant correlation of edaphic and nutrients elements with axis 3 of PCA ordination.

Table. 4.22 Correlation of PCA ordination Axis 1, 2 and 3 of understory vegetation with edaphic variables and soil nutrients

Parameters	Axis 1		Axis 2		Axis 3	
	r value	P. level	r value	P. level	r value	P. level
Soil texture	0.46		0.71		0.40	
pH	0.75		0.30		0.59	
% Organic matter	0.53		0.56		0.41	
% Lime (CaCO ₃)	0.92	<i>P<0.05</i>	0.17		0.35	
EC 1:5 ms/cm	0.20		0.51		0.81	
TDS ppm	0.18	<i>P<0.05</i>	0.52		0.81	
SAR millieq/L	0.37		0.78		0.29	
Nitrogen-N %	0.50		0.62		0.33	
Phosphorous µg/g	0.20		0.87	<i>P<0.05</i>	0.33	
Potassium µg/g	0.80		0.14		0.51	
Aluminum µg/g	0.59		0.10		0.56	
Barium µg/g	0.72		0.61		0.13	
Calcium µg/g	0.71		0.01		0.59	
Magnesium µg/g	0.68		0.14		0.57	
Sodium µg/g	0.67		0.09		0.71	
Sulphur µg/g	0.93	<i>P<0.01</i>	0.07		0.14	
Sulphates µg/g	0.93	<i>P<0.01</i>	0.07		0.14	
Titanium µg/g	0.39		0.80		0.04	
Vanadium µg/g	0.87	<i>P<0.05</i>	0.02		0.44	
Chromium µg/g	0.07		0.05		0.07	
Iron µg/g	0.81		0.02		0.35	
Cobalt ppm	0.51		0.32		0.51	
Manganese µg/g	0.77		0.44		0.27	
Nickel µg/g	0.15		0.66		0.38	
Copper µg/g	0.43		0.26		0.81	
Zinc µg/g	0.28		0.67		0.04	
Lead ppm	0.94	<i>P<0.01</i>	0.29		0.18	
Silver ppm	0.86	<i>P<0.05</i>	0.33		0.31	
Cadmium ppm	0.88	<i>P<0.05</i>	0.15		0.33	

4.3.10 NMS Ordination of understory vegetation

The NMS ordination of understory vegetation is represented in Figure. 12. The four groups of understory vegetation obtained through Ward's Cluster analysis were also superimposed on the NMS ordination Axis. In the Plane of NMS ordination axis 1-2 of understory vegetation group 1 is located in the middle to left side upper corner, while group 2 is placed in the right side lower portion between the two Axis of NMS. Group 3 is separated toward the right side upper corner of the ordination plane. Group 4 is overlapping on axis 1 in the left corner of the plane.

Correlation of NMS Ordination Axis of understory vegetation with edaphic variables and soils

The results of correlation of NMS ordination Axis 1, Axis 2 of understory vegetation with edaphic factors and soil nutrient elements revealed that only two parameters were found in significant correlation with NMS ordination Axis 1. These parameters are pH and Copper $\mu\text{g/g}$ soil. Between these parameters the correlation of soil pH is significant at $P < 0.01$ probability level while Copper was found in significant correlation with Axis 1 at probability level, $P < 0.01$. The result also shows that none of the parameter was found in significant correlation with NMS ordination Axis 2 of understory vegetation (Table. 4.23).

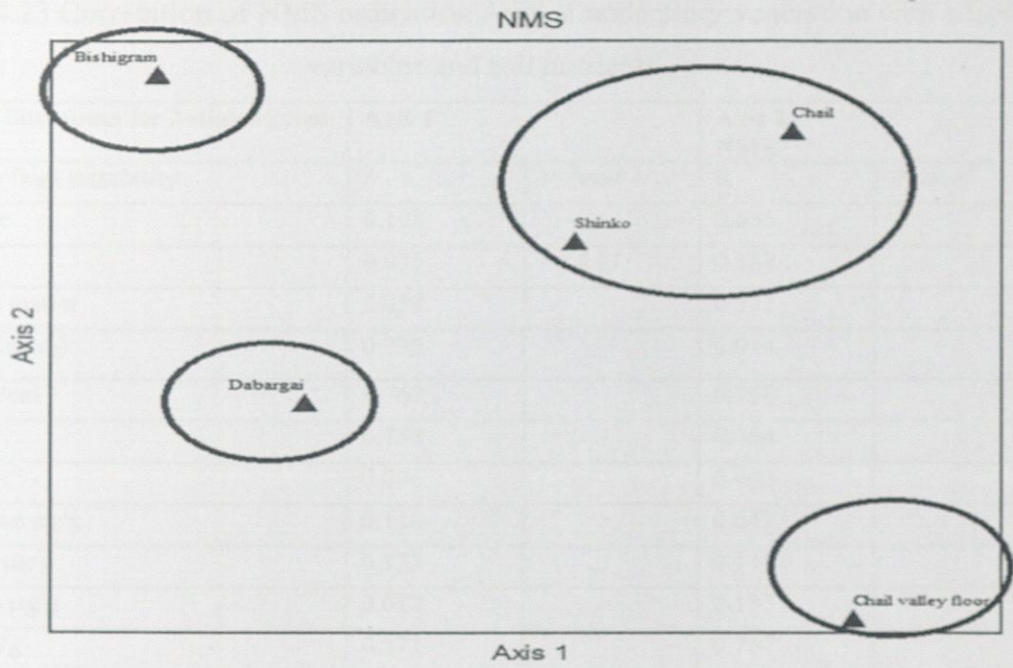


Fig: 12. NMS ordination plot of understory species in relation to edaphic variables and soil nutrients

Table.4.23 Correlation of NMS ordination Axis of understory vegetation with edaphic variables and soil nutrients

0.00000 = final stress for 2-dimensional solution	Axis 1		Axis 2 NMS	
0.10574 = final instability	r	P. level	R	P. level
Soil texture	0.108		0.665	
pH	0.935	$P < 0.01$	0.189	
% Organic matter	0.056		0.375	
% Lime (CaCO_3)	0.295		0.014	
EC 1:5 ms/cm	0.767		0.768	
TDS ppm	0.757		0.764	
Nitrogen-N %	0.006		0.404	
Phosphorous $\mu\text{g/g}$	0.116		0.642	
Potassium $\mu\text{g/g}$	0.133		0.149	
Aluminum $\mu\text{g/g}$	0.013		0.195	
Barium $\mu\text{g/g}$	0.572		0.757	
Calcium $\mu\text{g/g}$	0.031		0.037	
Magnesium $\mu\text{g/g}$	0.030		0.058	
Sodium $\mu\text{g/g}$	0.112		0.001	
Sulphur $\mu\text{g/g}$	0.415		0.251	
Sulphates $\mu\text{g/g}$	0.416		0.247	
SAR millieq/L	0.536		0.504	
Titanium $\mu\text{g/g}$	0.159		0.493	
Vanadium $\mu\text{g/g}$	0.217		0.071	
Chromium $\mu\text{g/g}$	0.247		0.071	
Iron $\mu\text{g/g}$	0.293		0.036	
Cobalt ppm	0.166		0.189	
Manganese $\mu\text{g/g}$	0.332		0.283	
Nickel $\mu\text{g/g}$	0.132		0.371	
Copper $\mu\text{g/g}$	0.859	$P < 0.05$	0.269	
Zinc $\mu\text{g/g}$	0.057		0.380	
Lead ppm	0.696		0.633	
Silver ppm	0.808		0.073	
Cadmium ppm	0.241		0.090	

Correlation among edaphic and mineral parameters

Highly significant positive correlation (0.99) was found between TDS and EC. Organic matter showed positive significant correlation (0.99) with nitrogen. Significant positive correlation (0.98) was observed between calcium and potassium levels. Calcium exhibited negative significant correlation (0.96) with aluminum. Magnesium exhibited significant positive correlation (0.98) with potassium. Magnesium also showed significant positive correlation (0.95) with calcium. Significant negative correlation (0.97) was found between sodium and potassium. Sodium showed positive significant correlation (0.99) with sulphates. There was significant negative correlation (0.94) between titanium and nitrogen. Vanadium showed negative significant correlation (0.99) with potassium. Iron revealed significant positive correlation with aluminum, calcium, magnesium and vanadium. Significant positive correlation was observed between nickel and phosphorous. Zinc revealed significant negative correlation with TDS. Cadmium showed significant positive correlation (0.98) with sodium and sulphur Table. 4.24.

Major part of Chail valley lies in moist temperate region of the country. The vegetation of the valley was classified using Multivariate techniques i.e. Ward's cluster analysis and Ordination (Ward, 1963). Multivariate analysis is exceedingly useful in exposing the underlying group structure in vegetation data (Khan, 2012; Awan *et al.*, 2001). This method is also considered to be valuable for the investigation of relationship among the distribution of vegetation in relation to properties of the soil (Beals, 1984; Gauch *et al.*, 1981; Green, 1974; Li *et al.*, 2008; McCune and Grace, 2002). In the present study the IVI of 33 trees species of five different sites was subjected to PC-Ord software (Version 5.10) for Cluster Analysis which resulted in the formation of three vegetation groups. Similarly, the understory vegetation was also classified through Ward's cluster Analysis. Based on the IVI mean values, Cluster Analysis separated the understory vegetation into four communities. Our results are in agreement with Khan *et al.* (2012) who also reported three vegetation groups at 75% remaining information of the species from District Upper Dir. Phytosociology of forest and non-forest vegetation communities of Chitral, Hindukush range, was reported to have 19 plant communities including 10 of trees and nine communities of understory vegetation. Ahmed *et al.* (2011) while using Cluster analysis and ordination for the analysis of *Cedrus* dominated forests

of Hindu Kush and Himalayan ranges of Pakistan reported six vegetation associations. Sher *et al.* (2013) reported the Phytosociology of summer vegetation of Sodan Galli Hills, Azad Kashmir, and reported thirteen communities. Ilyas *et al.* (2015) reported nine communities using multivariate approach for the analysis of vegetation of Tehsil Kabal, Swat (Pakistan). Similarly, Nafeesa (2007) conducted research on the phytosociological attribute of vegetation communities of Pir Chinasi hills of Azad Jammu and Kashmir and reported 13 plants communities. In the present study a total of 29 parameters of edaphic and soil nutrients elements were also studied in order to know the effect of edaphic factors and nutrient elements on the composition and distribution of vegetation communities. The results revealed that among the communities, *Pinus wallichiana* was dominant in group I and group II while in group III it was found as second dominant species with *Apies pindrow*. The mean IVI of this species is 25.4 while co-dominant species was *Diospyros lotus* with an IVI value of 23.39. The other tree species found in this community were *Quercus dilatata* (15.63 IVI), *Juglans regia* (12.94 IVI) *Ailanthus altissima* (9.22 IVI), *Ficus carica* (8.94 IVI) and *Crataegus songarica* (4.49 IVI). Akbar *et al.* (2011) reported *Pinus wallichiana*- *Juniperus excels* and *Pinus wallichiana* -*Picea smithiana* communities in the form of monospecific stand from dry temperate area of Gilgit Baltistan. Similarly, Ahmed *et al.* (2006) reported *Pinus wallichiana* and *Betula utilis* community from Rama Astore as well as in the form of mono-specific stand from Nalter Gilgit. *Pinus wallichiana* community was also reported from moist temperate area by Siddiqui *et al.* (2013). *Pinus wallichiana* was also reported by Khan *et al.* (2012) in dominant form with other trees species in dry temperate area of Chitral. The above finding shows that *Pinus wallichiana* can form community with other species as well as grow in the form of pure forest while the presence of this species in dry temperate and moist temperate area indicate its wide range of ecological amplitude as reported by Nafeesa, 2007; Siddiqui *et al.* 2013 and Sher *et al.* 2013. The co-dominant species of this community was *Diospyros lotus*. The number of trees species of this community was low as compared to the other communities. As *Juglans regia* is not only an important fruit yielding species but is also severely exploited by the local inhabitant for its valuable wood for making furniture (Khan, 2012). Our findings are also supported by Cierjack and Hensen (2003) and Nafeesa (2007), who stated that besides the difference in

environmental conditions, topography and soil's anthropogenic disturbances, such as deforestation, over grazing up to a great extent might be the cause of the removal of trees species. The soil characteristics in group I (Chail valley) showed that the soil was loamy sand with low pH, CaCO_3 , SO_4 , Ag, Cd, K and S contents of soil, while high SAR, N_2 , P, Mg, Mn, Na, Al, Ti, V, Fe, Ca and Cr contents.

In group 2 (Chail Valley floor) a total of 14 trees species were found. This community was also dominated by *Pinus wallichiana*. (18.07 IVI). The co-dominant specie of this community was *Quercus baloot* (15.53 IVI). Similar results are reported by Ilyas *et al.* (2015) when they studied the vegetation of Kabal Valley. They reported *Pinus wallichiana* and *Quercus incana* community in which the IVI mean value of *Pinus wallichiana* was recorded as 36.2, they also reported some of the other species of this community with different IVI mean values. The difference in IVI is due to the difference in soil properties, environmental factors, and micro climatic condition which are also reported by other workers such as Khan *et al.*, 2016. Similarly, Ahmed *et al.* (2011) and Siddiqui *et al.* (2011) documented the vegetation of Himalayan moist temperate and Hindukush ranges have reported *Pinus wallichiana* having 56-81% IVI. They also reported *Juglans regia*, *Diospyros lotus*, *Ficus carica*, *Olea ferruginea*, *Salix denticulate*, *Punica granatum*, *Populus alba*, *Prunus persica*, *Morus nigra*, *Malus pumila*, and *Crataegus songarica* from these regions. Among the recorded species of this community the vegetation structure and regeneration dynamics of *Olea ferruginea* is reported by Khan *et al.* (2015) from Hindu-Kush range of Pakistan and the phytosociology of *Quercus baloot* is reported by Khan *et al.*, (2010) from Chitral. The unique characteristics of edaphic variables and nutrients elements shows that the soil of Chail Valley Floor (Group 2) is silt loam with low contents of Ba, Ca, Mg, Na, Ti, V, Fe, Co, P, Al, Mn, Zn in soil, while the quantity of organic matter, TDS, SO_4 , N_2 , K, S, Cr, Cd, and Cu of the soil were high as compared to other groups. Similar findings are reported by Wahab *et al.* (2011) who recorded *Pinus wallichiana* community with 51% mean IVI and the associated spices *Cedrus deodara* and *Abies pindrow* possessed 25% and 10.3% mean IVI. They found high amount of calcium, magnesium, manganese and cobalt in soil of their their study.

In group 3, out of 28 trees species the first dominant species was *Abies pindrow* with a mean IVI of 15.66 followed by *Pinus wallichiana* (13.50). *Abies pindrow* was also reported by Hussain *et al.* (2010) from Central Karakoram National Park while Duthie (1893) observed this species from Nalter, Gilgit-Baltistan, Ahmed *et al.* (2006) reported this species from Rama Astore with 87% mean IVI with *Pinus wallichiana* and *Betula utilis* in an association. Similarly, *Abies pindrow* was also reported by Siddiqui *et al.* (2010), Ahmed *et al.* (2011) in the range of 44.25% to 58.8% mean IVI from moist temperate forests of Himalayan. Ilyas *et al.* (2015) while working on the vegetation of Kabal Valley also reported *Abies Pindrow* as a dominant species with *Picea smithiana*. *Abies pindrow* is also reported by Khan *et al.* (2012) with 25% IVI from dry temperate area of Chitral as a second dominant species in *Pinus wallichiana* community. The difference in IVI is because of the different climatic conditions, soil and difference in anthropogenic pressure. Our findings are also supported by Ali *et al.* (2015) who stated that *Abies pindrow*, *Pinus wallichiana* and *Picea smithiana* show good association with each other and prefer high elevations and are affected in almost equal manner by abiotic and biotic pressure. Other associated species of this community are *Cedrus deodara*, *Picea smithiana*, *Quercus incana*, *Juglans regia*, *Taxus fauana*, *Ficus carica*, *Diospyros lotus*, *Olea ferruginea*, *Salix denticulata*, *Alnus altissima*, *Pyrus pyrolifolia*, *Q. dilatata*, *Celtis caucasica*, *Morus alba*, *Crataegus songarica*, *P. pashia*, *Q. baloot*, *D. kaki*, *Platanus orientalis*, *Acer cappadocicum*, *Pinus roxburghii*, *Cedrela serrata*, *Melia azedarach*, *Q. semecarpifolia*, *S. babylonica* and *Pistacia chinensis*. Some of the above species are also reported by other workers such as Khan *et al.* 2012; Amjad *et al.* 2013; Ali *et al.*, 2015; Ilyas *et al.* 2015 and Khan *et al.* 2015. Similarly, in the soil associated with group 3 of trees species, the amount of Organic matter, EC, TDS, N₂ and Cr soil was low while pH, Ba, Co, Ni, Cu, Zn, Pb and Ag contents of the soil were high in comparison to the soils of other groups of tree communities. The difference in the species composition as well as IVI means values in different groups are due to the difference in soil properties as well as nutrients contents found in different monitoring sites. Our results are supported by work of Badshah *et al.* (2010a); Eni *et al.* (2012) and Ilyas *et al.* (2015).

Wards cluster analysis separated the data of understory vegetation into four distinct groups. Khan *et al.* (2012) reported 9 communities were of understory vegetation from Chitral. Akbar *et al.* (2011) reported six groups of understory vegetation from Gilgit, Astore and Skardu Districts. They also studied the effect of edaphic factors and soil micro and macro nutrients on the distribution of understory vegetation.

Our results show that out of 173 species of understory vegetation only five species including three herbs i.e. *Apluda mutica*, *Narcissus tazetta* and *Solanum nigrum* while two shrubs i.e. *Berberis lycium*, *Daphne mucronata* were found in all the study sites though their IVI mean values were different in each community. The presence of these plants in all communities was due to their wide range of ecological amplitude. Out of 58 species of understory vegetation the dominant species of group I was *Cynodon dactylon* (13.67 IVI) followed by *Apluda mutica*, *Daphne mucronata* and *Indigofera heterantha*. Edaphic variables and nutrient analysis shows that EC, pH, organic matter, N₂, S, SO₄ and Ag were low while SAR, P, Ti, Mn, Ni, Zn and Co were high.

Group II is more diverse and comprised of 85 species including 66 herbs and 19 shrubs species. The dominant and codominant species of this community are *Parrotiopsis jacquemontiana* and *Viburnum grandiflorum* with IVI mean values 25.52 and 13.09 respectively. This community was composed of 85 species of which 30 species were unique to this community only. Similarly, the edaphic characteristics and nutrients elements contents of the soil of this community showed that the soil was loamy with low SAR. The levels of CaCO₃, P, K, Ni and Cu were also low while the Al, Ca, Mg, Na, V, Cr and Iron contents were high as compared to the soil of other understory vegetation.

Group III was the second most diverse group having 78 species with 18 shrubs and 60 herbaceous members, in which the first dominant species was *Cenchrus pennisetiformis* with 18.9 mean IVI followed by *Cotoneaster nummularia* with 14.82 mean IVI. These two dominants were followed by *Indigofera heterantha* (11.96 IVI), *Medicago lupulina* (11.88 IVI) and *Rumex hastatus* (8.98 IVI). Among the remaining understory members, 34 species belonging to this community are not found in other groups. The characteristics of the soil associated with this community shows that the soil EC was lower than the soil of other groups. Similarly, the amount of Ca, Mg, Na, V, Cr,

Fe, Mn and TDS contents were low while CaCO_3 , K, Ba, S, SO_4 , Pb, Ag and Cd soil were high as compared to the soil associated with other communities.

The Group IV was less diverse, representing the understory vegetation of Chail valley floor in which a total of 52 species were recorded of which 13 were shrubs and 39 herbs. Dominant species in this group was *Rubus ulmifolius* with 15.92 mean IVI followed by *Isodon rugosus* with 13.67 mean IVI and *Ricinus communis* with 11.64 mean IVI. The soil associated with group IV showed low levels of Al, Ba, Ti, Zn, Pb and Co in the soil while high levels of N_2 , Cu and TDS. Similarly, this group contains 18 characteristics species which were unique to this group. *Isodon rugosus* was also reported by Ilyas *et al.* (2015) as dominant member in two associations at high altitude with *Berberis* and *Indigofera* in loamy sand soil which is an agreement with our findings. The slight variation in soil properties and mean values of nutrients elements is due to the difference in altitude, slope angle and aspect of the soil. Hanson and Churchill (1965) and Ilyas *et al.* (2015) reported that the floristic composition of species and their spatial distribution is determined by climatic condition, soil properties and composition, topography and biotic factors. These factors interact with each other and bring changes of different degrees resulting in the formation of micro-grades. Nafeesa *et al.* (2007); Sakya and Bania (1998) stated that elevation is the most important factor for the determination of vegetation type and the floristic composition of communities. Bakkenes *et al.* (2002) stated that the characteristics of soil can affect the distribution of vegetation on a very small scale. Our findings are also supported by work of Amjad *et al.* (2013) who stated that soil's physical and chemical properties, topography, slope, aspect and altitude play major role in the distribution and establishment of different communities.

The IVI mean values of trees species as well as understory vegetation were also analyzed by PC-Ord software for ordination. PCA was used for trees species while NMS and PCA were applied for the ordination of understory vegetation. The groups obtained through Ward's cluster analysis of trees species as well as understory vegetation were also superimposed on the PCA and NMS ordination axis. Present study is in line with the work of Akbar *et al.* (2011), who used cluster analysis for classification and PCA, CCA, and DCA for ordination of trees species as well as understory vegetation. Similar techniques were used by Ilyas *et al.* (2015); Khan *et al.* (2012) and Greig-Smith (1983) in

their studies. The soil and nutrients associated with different vegetation groups of trees species and understory vegetation were correlated with PCA and NMS ordination axis in order to elaborate the factors which have an effect on the distribution of these species. Among the edaphic factors, only EC and TDS were found in significant relation with Axis 1 of PCA ordination of tree species ($P < 0.01$), pH was significantly correlated with Axis 3 ($P < 0.01$) CaCO_3 were significantly correlated with Axis 2 ($P < 0.05$). Among the soil nutrients K, Na, V and Pb were found in significant correlation with PCA Axis 2 at $P < 0.05$. S, SO_4 and Cd were also significantly correlated with Axis 2 at a probability level ($P < 0.01$). Only Cu was found in significant correlation with Axis 3. The results of correlation of PCA ordination Axis 1, 2, 3 revealed that among the 29 edaphic parameters, CaCO_3 , TDS, V, Ag and Cd were significantly correlated with PCA axis 1 at $p < 0.05$ while S and SO_4 were found in significant correlation with axis 1 at $p < 0.05$ probability level. Axis 2 of PCA ordination was only significantly correlated with P ($P < 0.05$), while there was no significant correlation of edaphic and nutrients elements with PCA Axis 3. Similarly, the results of correlation of NMS ordination Axis 1, 2 of understory vegetation with edaphic factors and soil nutrient elements revealed that only pH and Cu were found in significant correlation with Axis 1 at $P < 0.01$ probability level while, none of the other parameters were found in significant correlation with Axis 2 of NMS ordination. Similar study was conducted by Khan *et al.* (2012), and they found no significant correlation of DCA ordination Axes with edaphic and environmental variables. McCune and Grace (2002); Hill and Gauch (1980) reported that ordination gives at least one basic gradient linked with distribution of communities. However, our findings are not in agreement with them because significant correlation of more than one factors with PCA and NMS ordination was observed. So the distribution of vegetation communities is the combined outcome of edaphic characters as well as the nutrient elements, which were found in significant correlation with PCA and NMS ordination of trees as well as understory vegetation. Our results are strongly supported by findings of Akbar *et al.* (2011) who found significant correlation of PCA axis 1 with N2, Mg, Zn, Fe and Mn, of trees vegetation data while for understory they found significant correlation of PCA axis 1, 2 with pH and EC with axis 1, TDS with axis 1, 3, Ca, Mg and Fe with Axis 1. P and Co with Axis 3 and Axis 2 while, Mn in strong significant correlation with

Axis1. They also found significant correlation of soil salinity of trees vegetation with DCA axis 1, K with axis 2, 3. Soil pH of understory vegetation was found in significant correlation with DCA axis 1, 3 and Fe with axis 3. Our results of NMS ordination are supported by Oswalt *et al.* (2006). They used Ward cluster and NMS ordination for the exploration of vegetation environmental relationship and found significant correlation of NMS ordination Axis 1, 2 with different edaphic and environmental variables. The results of cross correlation of edaphic variables and nutrients contents show that among the 29 parameters, positive significant correlation was found between TDS and EC, Organic matter and N₂, Ca and K, while negative significant correlation was found between Ca and Al, Mg and K, Mg and Ca. Na was found in negative significant correlation with K, while in positive significant correlation with SO₄. Negative significant correlation was observed between Ti and N₂, V showed negative significant correlation with K while, Fe was found in significant positive correlation with Al, Ca, Mg and V. Significant positive correlation was observed between Ni and P. Zn revealed significant negative correlation with TDS. Cd showed significant positive correlation (0.98) with Na and S. Our results are supported by Zhang & Zhang, (2011) who reported positive significant relation of soil organic matter with elevation, N₂, P and reported that the degradation of organic matter, as both Nitrogen and phosphorus comes from the same source. Our findings are also in agreement with work of Khan *et al.* (2012) who found positive significant relation between altitude and K, K and Na, soil moisture with N₂.

pH	Ca	Mg	K	Na	Cl	Fe	Cu	Mn	Zn	Al	Ba	Ti	V	Cr	Ni	Pb	Ag	Cd
0.2	1																	
0.3	0.2	1																
0.4	0.3	0.2	1															
0.5	0.4	0.3	0.2	1														
0.6	0.5	0.4	0.3	0.2	1													
0.7	0.6	0.5	0.4	0.3	0.2	1												
0.8	0.7	0.6	0.5	0.4	0.3	0.2	1											
0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	1										
1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	1									
1.1	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.9	1								
1.2	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.8	0.9	0.8	1							
1.3	0.6	0.5	0.4	0.3	0.2	0.1	0.7	0.7	0.8	0.7	0.6	1						
1.4	0.5	0.4	0.3	0.2	0.1	0.6	0.6	0.6	0.7	0.6	0.5	0.4	1					
1.5	0.4	0.3	0.2	0.1	0.5	0.5	0.5	0.5	0.6	0.5	0.4	0.3	0.2	1				
1.6	0.3	0.2	0.1	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.2	0.1	0.9	1			
1.7	0.2	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.1	0.8	0.8	0.7	1		
1.8	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.1	0.7	0.7	0.7	0.6	0.5	1	
1.9	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.6	0.6	0.6	0.5	0.4	0.3	1
2.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	-0.1	0.4	0.4	0.4	0.3	0.2	0.1	-0.1
2.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	-0.2	-0.2	0.3	0.3	0.3	0.2	0.1	-0.2	-0.2
2.2	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.0	-0.3	-0.3	0.2	0.2	0.2	0.1	0.0	-0.3	-0.3
2.3	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.1	-0.4	-0.4	0.1	0.1	0.1	0.0	-0.4	-0.4	-0.4
2.4	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	0.2	-0.5	-0.5	0.2	0.2	0.2	0.1	-0.5	-0.5	-0.5
2.5	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	0.3	-0.6	-0.6	0.3	0.3	0.3	0.2	-0.6	-0.6	-0.6
2.6	-0.7	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	0.4	-0.7	-0.7	0.4	0.4	0.4	0.3	-0.7	-0.7	-0.7
2.7	-0.8	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	0.5	-0.8	-0.8	0.5	0.5	0.5	0.4	-0.8	-0.8	-0.8
2.8	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	0.6	-0.9	-0.9	0.6	0.6	0.6	0.5	-0.9	-0.9	-0.9
2.9	-1.0	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	0.7	-1.0	-1.0	0.7	0.7	0.7	0.6	-1.0	-1.0	-1.0
3.0	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	0.8	-1.1	-1.1	0.8	0.8	0.8	0.7	-1.1	-1.1	-1.1
3.1	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	0.9	-1.2	-1.2	0.9	0.9	0.9	0.8	-1.2	-1.2	-1.2
3.2	-1.3	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	1.0	-1.3	-1.3	1.0	1.0	1.0	0.9	-1.3	-1.3	-1.3
3.3	-1.4	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	1.1	-1.4	-1.4	1.1	1.1	1.1	1.0	-1.4	-1.4	-1.4
3.4	-1.5	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	1.2	-1.5	-1.5	1.2	1.2	1.2	1.1	-1.5	-1.5	-1.5
3.5	-1.6	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	1.3	-1.6	-1.6	1.3	1.3	1.3	1.2	-1.6	-1.6	-1.6
3.6	-1.7	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	1.4	-1.7	-1.7	1.4	1.4	1.4	1.3	-1.7	-1.7	-1.7
3.7	-1.8	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	1.5	-1.8	-1.8	1.5	1.5	1.5	1.4	-1.8	-1.8	-1.8
3.8	-1.9	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	1.6	-1.9	-1.9	1.6	1.6	1.6	1.5	-1.9	-1.9	-1.9
3.9	-2.0	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	-1.9	1.7	-2.0	-2.0	1.7	1.7	1.7	1.6	-2.0	-2.0	-2.0
4.0	-2.1	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	1.8	-2.1	-2.1	1.8	1.8	1.8	1.7	-2.1	-2.1	-2.1
4.1	-2.2	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	1.9	-2.2	-2.2	1.9	1.9	1.9	1.8	-2.2	-2.2	-2.2
4.2	-2.3	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	2.0	-2.3	-2.3	2.0	2.0	2.0	1.9	-2.3	-2.3	-2.3
4.3	-2.4	-2.3	-2.3	-2.3	-2.3	-2.3	-2.3	-2.3	2.1	-2.4	-2.4	2.1	2.1	2.1	2.0	-2.4	-2.4	-2.4
4.4	-2.5	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	2.2	-2.5	-2.5	2.2	2.2	2.2	2.1	-2.5	-2.5	-2.5
4.5	-2.6	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	2.3	-2.6	-2.6	2.3	2.3	2.3	2.2	-2.6	-2.6	-2.6
4.6	-2.7	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	2.4	-2.7	-2.7	2.4	2.4	2.4	2.3	-2.7	-2.7	-2.7
4.7	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	2.5	-2.8	-2.8	2.5	2.5	2.5	2.4	-2.8	-2.8	-2.8
4.8	-2.9	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8	2.6	-2.9	-2.9	2.6	2.6	2.6	2.5	-2.9	-2.9	-2.9
4.9	-3.0	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	2.7	-3.0	-3.0	2.7	2.7	2.7	2.6	-3.0	-3.0	-3.0
5.0	-3.1	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	2.8	-3.1	-3.1	2.8	2.8	2.8	2.7	-3.1	-3.1	-3.1
5.1	-3.2	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	2.9	-3.2	-3.2	2.9	2.9	2.9	2.8	-3.2	-3.2	-3.2
5.2	-3.3	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2	-3.2	3.0	-3.3	-3.3	3.0	3.0	3.0	2.9	-3.3	-3.3	-3.3
5.3	-3.4	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3	3.1	-3.4	-3.4	3.1	3.1	3.1	3.0	-3.4	-3.4	-3.4
5.4	-3.5	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4	3.2	-3.5	-3.5	3.2	3.2	3.2	3.1	-3.5	-3.5	-3.5
5.5	-3.6	-3.5	-3.5	-3.5	-3.5	-3.5	-3.5	-3.5	3.3	-3.6	-3.6	3.3	3.3	3.3	3.2	-3.6	-3.6	-3.6
5.6	-3.7	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6	3.4	-3.7	-3.7	3.4	3.4	3.4	3.3	-3.7	-3.7	-3.7
5.7	-3.8	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	3.5	-3.8	-3.8	3.5	3.5	3.5	3.4	-3.8	-3.8	-3.8
5.8	-3.9	-3.8	-3.8	-3.8	-3.8	-3.8	-3.8	-3.8	3.6	-3.9	-3.9	3.6	3.6	3.6	3.5	-3.9	-3.9	-3.9
5.9	-4.0	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	3.7	-4.0	-4.0	3.7	3.7	3.7	3.6	-4.0	-4.0	-4.0
6.0	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	3.8	-4.1	-4.1	3.8	3.8	3.8	3.7	-4.1	-4.1	-4.1
6.1	-4.2	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	3.9	-4.2	-4.2	3.9	3.9	3.9	3.8	-4.2	-4.2	-4.2
6.2	-4.3	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	4.0	-4.3	-4.3	4.0	4.0	4.0	3.9	-4.3	-4.3	-4.3
6.3	-4.4	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	4.1	-4.4	-4.4	4.1	4.1	4.1	4.0	-4.4	-4.4	-4.4
6.4	-4.5	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	4.2	-4.5	-4.5	4.2	4.2	4.2	4.1	-4.5	-4.5	-4.5
6.5	-4.6	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5	4.3	-4.6	-4.6	4.3	4.3	4.3	4.2	-4.6	-4.6	-4.6
6.6	-4.7	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	-4.6	4.4	-4.7	-4.7	4.4	4.4	4.4	4.3	-4.7	-4.7	-4.7
6.7	-4.8	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7	-4.7	4.5	-4.8	-4.8	4.5	4.5	4.5	4.4	-4.8	-4.8	-4.8
6.8	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	4.6	-4.9	-4.9	4.6	4.6	4.6	4.5	-4.9	-4.9	-4.9
6.9	-5.0	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	4.7	-5.0	-5.0	4.7	4.7	4.7	4.6	-5.0	-5.0	-5.0
7.0	-5.1	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	4.8	-5.1	-5.1	4.8	4.8	4.8	4.7	-5.1	-5.1	-5.1
7.1	-5.2	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	4.9	-5.2	-5.2	4.9	4.9	4.9	4.8	-5.2	-5.2	-5.2
7.2	-5.3	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	5.0	-5.3	-5.3	5.0	5.0	5.0	4.9	-5.3	-5.3	-5.3
7.3	-5.4	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	-5.3	5.1	-5.4	-5.4	5.1	5.1	5.1	5.0	-5.4	-5.4	-5.4
7.4	-5.5	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	-5.4	5.2	-5.5	-5.5	5.2	5.2	5.2	5.1	-5.5	-5.5	-5.5
7.5	-5.6	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5	5.3	-5.6	-5.6	5.3	5.3	5.3	5.2	-5.6	-5.6	-5.6
7.6	-5.7	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	5.4	-5.7	-5.7	5.4	5.4	5.4	5.3	-5.7	-5.7	-5.7
7.7	-5.8	-5.7	-5.7	-5.7	-5.7	-5.7	-5.7	-5.7	5.5	-5.8	-5.8	5.5	5.5	5.5	5.4	-5.8	-5.8	-5.8
7.8	-5.9	-5.8	-5.8	-5.8	-5.8	-5.8	-5.8	-5.8	5.6	-5.9	-5.9	5.6	5.6	5.6	5.5	-5.9	-5.9	-5.9
7.9	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9	5.7	-6.0	-6.0	5.7	5.7	5.7	5.6	-6.0	-6.0	-6.0
8.0	-6.1	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	5.8	-6.1	-6.1	5.8	5.8	5.8	5.7	-6.1	-6.1	-6.1
8.1	-6.2	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	5.9	-6.2	-6.2	5.9	5.9	5.9	5.8	-6.2	-6.2	-6.2
8.2	-6.3	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	6.0	-6.3	-6.3	6.0	6.0	6.0	5.9	-6.3	-6.3	-6.3
8.3	-6.4	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	6.1	-6.4	-6.4	6.1	6.1	6.1	6.0	-6.4	-6.4	-6.4
8.4	-6.5	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4	6.2	-6.5	-6.5	6.2	6.2	6.2				

ETHNOBOTANY AND CONSERVATION STATUS OF MEDICINAL PLANTS

4.4 Ethnobotany and conservation status of medicinal plants

The relationship of man and medicinal plants is as old as the history of mankind. Prehistoric man acquired the knowledge about medicinal values of plants on trial and error basis, and such knowledge descended in generations to come making the very core of the subject of ethnobotany. Oldest records on medicinal plants date back to time of famous Greek botanist, Theophrastus. Most of the botanists of the early ages were herbalists and even the primitive taxonomic schemes were inspired by knowledge of medicinal plants. It is estimated that about 10% of all the known plants have some medicinal uses (Shinwari, 2010). Rig Veda is the oldest document with descriptions of diseases and their cure from plants, which was compiled from 4500 to 1600 BC. Ayurvedic, Greek and Arab system of medicine all have benefited from the local knowledge of medicinal plants. Although ethnobotanical research in Pakistan is mostly in documentation phase, yet there are plenty of references on ethnobotanical studies. Ajaib *et al.* (2015) documented 45 species with ethnobotanical importance from Tehsil Ahmad Pur, District Bahawalpur, Pakistan. Ajaib *et al.* (2014) reported 64 herbaceous species of medicinal value from Agra valley, Parachinar, Kurram Agency. Asteraceae, Lamiaceae and Papilionaceae were the dominant plant families in terms of species richness in their study area. Khan & Musharaf (2014) listed 73 species of medicinal plants from Sheikh Maltoon area of District Mardan. Wariss *et al.* (2014) reported 84 plants of medicinal value from Lal Suhanra National Park, Bahawalpur. Asteraceae, Chenopodiaceae and Papilionaceae appeared to be the major families in their study area. Bano *et al.* (2013) reported 140 plant with medicinal value from Himalayan range of Azad Jammu and Kashmir. Khan *et al.* (2013) documented 161 medicinal plant species from Takht-e-Nasratti, District Karak. Qaisar *et al.* (2013) reported 88 medicinal plant species from North Waziristan Agency, these plants are being used by Wazir and Dawar tribes. Badshah *et al.* (2012) reported 205 plant species from District Tank, including 49 medicinal species. Marwat *et al.* (2012) documented the ethnobotanical uses and socioeconomic impact of *Nannorhops ritchieana* and *Phoenix dactylifera* in District Dera Ismail Khan. Nasrullah *et al.* (2012) documented traditional uses of 67 plant species from Jandool Valley. Shah & Hussain (2012) reported 82 plants with different traditional uses from Mastuj valley, Hindukush range. Jan *et al.* (2011) listed 62 plant species from Dir Kohistan which are being used as crude drugs. Hussain *et al.* (2010) recorded the medicinal uses of 88 plant species from Jalalpur Jattan, Gujrat. Tareen *et al.* (2010) documented 61

medicinal plants from Kalat and Khuzdar regions of Balochistan. Ali & Qaiser (2009) collected ethnobotanical data from Chitral Valley. Khan *et al.* (2009) reported 51 medicinal plants used as crude drugs in Naltar, Hunza, Astore, Skardu, Ghizar and Diamer, Pakistan.

Sher *et al.* (2011) and Alam *et al.* (2011) documented the traditional uses of 138 and 141 medicinal plants respectively from Chagharzai Valley, District Buner. Barkatullah *et al.* (2009) listed 66 medicinal plants from Batkhela District Malakand. Ahmad *et al.* (2014) reported 50 medicinally important plants from Chail Valley. They also calculated the relative frequency of citation (RFC) for each species. *Origanum vulgare*, *Geranium wallichianum* and *Skimmia laureola* were found to have highest RFC values. Ahmad *et al.* (2013) documented 100 plants of medicinal importance from Madyan. Ahmad *et al.* (2011) listed 140 medicinal plants from Kabal along with traditional medicinal recipes. Hussain *et al.* (2006) documented 126 species of medicinal plants from Ghalegay area of District Swat, which were used for treating different health disorders. Hindukush range has rich floral biodiversity (Hussain *et al.*, 2015). Although, the review shows that there is no reference on medicinal plants from Hindukush range, District Swat, Pakistan with the exception of Ahmad *et al.* (2014) from Chail valley only. Therefore, the present study regarding Chail valley, Dabargai, Shinko and Bishigram, District Swat will improve the already existing knowledge on ethnobotany of this part of Hindukush. Swat is reported to have 500 known plants with medicinal importance (Shinwari, 2010), whereas the present study records 174 medicinal plants which make 34.8 % of the total medicinal plant flora of Swat Valley.

4.4.1 Conservation Status

On the basis of availability, collection status, growth status and part used the medicinal plants were assessed for their conservation status as per

IUCN criteria (IUCN, 2001).

4.4.2 Family Importance Value

Family importance value (FIV) was calculated according to following formula.

$$FIV = \frac{FC(\text{Family})}{N} \times 100$$

FC is frequency of citation of the family while N is the total number of informants. Conservation status of the medicinal plants was enumerated according to the IUCN standard (IUCN, 2001).

4.4.3 Relative Frequency of Citation

Relative frequency of citation (RFC) was calculated as per following formula:

$$RFC = \frac{FC}{N} \quad (0 < RFC < 1)$$

Where RFC stands for relative frequency of citation and its value is less than one and greater than zero, FC is the number of informants who mentioned the plant species and N is the total number of informants (Ugulu *et al.*, 2009). RFC index reflects the local importance of each species.

Table. 4.25 shows recorded 174 species arranged alphabetically along with their RFC, FIV, conservation status and uses. They were represented by 3 families (3.75%) with 7 species (4.02%) of gymnosperms, 9 families (11.25%) with 11 species (6.32%) of monocotyledons and 68 families (85%) with 156 species (Fig.13) of angiosperms (89.66%). Plant species belonging to Family Alliaceae, Colchicaceae, Apiaceae, Asteraceae, Brssicaceae, Lamiaceae, Moraceae, Polygonaceae, Rosaceae and Solanaceae are used as diuretic, carminative, laxative, cardiac tonic, antidiabetic, anthelmintic, expectorant, antipyretic, liver tonic, oral inflammations, nerve tonic and aphrodisiac. Most common mode of administration was found to be decoction. Some medicinal plants or their effective parts are powdered while in few cases fresh plants are used as crude drug.

Conservation biology focuses on conservation and preservation of biodiversity and ecosystems (Soule, 1985). During this study conservation status of 174 medicinal plants was studied by applying IUCN criterion (IUCN, 2001). Several stresses from biotic and abiotic origins were found to have profound impact on these plants in the locality. This study revealed that 61.49% (107 species) were rare, 24.14% (42 species) were vulnerable and 13.79% (24 species) were infrequent. One species (0.57%) i.e. *Melia azrdarach* appeared to be endangered (Fig. 14). Anthropogenic influences, excessive collection, grazing and over exploitation are the main reasons behind the poor conservation status of these medicinal plants. This is also evident from the collected data, as none of the species qualified the criterion to be declared dominant.

Some important plants of the locality which fell under the category of rare plants due to their conservation status included *Abies pindrow*, *Cedrus deodara*,

Cypripedium cordigerum, *Swertia cordata*, *Hypericum oblongifolium*, *Caltha alba* and *Hyoscyamus niger*. *Pinus roxburghii*, *Taxus fauana* were found to be vulnerable species due to dependence of local community on them for fire wood and timber. *Trillium govanianum* was vulnerable due to overexploitation and improper collection methods. Some other important plants of the study area which were declared vulnerable as per applied criteria included *Datisca cannabina*, *Hypericum perforatum*, *Quercus incana*, *Cedrela serrata*, *Paeonia emodi*, *Podophyllum emodi*, *Crataegus songarica* and *Sambucus wightiana*. Some important medicinal plants such as *Ammi visnaga*, *Artemisia scoparia*, *A. vulgaris*, *Carthamus oxyacantha*, *Ajuga parviflora* and *Atropa acuminata* were found to be infrequent. Ethnoflora is under threat due to several factors and measures to protect and conserve this wealth are needed on a war footing before it is too late.

As mentioned above several factors contribute to threaten the plants in the study area, one of such causes is slow growth rate as well. Harsh winters also effect the medicinal plant wealth adversely. Habitat destruction, over grazing, over collection and other biotic stresses are contributing to removal of vegetation cover and low population density of medicinally important plants. Research work focused purely on conservational aspects is a rarity in Pakistan (Alam & Ali, 2010). Ali & Qaiser (2010) have reported 21 species of vascular plants to be threatened in Pakistan. Results presented in this study are backed by works of Haq (2011) and Kim (2006). Pinnaceae (23.97) had highest FIV values among gymnosperms, Alliaceae (33.56) among monocotyledons and Lamiaceae (97.94), Rosaceae (91.09), Solanaceae (83.13), Asteraceae (76.02), Moraceae (70.54), Apiaceae (67.12), Polygonaceae (60.95), Brassicaceae and Violaceae (56.68) had higher FIV among dicotyledons (Table. 1). These families were also leading families in earlier ethnobotanical studies on Chail (Ahmad *et al.*, 2014) and in the adjacent areas like Madyan (Ahmad *et al.*, 2013), Dir Lower (Nasrullah *et al.*, 2012), Buner (Sher *et al.*, 2011), Kabal (Ahmad *et al.*, 2011), Shangla (Ibrar *et al.*, 2003) and Ghalegay (Hussain *et al.*, 2006).

Highest RFC values (Fig. 15) were recorded for *Skimmia laureola* (0.321), *Juglans regia*, *Olea ferruginea*, *Papaver somniferum* each with 0.294, *Crataegus songarica*, *Salix babylonica*, *Viola canescens* each with 0.28 and *Punica granatum* and *Solanum nigrum* each with 0.267 (Table. 4.25). A total of 45 plants (25.86%) had single uses, 57 plants (32.76%) exhibited dual uses, 44 plants (25.29%) had three particular uses, 22 plants (12.64%) with four different uses, 2 plants (1.15%) with

fives uses, 3 plants (1.72%) with six uses and only one plant (0.57%) with 7 uses. Similar reports have been provided for Chail (Ahmad *et al.*, 2014), Parachinar (Ajaib *et al.*, 2014), Madyan (Ahmad *et al.*, 2013), North Waziristan (Qaisar *et al.*, 2013), Dir Lower (Nasrullah *et al.*, 2012), Buner (Sher *et al.*, 2011), Kabal (Ahmad *et al.*, 2011), Dir Kohistan (Jan *et al.*, 2011), Malakand (Barkatullah *et al.*, 2009) and Shangla (Ibrar *et al.*, 2003). It was noticed during this study that almost all parts of various species are used to cure different diseases with a slight change of recipe in different villages. Most of the species such as *Anethum graveolens*, *Coriandrum sativum*, *Foeniculum vulgare*, *Diospyros lotus*, *Mentha longifolia* etc. were used for curing digestive disorders; *Potentilla reptans*, *Tribulus terrestris*, *Allium sativum*, *Dioscorea deltoidea* etc for urinary disorders (diuretics); *Trillium govanianum*, *Ammi visnaga*, *Berberis lyceum*, *Juglans regia* etc as tonics and nerve stimulants; *Arisaema flavum*, *Artemisia vulgaris*, *Melia azedarach*, *Jasminum humile* etc. as anthelmintics; *Sorbaria tomentosa*, *Bergenia ciliate*, *Valeriana jatamansi* etc. as astringents and *Polygonum aviculare*, *Polygala abyssinica* etc. as emetics.

4.4.4 Recommendations

People depend mostly on herbal cure for various ailments as majority of the population in the study area fall into lower strata on socio-economic scale. Due to this reason the medicinal plant flora in the region is under immense biotic stress. Yet another factor having an ill effect on medicinal plants in this region is deforestation. The local are cutting trees as timber and fuel wood species, which is reducing forest cover. Grazing in combination with fuel wood and timber extraction from the forest area of the study area is also a huge threat to ethnoflora especially in reducing the regeneration potential of these species. Moreover, some plant species such as *Colchicum luteum*, *Trillium govanianum*, *Paeonia emodi*, *Spiraea canescens* etc. have very low population density due to overuse and improper collection practices. Findings of present study strongly recommend the in-situ conservation strategies to ensure the overall biological productivity and rehabilitation of degraded habitats. This can be achieved by introducing fast growing medicinal plants and to guarantee the sustainable utilization of the harassed flora (Cunningham 2001; Hamilton, 2004; Hamilton *et al.*, 2000; Tuxill and Nabhan, 2001). In the recent past some NGOs have conducted training sessions for the local community in connection with livelihood opportunities. Present study clearly indicates that such initiatives have badly backfired because some very important medicinal plants are now on the verge of

extinction due to lavish and improper collection methods. One of such examples is *Trillium govanianum*, which was once abundant in the study area but now has a very low population density due to over collection. Locals have a knowledge about medicinal wealth of the area but most of them have no idea about their importance on global scale. At times medicinal plants are collected in excess unnecessarily for short term financial returns. Moreover, the collection methods are also crude and there is no proper care taken in preserving or processing of the medicinal plants before taking them to market, which results in low grade product in the end. Governmental and Non-Governmental organizations can play an important role in this regard by using the present study as a baseline for future studies and projects. There is a dire need to initiate programs for the protection and conservation of medicinal plant wealth before it is too late.

Table 4.25 Ethnomedicinal plants, RFC, FIV and their conservation status

	Taxon	Local Name	Part used	C	RFC	FIV	1	2	3	4	5	Conservation status	Uses and remedies
	Gymnosperms												
	Cupressaceae					3.42							
1	<i>Cupressus sempervirens</i> L.	Suru	Fruit and Wood	3	0.02		2	3	0	2	7	Vulnerable	Anthelmintic and Astringent
2	<i>Juniperus communis</i> L. var. <i>saxatilis</i> Palls	Gugar	Fruit	2	0.013		2	3	0	2	7	Vulnerable	Carminative, Diuretic and Stimulant
	Pinnaceae					23.97							
3	<i>Abies pindrow</i> Royle.	Achar	Leaves	9	0.061		3	3	0	4	10	Rare	Carminative, Tonic, used to relieve stomach pain and Expectorant
4	<i>Cedrus deodara</i> (Roxb. ex Lamb.) G. Don	Ranzra	Wood, Oil & Gum	7	0.047		3	2	0	4	9	Rare	Oil is diuretic, carminative, antipyretic and diaphoretic. Used against piles and acne.
5	<i>Pinus roxburghii</i> Sargent	Nakhtar	Wood, Resin	11	0.075		3	2	0	1	6	Vulnerable	Wood is diuretic and diaphoretic. Resin is stimulant, relieves stomach pain
6	<i>Pinus wallichiana</i> A.B. Jackson	Pewuch	Resin & Wood	8	0.054		3	3	0	4	10	Rare	Resin effective in face Acne. Wood is stimulant and Diaphoretic
	Taxaceae					10.27							
7	<i>Taxus fauana</i> (Zucc.) Pilger	Banya	Leaves & Seeds	15	0.102		3	1	0	4	8	Vulnerable	Leaves effective against Asthma, Epilepsy and are Aphrodisiac. Seeds are Sedative
	Monocotyledonae												
	Alliaceae					33.56							
8	<i>Allium cepa</i> L.	Piyaz	Bulb	21	0.143		3	1	4	0	8	Vulnerable	Good for high blood pressure, Diuretic and Expectorant
9	<i>Allium sativum</i> L.	Oga	Cloves	28	0.191		3	1	4	0	8	Vulnerable	Diuretic, Good for high blood pressure and antiseptic
	Araceae					6.16							
10	<i>Acorus calamus</i> L.	Warch	Rhizome	4	0.027		2	3	4	0	7	Vulnerable	Used for respiratory disorders. Relieves Constipation, Flatulence and Piles.
11	<i>Arisaema flavum</i> (Forsk.) Schott	Mergai	Seeds & Root	5	0.034		3	3	4	2	12	Rare	Seeds are used to treat digestive disorders of

23	<i>Prinosia chinensis</i> Bunge ssp. <i>integrifolia</i> (J.L.S) Rech. f.	Shanai	Leaves & Bark	11	0.075		2	3	0	4	9	Rare	Antidiabetic. Decoction used in jaundice
24	Apiaceae <i>Ammi visnaga</i> (L.) Lam.	Sperkai	Fruit & Flower	9	0.061	67.12	3	3	4	3	13	Infrequent	Heart tonic if used with dried fruits of <i>Bunium persicum</i> , asthma, Whooping cough
25	<i>Anethum graveolens</i> L.	Sowa	Fruit	12	0.082		3	3	4	2	12	Rare	Used to treat flatulence. Relieves abdominal pain
26	<i>Bunium persicum</i> (Boiss.) Fedtsch.	Tora Zeera	Fruit	13	0.089		2	3	4	2	11	Rare	Heart tonic if used in combination with <i>Ammi</i> <i>visnaga</i> .
27	<i>Bupleurum falcatum</i> L.	Gillu	Whole Plant	4	0.027		3	0	4	0	7	Vulnerable	Used to treat Typhoid. Laxative
28	<i>Coriandrum sativum</i> L.	Dhanrya	Leaves & Fruit	21	0.143		3	0	4	4	11	Rare	Carminative and Stimulant
29	<i>Foeniculum vulgare</i> Mill.	Kaga	Seeds & Leaves	24	0.164		3	0	4	2	9	Rare	Carminative and Laxative
30	<i>Pimpinella diversifolia</i> DC.	Watani Kaga	Whole Plant	6	0.041		3	0	4	0	7	Vulnerable	Carminative
31	<i>Trachyspermum ammi</i> (L.) Sprague	Sperkai	Root & Fruit	9	0.061		3	0	4	2	9	Rare	Powdered root is stimulant and diuretic. Fruit is good for dyspepsia and is used as carminative.
32	Apocynaceae <i>Nerium oleander</i> L.	Gandery	Whole Plant	18	0.123	12.32	2	3	3	0	8	Vulnerable	Antidiabetic. Poisonous plant
33	Araliaceae <i>Hedera nepalensis</i> K. Koch	Palul Zelai	Berries & Leaves	23	0.157	15.75	3	3	4	4	14	Infrequent	Antidiabetic and Blood purifier
34	Asteraceae <i>Achillea millefolium</i> L.	Jarai	Leave and Root	5	0.034	76.02	3	3	4	4	14	Infrequent	Mouth ulcers, toothache, tonic, dysentery
35	<i>Artemisia scoparia</i> Waldst. & Kit.	Naray Jaukai	Young shoots & Seeds	13	0.089		3	3	4	3	13	Infrequent	Anthelmintic, respiratory stimulant and mild purgative
36	<i>Artemisia vulgaris</i> L.	Jaukai	Young shoot	11	0.075		3	3	4	3	13	Infrequent	Anthelmintic
37	<i>Calendula arvensis</i> L.	Ziar Gulay	Inflorescen ce	5	0.068		3	3	4	3	13	Infrequent	Carminative and stimulants.
38	<i>Calendula officinalis</i> L.	Ziar Gulay	Inflorescen ce	4	0.027		3	3	4	3	13	Infrequent	Dried heads applied to wounds which enhance the

			Kareza	Seeds & Leaves	5	0.034												healing process
39	<i>Carthamus oxyacantha</i> M.B.																	Leaves used as vegetable, cooked with rice. Oil from seeds is used to cure mouth ulcers
40	<i>Cichorium intybus</i> L.		Han	Root & Leaves	15	0.102												Root decoction is anti-pyretic
41	<i>Conyza Canadensis</i> (L.) Cronquist		Malooch	Whole Plant	2	0.013												Used as diuretic and stimulant. Also used in diarrhea
42	<i>Silybum marianum</i> Gaertn.		Kandialai	Whole Plant	9	0.061												Plants are dried and the powdered drug is used to treat hepatitis
43	<i>Solidago virgaurea</i> L.		Bangira	Whole Plant	6	0.041												Plants dried and powdered, used as diuretic, antiseptic and mild carminative
44	<i>Sonchus asper</i> (L.) Hill		Shouda Pai	Whole Plant	3	0.02												Shoots fed to livestock for enhancing lactation
45	<i>Sonchus oleraceus</i> L.		Dodak	Whole Plant	5	0.034												Juice of fresh leaves and root is febrifuge
46	<i>Tagetes erecta</i> L.		Zanagli Hamesha	Flowers & Leaves	9	0.061												Flowers used to treat piles. Local healers use it as a blood purifier. Leaves applied on boils
47	<i>Taraxacum officinale</i> Wigg.		Boda Budai	Root & Leaves	11	0.075												Grinded leaves are tonic, root decoction against kidney and liver disorders
48	<i>Xanthium strumarium</i> L.		Geshkay	Whole Plant	8	0.054												Leaf decoction recommended in malarial fever
49	Berberidaceae <i>Berberis lycium</i> Royle		Kwary	Fruit	29	0.198	19.86											Dried root bark given orally as body tonic
50	Betulaceae <i>Alnus nitida</i> (Spach) Endl.		Girae	Leaves & Bark	27	0.184	30.82											Used as sedative and expectorant. Mild diuretic
51	<i>Betula utilis</i> D. Don.		Braj	Leaves & Bark	18	0.123												Diuretic. Used to relieve pain in gout
52	Boraginaceae <i>Cynoglossum lanceolatum</i> Forsk.		Gaty gul	Whole Plant	11	0.075	34.24											Powdered plant taken with a decoction of <i>Coriandrum sativum</i> fruits as laxative
53	<i>Helliotropium strigosum</i>		Gulgulay	Whole	26	0.178												Used in snake bites. Leaf

66	<i>Mitynas royleanus</i> (Wall. ex Lawson) Cuf.	Sorazghay	Whole Plant	18	0.123		3	3	3	0	9	Rare	Fresh leaves are collected, cleaned, crushed and extract is used as eye drops. Effective in toothache and Eyes inflammation
	Chenopodiaceae					46.57							
67	<i>Chenopodium album</i> L.	Sarmay	Whole Plant	23	0.157		3	3	4	0	10	Rare	Dried powdered plant considered as carminative and diuretic agent
68	<i>Chenopodium ambrosioides</i> L.	Benakai	Whole Plant	31	0.212		3	3	4	0	10	Rare	Very common anthelmintic in the study area. Laxative and carminative
69	<i>Chenopodium botrys</i> L.	Skha Khawra	Whole Plant	14	0.095		3	3	4	0	10	Rare	Anthelmintic and provides relief in dry cough
	Convolvulaceae					9.58							
70	<i>Convolvulus arvensis</i> L.	Prewatai	Whole Plant	14	0.095		3	3	4	0	10	Rare	Purgative, also applied in skin disorders
	Cuscutaceae					17.12							
71	<i>Cuscuta reflexa</i> Roxb.	Prewatkai	Stem	25	0.171		3	3	4	1	11	Rare	Decoction for urine control, diabetes and blood purification; plant extract used as anti-lice
	Datisaceae					1.36							
72	<i>Datisca cannabina</i> L.	Kalbarai	Root	2	0.013		2	2	4	0	8	Vulnerable	Bitter diuretic and purgative
	Ebenaceae					47.94							
73	<i>Diospyros kaki</i> L.	Amluk	Fruit	32	0.219		3	2	0	2	7	Vulnerable	Laxative
74	<i>Diospyros lotus</i> L.	Tor Amluk	Fruit & Seeds	38	0.260		3	2	0	2	7	Vulnerable	Carminative, purgative and causing flatulence; boiled in milk and taken against constipation and dysentery
	Elaeagnaceae					5.47							
75	<i>Elaeagnus umbellata</i> Thunb	Gehain	Flower, Fruit & Seed	8	0.054		2	3	3	3	11	Rare	Decoction of flowers is used to cure heart diseases; decoction of leaves for cough
	Euphorbiaceae					38.35							
76	<i>Andrachne cordifolia</i> (Wall. ex Dene.) Muell. Arg.	Krachai	Leaves & Twigs	20	0.136		3	1	3	4	11	Rare	Poisonous plant
77	<i>Euphorbia helioscopia</i> L.	Parparak	Whole Plant	2	0.013		3	3	4	0	10	Rare	Provides relief in constipation but overdose may cause poisonous effects. Purgative and anthelmintic
78	<i>Ricinus communis</i> L.	Aranda	Seeds	34	0.232		3	2	3	2	10	Rare	Seed oil demulcent and to evacuate bowels in children

[illegible]

118	<i>Oxalis corniculata</i> L.	Tarukey	Whole Plant	2	0.013		3	3	4	0	10	Rare	Decoction of plant to enhance digestion
	Paeoniaceae					24.65	2	2	4	0	6	Vulnerable	Powdered rhizome mixed with milk to cure backache and general weakness. Considered an effective general tonic by local healers
119	<i>Paeonia emodi</i> Wall. ex Royle	Mamekh	Tuber and Flower	36	0.246								
	Papaveraceae					29.45	2	3	4	2	11	Rare	Capsules and seeds as narcotic; dried capsule to make tea for cough and fever
120	<i>Papaver somniferum</i> L.	Kashkash	Seeds & Capsule	43	0.294								
	Papilionaceae					41.78	3	3	3	0	9	Rare	Dried powdered root taken with glass of water against scabies; leaves against stomach problems
121	<i>Indigofera heterantha</i> Wall. ex Brandis var. <i>heterantha</i>	Ghoreja	Whole Plant	32	0.219		3	2	4	0	9	Rare	Decoction of dried powdered plant with ghee or boiled water is aphrodisiac. Also good for backache
122	<i>Lotus corniculatus</i> L. var. <i>corniculatus</i>	Patikana	Whole Plant	2	0.013		3	2	4	0	9	Rare	Edible beans
123	<i>Phaseolus lunatus</i> L.	Lobia	Seeds	18	0.123		3	2	4	2	11	Rare	Carminative, diuretic, immune-modulatory, diaphoretic
124	<i>Pisum sativum</i> L. var. <i>sativum</i>	Matar	Seeds	9	0.061		3	2	4	2	11	Rare	
	Plantaginaceae					37.67	3	3	4	0	10	Rare	Leaves applied to treat bedsores, inflamed surfaces and candidiasis
125	<i>Plantago lanceolata</i> L.	Jabi	Root, Leaves & Seed	31	0.212		3	3	4	0	10	Rare	Leaves applied to treat bedsores and candidiasis
126	<i>Plantago major</i> L.	Ghwa jabi	Leaves & Seed	24	0.164		3	3	4	4	14	Infrequent	Leaves applied to treat bedsores and candidiasis
	Plantaceae					10.95	2	3	0	4	9	Rare	Powdered bark taken orally to control diarrhea
127	<i>Platanus orientalis</i> L.	Chinar	Bark & Leaves	16	0.109								
	Podophyllaceae					23.38	2	3	3	0	8	Vulnerable	Rhizome is used for hepatic disorders and is a purgative. Fruit is laxative
128	<i>Podophyllum emodi</i> Wall. ex Royle	Gangura	Rhizome & Fruit	34	0.232								
	Polygalaceae					4.79	2	3	4	0	9	Rare	Good expectorant and emetic
129	<i>Polygala abyssinica</i> R. Br. ex Fresen	-	Whole Plant	7	0.047								
	Polygonaceae					60.95							

130	<i>Bistorta amplexicaulis</i> (D. Don) Green	Tarwa panra	Rhizome	29	0.198		3	2	4	0	9	Rare	Used to treat mouth ulcers, oral inflammations and sore throat
131	<i>Polygonum aviculare</i> L.	Pulpalak	Whole Plant	11	0.075		3	3	4	0	10	Rare	Mild purgative. Also used as emetic
132	<i>Rumex dentatus</i> L.	Shalkhay	Root & Leaves	25	0.171		3	2	4		9	Rare	Rhizome and leaves used as poultice for wound healing
133	<i>Rumex hastatus</i> D. Don	Taruky	Whole Plant	24	0.164		3	3	4	0	10	Rare	Very effective in scurvy. Diuretic and cooling agent
	Portulacaceae					14.38							
134	<i>Portulaca oleracea</i> L.	Warkhari	Whole Plant	21	0.143		3	2	4	0	9	Rare	Shoot decoction against liver and kidney diseases
	Primulaceae					11.64							
135	<i>Anagallis arvensis</i> L. var. <i>coerulea</i> (L.) Gouan.	Gutialai	Whole Plant	17	0.116		3	3	4	0	10	Rare	Decoction is used as a vermicide
	Punicaceae					26.71							
136	<i>Punica granatum</i> L.	Anar	Fruit	39	0.267		2	2	0	2	6	Vulnerable	Dried fruit in bolus form for removal of intestinal helminths. Often mixed with yogurt for good results
	Ranunculaceae					28.76							
137	<i>Aconitum violaceum</i> Jacq. ex Stapf	Zaharmora	Roots	7	0.047		3	2	4	0	9	Rare	Rhizomes, wrapped in sheep or goat intestine and thoroughly boiled in milk; milk discarded and rhizomes crushed into powder, taken against rheumatism and arthritis; administering as such may cause death or mental problems if overdosed
138	<i>Caltha alba</i> Camb. var. <i>alba</i>	Makhan pat	Whole Plant	35	0.239		3	2	4	0	9	Rare	Leaves cooked as vegetable and laxative in nature
	Rosaceae					91.09							
139	<i>Cotoneaster microphyllus</i> Wall. ex Lindl.	Kharawa	Leaves	19	0.130		3	2	3	4	12	Rare	Used as astringent
140	<i>Cotoneaster nummularia</i> Fisch. & Mey.	Mamanra	Fruit	15	0.102		3	2	3	2	10	Rare	Fruit is astringent and expectorant. Also used to relieve abdominal pain
141	<i>Crataegus songarica</i> G. Koch.	Barsanga	Flowers & Fruit	17	0.116		3	1	0	3	7	Vulnerable	Heart tonic and good for improving blood flow.
142	<i>Duchesnea indica</i> (Andr.) Focke	Zmakay Toot	Fruit	16	0.109		3	3	4	2	12	Rare	Mild laxative and nerve tonic

143	<i>Geum uranum</i> L.	Karachi	Whole Plant	3	0.02		3	3	3	4	0	10	Rare	Used to treat dysentery and diarrhea. Also administered in cases of sore throat
144	<i>Potentilla reptans</i> L.	Zangali Gulab	Whole Plant	12	0.082		3	2	4	0	9		Rare	Anti-inflammatory in cases of Urinary tract inflammations. Also used in diarrhea
145	<i>Rosa webbiana</i> Wall. ex Royle	Ziara Karwara	Flower & Twigs	9	0.061		2	2	3	3	10		Rare	Mild astringent
146	<i>Rubus ellipticus</i> Smith	Karwara	Fruit	12	0.082		3	3	3	2	11		Rare	Decoction of fruit is quite effective against diarrhea
147	<i>Rubus fruticosus</i> L.	Jijrai	Fruit & Leaves	11	0.075		3	3	3	2	11		Rare	Effective against diarrhea. Also used as a tonic
148	<i>Sorbaria tomentosa</i> (Lindl.) Rehder	Kharawa	Whole Plant	9	0.061		3	2	3	0	8		Vulnerable	Used as astringent
149	<i>Spiraea canescens</i> D. Don	Krachi	Fruit	10	0.068		3	2	3	2	10		Rare	Used to ease the labor pain
150	<i>Rubiaceae</i> <i>Galium aparine</i> L.	Kargha mukhuka	Whole Plant	11	0.075	7.53	3	3	4	0	10		Rare	Used as diuretic
151	<i>Rutaceae</i> <i>Skimmia laureola</i> (DC.) Sieb. & Zucc. ex Walp	Nazar panra	Leaves	47	0.321	47.94	2	2	3	4	11		Rare	Burnt to expel evils and bad omens; tea used to cure indigestion, fumes considered as antiseptic
152	<i>Zanthoxylum armatum</i> DC.	Dambara	Fruit	23	0.157		3	3	0	2	8		Vulnerable	Fruits as antipyretic and for treating stomachache
153	<i>Salicaceae</i> <i>Salix babylonica</i> L.	Waela	Bark & Leaves	41	0.280	28.08	3	2	0	4	9		Rare	Used to cure wounds and insect bites
154	<i>Sambucaceae</i> <i>Sambucus wightiana</i> Wall. ex Wight & Arn.	Benakai	Whole Plant	22	0.150	15.06	2	3	3	0	8		Vulnerable	Expectorant, purgative and mild diuretic
155	<i>Saxifragaceae</i> <i>Bergenia ciliata</i> (Haw.) Sternb. var. <i>ciliata</i> Yeo	Gat panra	Rhizome	28	0.191	35.61	3	2	4	0	9		Rare	Diuretic and astringent. Also used to dissolve kidney stones.
156	<i>Bergenia stracheyi</i> (Hk.f. & Thoms.) Engl.	Gat panra	Rhizome	24	0.164		3	3	4	0	10		Rare	Powdered rhizome with milk in the mornings as tonic
157	<i>Scrophulariaceae</i> <i>Picrorhiza kurroa</i> Royle ex Bth.	-	Rhizome & Root	16	0.109	28.08	2	3	4	0	9		Rare	Effective for digestive disorders and Heart diseases
158	<i>Verbasum thapsus</i> L.	Khardag	Whole	25	0.171		3	3	4	0	10		Rare	Seeds narcotic and

171	<i>Viola biflora</i> L.	Banafsha	Whole Plant	33	0.226		2	2	4	0	8	Vulnerable	Relieves spasm. and emollient	Laxative
172	<i>Viola canescens</i> Wall. ex Roxb.	Banafsha	Whole Plant	41	0.280		2	2	4	0	8	Vulnerable	Diuretic, laxative and antipyretic	
	Vitaceae					19.17								
173	<i>Vitis vinifera</i> L.	Kuwar	Fruit & Leaves	28	0.191		3	1	3	2	9	Rare	Fruit is laxative and quite effective in dyspepsia. Also used in asthma. Leaves used as astringent	
	Zygophyllaceae					3.42								
174	<i>Tribulus terrestris</i> L.	Markundai	Fruit	5	0.034		2	3	4	2	11	Rare	Commonly used to treat urinary disorders. Effective in cough and bleeding gums.	

Key: C- Number of respondents citing the plant

RFC- Relative Frequency of citation

FIV- Family Importance Value

IUCN criteria

1. Availability Class

0 = Uncommon or very rare

1 = Less common or rare

kg/yr

2 = Occasional

kg/yr

3 = Abundant

kg/yr

3. Growth Behavior

0 = Regrowth in more 3 years

1 = Regrowth within 3 years

2 = Regrowth within 2 years

3 = Regrowth within 1 year

4 = Regrowth in a season

5. Total Score:

1. 0 - 4 Endangered:

2. 5 - 8 Vulnerable:

3. 9 - 12 Rare:

4. 13 - 14 Infrequent:

5. 15 - 16 Dominant.

2. Collection Status

0 = More than 1000 kg/yr

1 = Consumed from 500-1000

2 = Consumed from 300-500

3 = Consumed from 100-200

4. Part used

0 = Root/Whole plant

1 = Bark

2 = Seeds, Fruits

3 = Flowers

4 = Leaves/Gum/Latex

Fig. 13 Family importance value

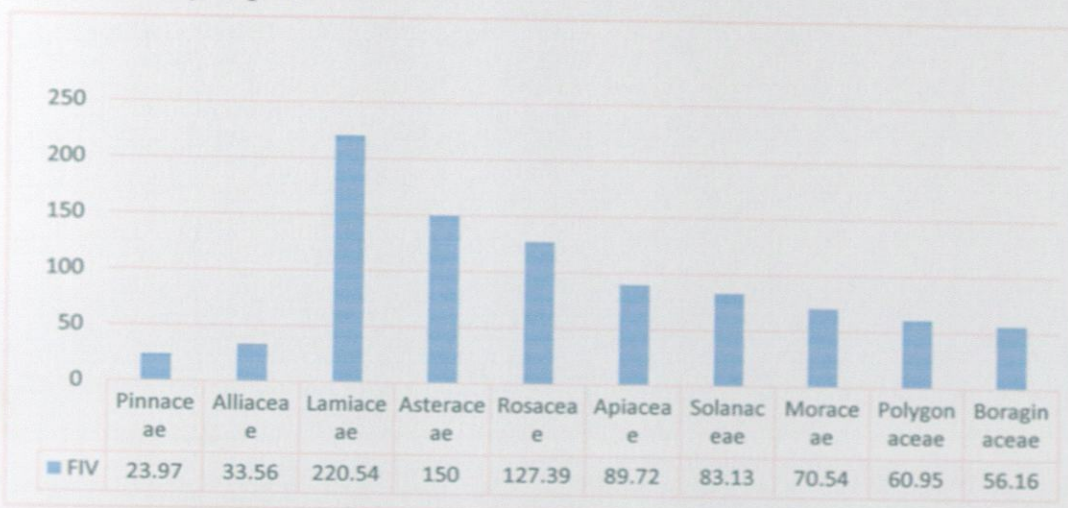
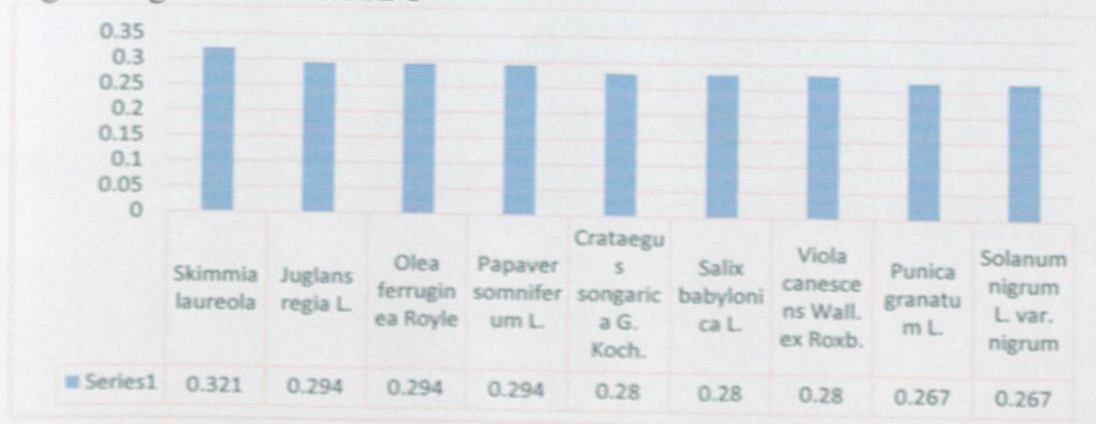


Fig. 14 Conservation status of medicinal plants



Fig. 15 Highest scores for RFC



PLANT PALATABILITY AND CHEMICAL EVALUATION OF FORAGE PLANTS

4.5 Plant palatability

Grazing is the most common of the land uses by domestic and wild animals. Grazing is the most important biotic stress in terrestrial ecosystems, after the fire factor (Huntly, 1991). Acceptability of plants by animals is determined by plant palatability. Various factors influence the palatability of plants in any locality. These factors include phenology, morphology and secondary metabolites in a plant (Khan and Hussain, 2012; Hussain and Durrani, 2009). Some plants are found to be more palatable in their pre-reproductive stage while the others are consumed more in their post-reproductive stage. Growth and development bring changes not only in the morpho-anatomical structure of the plant but also in the chemical profile which in turn determine its potential in terms of palatability. In addition to this some grazing animals prefer to consume a plant in its fresh form while others eat it in dry form. On the basis of preferences, animals may be categorized as grainvores, frugivores, foliovores, grazers and browsers (Chapman and Reiss, 2004).

Gorade and Datar (2014) prepared a checklist of palatable grass species from peninsular India. Plants were classified on the basis of habitat into nine categories. Gunasekaran *et al.* (2014) conducted a study on tree fodder in goats and sheep in Madras, India. They also analyzed four tree species *Albizia lebbek*, *Gliricidia sepium*, *Leucaena leucocephala* and *Inga dulce* for their mineral composition. It was concluded that leaves of *Leucaena leucocephala* served as better fodder for ruminants. Ho and Pennings (2013) suggested that high latitude plants are of high quality to herbivores than the low latitude plants. Pearse *et al.* (2012) reported that damage to a plant in field due to herbivory depends upon the extent of similarity between the interactions. According to Wardle and Bardgett (2004) grazer densities are altered in response to climatic conditions as well as land use which are important elements of global change. The role of cultivated trees and shrubs as a source of food for livestock has been reported in Australia, these cultivars provide fodder to livestock in April to October in northern Australia while from February to May in southern Australia (Lefroy *et al.*, 1992). According to Heady (1964) palatability, associated species, climate and edaphic factor, type of animal and physiological status of a plant influence the selection of a plant for herbivory.

Extensive study has been carried on rangeland degradation and management in Balochistan. Shrubs such as *Atriplex canescens* and *Salsola vermiculata* had the potential to be used as fodder species on large scale in the locality which may

contribute to proper management of the rangelands (Ahmad *et al.*, 2012). The most preferred species included *Zizyphus mauritiana*, *Acacia modesta*, *Dichanthium annulatum* and *Kickxia ramosissima* (Khan and Hussain, 2012). Sher *et al.* (2012) studied the macro-mineral composition of *Berberis lyceum*, *Debergeasia salicifolia*, *Dodonaea viscosa*, *Gymnosporia royleana*, *Indigofera heterantha*, *Justicia adhatoda*, *Rosa moschata* and *Zizyphus nummularia* at three phenological stages. A significant difference in nitrogen, calcium, magnesium and sodium content except *Debergeasia* and *Indigofera* were noticed. Seasonal variation in the mineral content of *Chrysopogan aucheri* and *Cymbopogan jawarancusa* were observed in Balochistan. The concentrations of nitrogen, potassium, magnesium and Na in both species were high during spring season (Bano *et al.*, 2009). (Hussain and Durrani, 2008) studied the Mineral composition of some grasses and shrubs in Kalat, Balochistan displayed higher copper content in shrubs than grasses (Hussain and Durrani, 2008).

4.5.1 Palatability and related characteristics

Plants were categorized into five palatability classes i.e. not palatable, rarely palatable, less palatable, palatable and highly palatable. Results of present study (Table. 4.26) revealed that 89 (19.22%) plants were not palatable such as *Juniperus communis*, *Abies pindrow*, *Cedrus deodara*, *Acorus calamus*, *Xanthium strumarium*, *Sarcococca saligna*, *Cuscuta europaea*, *Euphorbia helioscopia* and *Andrachne cordifolia*. In the category of rarely palatable plants came 34 (7.34%), such as *Strobilanthes urticifolia*, *Achyranthes aspera*, *Serratula palida*, *Scabiosa candolii*, *Daphne mucronata* and *Verbena officinalis*. Grazing pressure promotes the species richness of non-palatable species in a locality in areas under severe grazing stress will have high number of non-palatable species than palatable ones (Gorde and Datar, 2014). Only 83 (17.93%) plants were found to be less palatable which included *Pistacia chinensis*, *Oenanthe javanica*, *Torilis leptophylla*, *Carthamus oxyacantha*, *Berberis lyceum*, *Anchusa arvensis*, *Onosma hispida*, *Sisymbrium irio*, *Lonicera asperifolia*, *Ribes orientale* and *Plantago lanceolata*. Highest number of plants fell under the category of palatable plants i.e. 225 (48.60%) plants such as *Agrostis munroana*, *Aristida cyanantha*, *Brachiaria reptans*, *Lolium temulentum*, *Phalaris minor*, *Stipa sibirica*, *Amaranthus viridis*, *Conyza Canadensis*, *Indigofera heterantha*, *Medicago lupulina* and *Rumex dentatus*. Number of highly palatable plant species was 32 (6.91%) which included *Apluda mutica*, *Avena fatua*, *Brachypodium sylvaticum*,

Chrysopogon fulvus, *Cynodon dactylon*, *Poa annua*, *Polypogon fugax*, *Zea mays*, *Trifolium repens*, *Anagallis arvensis* and *Duchesnea indica* (Fig. 16). Grazing influences, the morpho-anatomical features in plants hence promoting prostrate, stoloniferous and rosette habit (Diaz *et al.*, 2006; Hardison *et al.*, 1954). Plants are capable to cope with grazing pressure through developing certain morphological adaptations or by producing secondary metabolites which in turn give off bad odour or bad taste (Hussain and Durrani, 2009; Milewski and Madden, 2006; Lee *et al.*, 2000). Production of toxins by plants is yet another means of avoiding the grazing stress (Rosenthal and Bell, 1979). This strongly backs findings of this study which reports 89 non palatable plants. It was recorded that 152 plants were consumed as a whole. Foliovores had 220 plants to consume while there were 137 plants whose inflorescence or flowers were palatable. Previous studies also support findings of this study as grazing animals prefer floral parts (Gyamtocho *et al.*, 1996; Hussain and Mustafa, 1995; Nyamanagara and Ndlouv, 1995; Pfister and Malaechek, 1986). Nature of the plant part consumed is usually related to its nutrient contents. Present study is in line with the works of Heady and Torell (1959) and Heady (1964) that livestock prefer young foliage and fruits to stems. Reduced palatability of plants by livestock is often due to spines, hairs, rigidity, rough texture, bad odor and poor taste. Findings of this study are supported by Sultan *et al.* (2009); Milewski and Madden (2006); Hussain and Durrani (2009). They reported the production of thorns by plants in response to browsing.

A total of 340 plants were eaten fresh by the livestock. Most of the area falls under moist temperate region and plants have lush green foliage with a lot of moisture content. Livestock utilized a bulk of 190 plants in dry condition while 172 species were eaten in fresh as well as dry. Phenology affects the palatability of plants and it is a common observation for most of the plants that older they get less palatable they become. It is mainly due to the decreasing moisture content in plants with age. Cattle preferred the young foliage (Hardison *et al.*, 1954). Grasses and broad leaved shrubs experience an increase in the crude fiber, cellulose, lignin and carbohydrate content in post-reproductive phase but there is a marked decrease in crude protein content in them (Heady, 1964). Results presented here are in line with the works of Knop and Smith (2006); Miller and Thompson (2005); Holechek and Galt, (2000). Of the total, 328 species were consumed by cows, while goats were feeding upon 369 species in the locality. Though sheep are not that common in Chail and Shinko area but

Kohistani people do keep herds of sheep in Bishigram and Shinko area. They take sheep to green pastures especially during the early spring and summer season where 346 species were observed to be grazed and browsed. Results for animal preferences with similar nature are reported by Angasa and Baars (2001) and Hussain and Durrani (2009) who stated that sheep and goats preferred grasses and forbs.

Table 4.26 Palatability and related characteristics

S.No	Species	NP	RP	LP	P	HP	W	L	I	F	D	B	C	G	S	B
1	<i>Cupressus sempervirens</i> L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	<i>Juniperus communis</i> L. var. <i>saxatilis</i> Palls	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	<i>Thuja orientalis</i> L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	<i>Abies pindrow</i> Royle.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	<i>Cedrus deodara</i> (Roxb. ex Lamb.) G. Don	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	<i>Picea smithiana</i> (Wall.) Boiss.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	<i>Pinus roxburghii</i> Sargent	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	<i>Pinus wallichiana</i> A.B. Jackson	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	<i>Taxus fauana</i> (Zucc.) Pilger	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	<i>Alisma plantago- aquatica</i> L.	-	+	-	-	-	-	+	-	+	-	-	+	+	+	+
11	<i>Sagittaria trifolia</i> L.	-	+	-	-	-	-	+	-	+	-	-	+	+	-	+
12	<i>Allium cepa</i> L.	-	+	-	-	-	-	+	+	+	-	-	+	+	+	-
13	<i>Allium sativum</i> L.	-	+	-	-	-	-	+	+	+	-	-	-	+	+	-
14	<i>Ixiolirion tataricum</i> (Pall.) Herb.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	<i>Narcissus tazetta</i> L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	<i>Acorus calamus</i> L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	<i>Arisaema flavum</i> (Forsk.) Schott	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	<i>Arisaema jacquemontii</i> Blume	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	<i>Arum jacquemontii</i> Blume	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	<i>Colocasia esculenta</i> (L.) Schott	-	+	-	-	-	-	+	-	+	-	-	+	+	+	+
21	<i>Sauromatum venosum</i> (Ait.) Schott.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	<i>Eremurus himalaicus</i> Baker	-	-	-	+	-	+	+	+	-	+	-	+	+	+	+
23	<i>Colchicum luteum</i> Baker	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	<i>Commelina benghalensis</i> L.	-	-	-	+	-	+	-	-	+	-	-	-	-	+	-

[illegible]

[illegible]

460	<i>Viola canescens</i> Wall. ex Roxb.	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+
461	<i>Vitis jacquemontii</i> Parker	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+
462	<i>Vitis vinifera</i> L.	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+
463	<i>Tribulus terrestris</i> L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key: Palatability classes

- NP-Not palatable
- RP-Rarely palatable
- LP-Less palatable
- P-Palatable
- HP-Highly palatable

Part used

- W-Whole plant
- L-Leaves
- I-Inflorescence

Condition

- F-Fresh
- D-Dry
- B-Both fresh & dry

Livestock

- C-Cow
- G-Goat
- S-Sheep
- B-Buffalo

Buffalos are a rarity in the region as locals prefer cows over them; hence buffalos were found to consume 285 different plant species (Table. 4.26).

4.5.2 Chemical analysis of some selected plants

Five plants (Table 4.27) were selected for chemical analysis and each of them was analyzed to estimate the proportion of 15 elements in them at two phenological stages i.e. pre-reproductive stage and post-reproductive stage. These minerals included 5 macronutrients, 7 micronutrients and 3 trace elements.

Table 4.27 Forage plants selected for chemical analysis

S. No	Species	Family	Palatability class	Distribution
1	<i>Aristida cyanantha</i> Nees ex Steud.	Poaceae	Palatable	Common
2	<i>Andrachne cordifolia</i> (Wall.ex Dcne.) Muell. Arg.	Euphorbiaceae	Not Palatable	Common
3	<i>Quercus baloot</i> Griffth	Fagaceae	Less Palatable	Common
4	<i>Indigofera heterantha</i> Wall. ex Brandis var. <i>heterantha</i>	Papilionaceae	Palatable	Common
5	<i>Cotoneaster nummularia</i> Fisch. & Mey.	Rosaceae	Palatable	Common

4.5.2.1 *Aristida cyanantha* Nees ex Steud.

It is a perennial grass common to Chail, Shinko, Bishigram and Dabargai. It is densely tufted having linear leaves. It is a palatable species consumed commonly by cow, goat, sheep and buffalo. In *Aristida cyanantha*, phosphorus was found to be 262 µg/g at pre-reproductive stage while its concentration slightly decreased in post-reproductive stage. Potassium levels were very high in pre-reproductive stage (6151 µg/g), which decreased drastically in post-reproductive stage (3591 µg/g). Magnesium levels were almost same (244 µg/g) and (264 µg/g) in pre-reproductive and post reproductive stages respectively. Calcium content was high in post-reproductive stage (1789 µg/g) than pre-reproductive stage (1460 µg/g). Sulphur levels were high in pre-reproductive stage (440 µg/g) which decreased (379 µg/g) at post reproductive stage. While iron as micronutrients, was estimated as 94 µg/g in pre-reproductive stage, which slightly increased in post-reproductive stage to 109 µg/g. Similarly, cobalt levels were below the detection range at both phenological stages. Traces of nickel were found in post-reproductive stage (1 µg/g) whereas it was below detection range in pre-reproductive stage. Copper levels were low at both phenological stages (16

$\mu\text{g/g}$) and ($3 \mu\text{g/g}$) respectively at pre-reproductive and post-reproductive stages. Zinc content was almost same in both stages ($14 \mu\text{g/g}$) and ($13 \mu\text{g/g}$) respectively. Molybdenum content at both phenological stages was below detection range while manganese levels were also almost same at both phenological stages. The trace element, sodium was found to be $21 \mu\text{g/g}$ in pre-reproductive stage which increased to $76 \mu\text{g/g}$ during post reproductive phase. Similarly, silicon content also increased slightly with age of the plant from ($66 \mu\text{g/g}$) in pre-reproductive stage to ($75 \mu\text{g/g}$) in post-reproductive stage. Barium levels were very low both in pre-reproductive stage ($2 \mu\text{g/g}$) and in post-reproductive stage ($17 \mu\text{g/g}$). (Table. 4.28 & Fig.17).

4.5.2.2 *Andrachne cordifolia* (Wall.ex Dcne.) Muell. Arg.

Andrachne cordifolia being non-palatable plant was selected for chemical analysis to know how changes in mineral composition of this plant affect its palatability status (Sher *et al.* (2012). All macronutrients showed a decrease in post-reproductive stage than pre-reproductive stage except phosphorous. This apparently seems the reason behind its non-palatable status. Phosphorous levels were $381 \mu\text{g/g}$ in pre-reproductive stage and there was an increase in post reproductive stage to $574 \mu\text{g/g}$. Potassium content was $12659 \mu\text{g/g}$ in pre-reproductive stage which significantly decreased to $6187 \mu\text{g/g}$ in post reproductive stage. Marked decrease was also recorded in magnesium levels which were found to be $4146 \mu\text{g/g}$ and $1612 \mu\text{g/g}$ in pre-reproductive and post-reproductive stages respectively. Calcium content was $17723 \mu\text{g/g}$ in pre-reproductive stage while it decreased drastically to $11914 \mu\text{g/g}$ in post reproductive stage. Sulphur levels were $1198 \mu\text{g/g}$ and $822 \mu\text{g/g}$ in pre-reproductive and post-reproductive stage respectively, showing a significant decrease with maturity of the plant. Similar pattern was recorded for micronutrients, which showed a decrease with age of the plant. Iron levels were $349 \mu\text{g/g}$ in pre-reproductive stage which fell to $284 \mu\text{g/g}$ in post-reproductive stage. Cobalt was below detection range in both phenological stages. Nickel content remained unchanged ($1 \mu\text{g/g}$) in both phenological stages. Copper concentration was $23 \mu\text{g/g}$ in pre-reproductive stage which decreased to $4 \mu\text{g/g}$ in post-reproductive stage. Zinc content showed a slight decrease with age, where it was recorded as $32 \mu\text{g/g}$ and $20 \mu\text{g/g}$ in pre-reproductive and post reproductive stages respectively. Molybdenum levels were below detection range in both phenological stages. Manganese content remained almost same ($30 \mu\text{g/g}$) and ($31 \mu\text{g/g}$) in pre-reproductive and post reproductive stages. Sodium was $276 \mu\text{g/g}$ in pre-reproductive stage which dropped to just $66 \mu\text{g/g}$ in post-reproductive

stage. Silicon levels remained in similar range of 8 $\mu\text{g/g}$ and 9 $\mu\text{g/g}$ in both phenological stages. Barium content was estimated as 37 $\mu\text{g/g}$ in pre-reproductive stage and 12 $\mu\text{g/g}$ in post-reproductive stage. Apparently high levels of calcium, iron, copper and sodium contribute to non-palatability of *A. cordifolia*. In addition to this its bitter taste also does not agree with grazing animals. Our findings are in line with work of Gillani *et al.* (2010) have reported the phytotoxic principles in this plant. (Table. 4.29. & Fig. 18).

4.5.2.3 *Quercus baloot* Griffth

Usually the livestock consume its foliage, especially the young leaves, or its inflorescence. Results revealed that phosphorous was significantly increased during post-reproductive stage (965 $\mu\text{g/g}$) from 377 $\mu\text{g/g}$ during pre-reproductive stage. Potassium levels were 5696 $\mu\text{g/g}$ in pre-reproductive stage and 4664 $\mu\text{g/g}$ in post-reproductive stage. An increase in magnesium content was recorded with age of the plant, (1597 $\mu\text{g/g}$) in pre-reproductive and post-reproductive stages (1968 $\mu\text{g/g}$). Calcium content decreased with maturity from, 10905 $\mu\text{g/g}$ to 7205 $\mu\text{g/g}$ in pre-reproductive and post-reproductive stages respectively. Micronutrients showed a slight increase with growing age of the plant as iron was estimated as 147 $\mu\text{g/g}$ in pre-reproductive stage which increased significantly to 364 $\mu\text{g/g}$ in post-reproductive stage. Cobalt levels were below detection range in both phenological stages. Nickel content remained almost same in both phenological stages (1 $\mu\text{g/g}$ and 3 $\mu\text{g/g}$). Copper content was 8 $\mu\text{g/g}$ and 6 $\mu\text{g/g}$ in pre-reproductive and post-reproductive stage respectively, while zinc was estimated as 14 $\mu\text{g/g}$ in pre-reproductive stage and 18 $\mu\text{g/g}$ in post-reproductive stage. Molybdenum levels were below detection range in both stages. Marked increase of 65 $\mu\text{g/g}$ to 139 $\mu\text{g/g}$ was seen in manganese at pre-reproductive and post-reproductive stage. Sodium levels were found to be 4 $\mu\text{g/g}$ in pre-reproductive stage which increased to 33 $\mu\text{g/g}$ in post-reproductive stage. Similarly, silicon also showed a slight increase with growing age of the plant ranging from 11 $\mu\text{g/g}$ to 39 $\mu\text{g/g}$ in pre-reproductive and post-reproductive stage whereas the opposite trend was observed in barium concentration (Table. 4.30. & Fig. 19).

4.5.2.4 *Indigofera heterantha* Wall. ex Brandis var. *heterantha*

All macronutrients showed a visible increase in mature stage, where phosphorous was estimated as 344 $\mu\text{g/g}$ in pre-reproductive stage which increased to 1019 $\mu\text{g/g}$ in post reproductive stage. Significant increase in potassium content was recorded which was found to be 3654 $\mu\text{g/g}$ and 8274 $\mu\text{g/g}$ in pre-reproductive and

post reproductive stages respectively. Magnesium content was 3729 $\mu\text{g/g}$ in pre-reproductive stage and 4344 $\mu\text{g/g}$ in post reproductive stage. Calcium contents were recorded as 29802 $\mu\text{g/g}$ in pre-reproductive stage and 35269 $\mu\text{g/g}$ in post-reproductive stage. Noticeable increase was observed in sulphur during pre-reproductive (696 $\mu\text{g/g}$) and post-reproductive (3970 $\mu\text{g/g}$). Iron levels did not show ample increase as it was ranging between 136 $\mu\text{g/g}$ and 179 $\mu\text{g/g}$ during both the phases. Cobalt and nickel were either below detectable range or did not show any remarkable variation. Copper and zinc contents were low in both stages whereas molybdenum was below detection range. Manganese content was low in pre-reproductive stage (18 $\mu\text{g/g}$) while that of sodium during maturity (146 to 60 $\mu\text{g/g}$). Similar decrease was observed in silicon content and it was estimated as 205 $\mu\text{g/g}$ in pre-reproductive stage and 94 $\mu\text{g/g}$ in post-reproductive stage, but the barium remained almost same (Table. 4.31 & Fig. 20).

4.5.2.5 *Cotoneaster nummularia* Fisch. & Mey.

Cotoneaster nummularia exhibited phosphorous as 632 $\mu\text{g/g}$ in pre-reproductive stage and 551 $\mu\text{g/g}$ in post-reproductive stage. Potassium was estimated as 7173 $\mu\text{g/g}$ and 8393 $\mu\text{g/g}$ in pre-reproductive and post-reproductive stage respectively. Magnesium content decreased with age, as it was 3756 $\mu\text{g/g}$ in pre-reproductive stage and 2101 $\mu\text{g/g}$ in post reproductive stage. Calcium levels showed a significant decrease with growing age of the plant from, 18460 $\mu\text{g/g}$ in pre-reproductive stage to 14127 $\mu\text{g/g}$ in post-reproductive stage. A slight increase (659 to 916 $\mu\text{g/g}$) in sulphur was recorded in pre-reproductive and post-reproductive stages respectively. Among micronutrients, iron levels were raised (281 $\mu\text{g/g}$) in post reproductive stage which was just 188 $\mu\text{g/g}$ in pre-reproductive stage. Cobalt content was below detection range while nickel content remained same (3 $\mu\text{g/g}$ and 1 $\mu\text{g/g}$) in both phenological stages. Similarly, copper, zinc, and manganese contents were decreased with the maturity of the plants. Molybdenum was below detection range in both stages. Sodium content also showed a decrease with age of the plant, from 95 $\mu\text{g/g}$ in pre-reproductive stage to 41 $\mu\text{g/g}$ in post-reproductive stage. Significant decrease with growing age, in silicon levels was recorded (171 $\mu\text{g/g}$) in pre-reproductive stage and only 16 $\mu\text{g/g}$ in post reproductive stage. Barium was estimated as 52 $\mu\text{g/g}$ and 32 $\mu\text{g/g}$ in pre-reproductive and post-reproductive stage respectively (Table. 4.31 & Fig. 21).

Potential intake rate as well as relative preference of plants is determined by chemical profile of a plant (Sultan *et al.* 2009 & 2007). As the plants grow they increase in tenderness which in turn effects their potential intake by grazing animals while their relative preference is determined by their chemical constituents. Kothuman (1980) reported a decline in relative preference of palatable plants with growing age of plants. Findings of this study are in agreement with work of Sher *et al.* (2012); Bano *et al.* (2009); Sultan *et al.* (2009) and Rahim *et al.* (2008) who reported an increase in P, K, Mg, Ca, Cu, Mn and Co levels with increasing age of plants. The highest mean value for P (Table. 22) was recorded in *Indigofera heterantha* (68.51 µg/g), followed by *Quercus baloot* (671 µg/g), *Cotoneaster nummularia* (591.5 µg/g) and *Andrachne cordifolia* (477.5 µg/g) while the lowest P levels were estimated in *Aristida cyanantha* (238.5 µg/g). Similarly, highest K levels were recorded in *A. cordifolia* (9423 µg/g) followed by *C. nummularia* (7783 µg/g), *I. heterantha* (5964 µg/g), and *Q. baloot* (5180 µg/g) whereas *A. cyanantha* (4871 µg/g) showed lowest concentration. Mg levels were highest in *I. heterantha* (4036.5 µg/g), followed by *C. nummularia* (2928.5 µg/g), *A. cordifolia* (2879 µg/g) and *Q. baloot* (1782 µg/g) and lowest in and *A. cyanantha* (254 µg/g). Ca was abundantly found in *I. heterantha* (32535 µg/g), *C. nummularia* (16293.6 µg/g), *A. cordifolia* (14818.5 µg/g), and *Q. baloot* (9055 µg/g) while lowest in *A. cyanantha* (1624.5 µg/g). *I. heterantha* (2333 µg/g) had highest mean value for S, followed by *A. cordifolia* (1010 µg/g), *C. nummularia* (787.5 µg/g) and *Q. baloot* (686.5 µg/g) while the least S was recorded in *A. cyanantha* (409.5 µg/g). Fe levels were low in all selected plants with highest mean value observed in *A. cordifolia* (316.5 µg/g) and lowest in *A. cyanantha* (101.5 µg/g). Ni was not detected in *A. cyanantha* while *Q. baloot*, *I. heterantha* and *C. nummularia* had 2 µg/g mean value each while *A. cordifolia* had a mean value of 1 µg/g. Cu content was high in *A. cordifolia* (13.5 µg/g) and low in *I. heterantha* (6.5 µg/g). However highest mean value for Zn was observed in *A. cordifolia* (26 µg/g) followed by *C. nummularia* (23.5 µg/g), *I. heterantha* (16.5 µg/g) and *Q. baloot* (16 µg/g) and lowest in *A. cyanantha* (13.5 µg/g). Highest mean value for Mn was recorded in *Q. baloot* (102 µg/g), *I. heterantha* (35.5 µg/g) followed by *A. cordifolia* (30.5 µg/g) and *C. nummularia* (27 µg/g) and lowest in *A. cyanantha* (6 µg/g). Na exhibited highest value in *A. cordifolia* (171 µg/g) followed by *I. heterantha* (103 µg/g), *C. nummularia* (68 µg/g) and *A. cyanantha* (48.5 µg/g) while lowest in *Q. baloot* (18.5 µg/g). Equally Si levels were high in *I. heterantha* (149.5 µg/g) and low

in *A. cordifolia* (8.5 $\mu\text{g/g}$). Ba exhibited high concentration among the plant viz. *C. nummularia* (84 $\mu\text{g/g}$) followed by *I. heterantha* (39.5 $\mu\text{g/g}$), *Q. baloot* (27 $\mu\text{g/g}$) and *A. cordifolia* (24.5 $\mu\text{g/g}$). Some of the problems related to animal growth and reproduction are linked to low mineral content in soils as well as forage plants in the locality (Tiffany *et al.*, 2000). Variation in concentrations of macro and micronutrients are reported by Gull *et al.* (2015) and Dastgir *et al.* (2014). This supports findings of this study which reports a variation in concentration of macro and micronutrients in forage plants at different phenological stages. Studies of similar kind were conducted for Ba, Ca, Co, Cu, Fe, Mg, Mn, Mo, Ni, P, K, Si, Na, S and Zn (Gull *et al.*, 2015; Lamb *et al.*, 2013; Abreu 2012; Sher *et al.*, 2012; Cheema *et al.*, 2010; Sultan *et al.*, 2010, 2008; Bano *et al.*, 2009; Ahmad *et al.*, 2008; Rahim *et al.*, 2008; Hepler 2005; White and Broadley 2003).

Fig. 16 Palatability classes

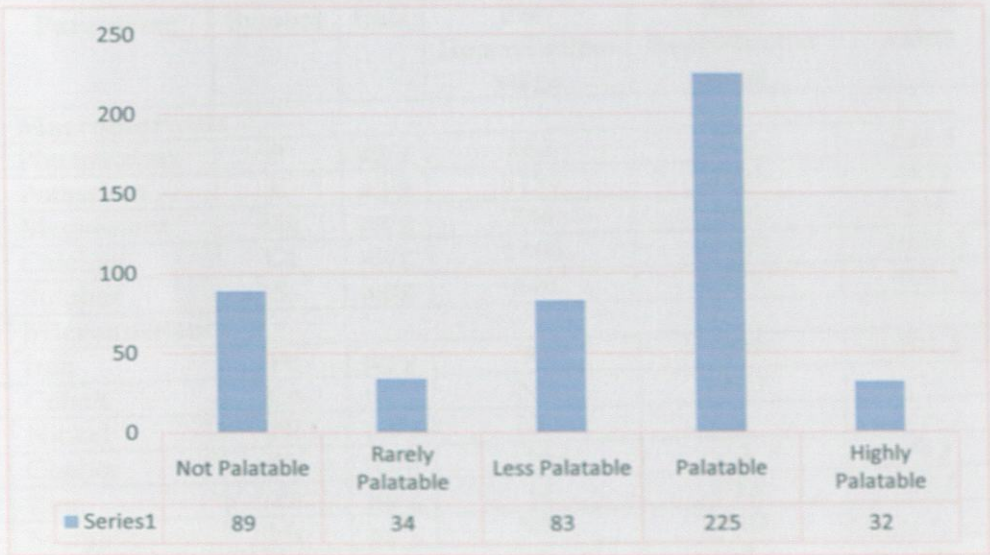


Table. 4.28 Mineral profile of *Aristida cyanantha*

S.No	Parameter	Symbol	Unit	Pre-Reproductive stage	Post-Reproductive stage	Mean value
Macronutrients						
1	Phosphorous	P	µg/g	262	215	238.5
2	Potassium	K	µg/g	6151	3591	4871
3	Magnesium	Mg	µg/g	244	264	254
4	Calcium	Ca	µg/g	1460	1789	1624.5
5	Sulphur	S	µg/g	440	379	409.5
Micronutrients						
6	Iron	Fe	µg/g	94	109	101.5
7	Cobalt	Co	µg/g	ND	ND	-
8	Nickel	Ni	µg/g	ND	1	-
9	Copper	Cu	µg/g	16	3	9.5
10	Zinc	Zn	µg/g	14	13	13.5
11	Molybdenum	Mo	µg/g	ND	ND	-
12	Manganese	Mn	µg/g	5	7	6
Trace elements						
13	Sodium	Na	µg/g	21	76	48.5
14	Silicon	Si	µg/g	66	75	70.5
15	Barium	B	µg/g	2	17	9.5

Table. 4.29 Mineral profile of *Andrachne cordifolia*

S.No	Parameter	Symbol	Unit	Pre-Reproductive stage	Post-Reproductive stage	Mean value
Macronutrients						
1	Phosphorous	P	µg/g	381	574	477.5
2	Potassium	K	µg/g	12659	6187	9423
3	Magnesium	Mg	µg/g	4146	1612	2879
4	Calcium	Ca	µg/g	17723	11914	14818.5
5	Sulphur	S	µg/g	1198	822	1010
Micronutrients						
6	Iron	Fe	µg/g	349	284	316.5
7	Cobalt	Co	µg/g	ND	ND	-
8	Nickel	Ni	µg/g	1	1	1
9	Copper	Cu	µg/g	23	4	13.5
10	Zinc	Zn	µg/g	32	20	26
11	Molybdenum	Mo	µg/g	ND	ND	-
12	Manganese	Mn	µg/g	30	31	30.5
Trace elements						
13	Sodium	Na	µg/g	276	66	171
14	Silicon	Si	µg/g	8	9	8.5
15	Barium	B	µg/g	37	12	24.5

Table 4.30 Mineral profile of *Quercus baloot*

S.No	Parameter	Symbol	Unit	Pre-Reproductive stage	Post-Reproductive stage	Mean value
Macronutrients						
1	Phosphorous	P	µg/g	377	965	671
2	Potassium	K	µg/g	5696	4664	5180
3	Magnesium	Mg	µg/g	1597	1968	1782
4	Calcium	Ca	µg/g	10905	7205	9055
5	Sulphur	S	µg/g	719	654	686.5
Micronutrients						
6	Iron	Fe	µg/g	147	364	255.5
7	Cobalt	Co	µg/g	ND	ND	-
8	Nickel	Ni	µg/g	1	3	2
9	Copper	Cu	µg/g	8	6	7
10	Zinc	Zn	µg/g	14	18	16
11	Molybdenum	Mo	µg/g	ND	ND	-
12	Manganese	Mn	µg/g	65	139	102
Trace elements						
13	Sodium	Na	µg/g	4	33	18.5
14	Silicon	Si	µg/g	11	39	25
15	Barium	B	µg/g	37	17	27

Table. 4.31 Minera profile of *Indigofera heterantha* var. *heterantha*

S.No	Parameter	Symbol	Unit	Pre-Reproductive stage	Post-Reproductive stage	Mean value
Macronutrients						
1	Phosphorous	P	µg/g	344	1019	681.5
2	Potassium	K	µg/g	3654	8274	5964
3	Magnesium	Mg	µg/g	3729	4344	4036.5
4	Calcium	Ca	µg/g	29802	35269	32535
5	Sulphur	S	µg/g	696	3970	2333
Micronutrients						
6	Iron	Fe	µg/g	136	179	225.5
7	Cobalt	Co	µg/g	ND	ND	-
8	Nickel	Ni	µg/g	2	2	2
9	Copper	Cu	µg/g	5	8	6.5
10	Zinc	Zn	µg/g	13	20	16.5
11	Molybdenum	Mo	µg/g	ND	ND	-
12	Manganese	Mn	µg/g	18	53	35.5
Trace elements						
13	Sodium	Na	µg/g	146	60	103
14	Silicon	Si	µg/g	205	94	149.5
15	Barium	B	µg/g	47	32	39.5

Table. 4.32 mineral profile of *Cotoneaster nummularia*

S.No	Parameter	Symbol	Unit	Pre-Reproductive stage	Post-Reproductive stage	Mean value
	Macronutrients					
1	Phosphorous	P	µg/g	632	551	591.5
2	Potassium	K	µg/g	7173	8393	7783
3	Magnesium	Mg	µg/g	3756	2101	2928.5
4	Calcium	Ca	µg/g	18460	14127	16293.6
5	Sulphur	S	µg/g	659	916	787.5
	Micronutrients					
6	Iron	Fe	µg/g	188	281	234.5
7	Cobalt	Co	µg/g	ND	ND	-
8	Nickel	Ni	µg/g	3	1	2
9	Copper	Cu	µg/g	13	5	9
10	Zinc	Zn	µg/g	29	18	23.5
11	Molybdenum	Mo	µg/g	ND	ND	-
12	Manganese	Mn	µg/g	24	30	27
	Trace elements					
13	Sodium	Na	µg/g	95	41	68
14	Silicon	Si	µg/g	171	16	93.5
15	Barium	B	µg/g	52	32	84

Fig. 17 Macro- Micronutrients and trace element analysis of *Aristida cyanantha*

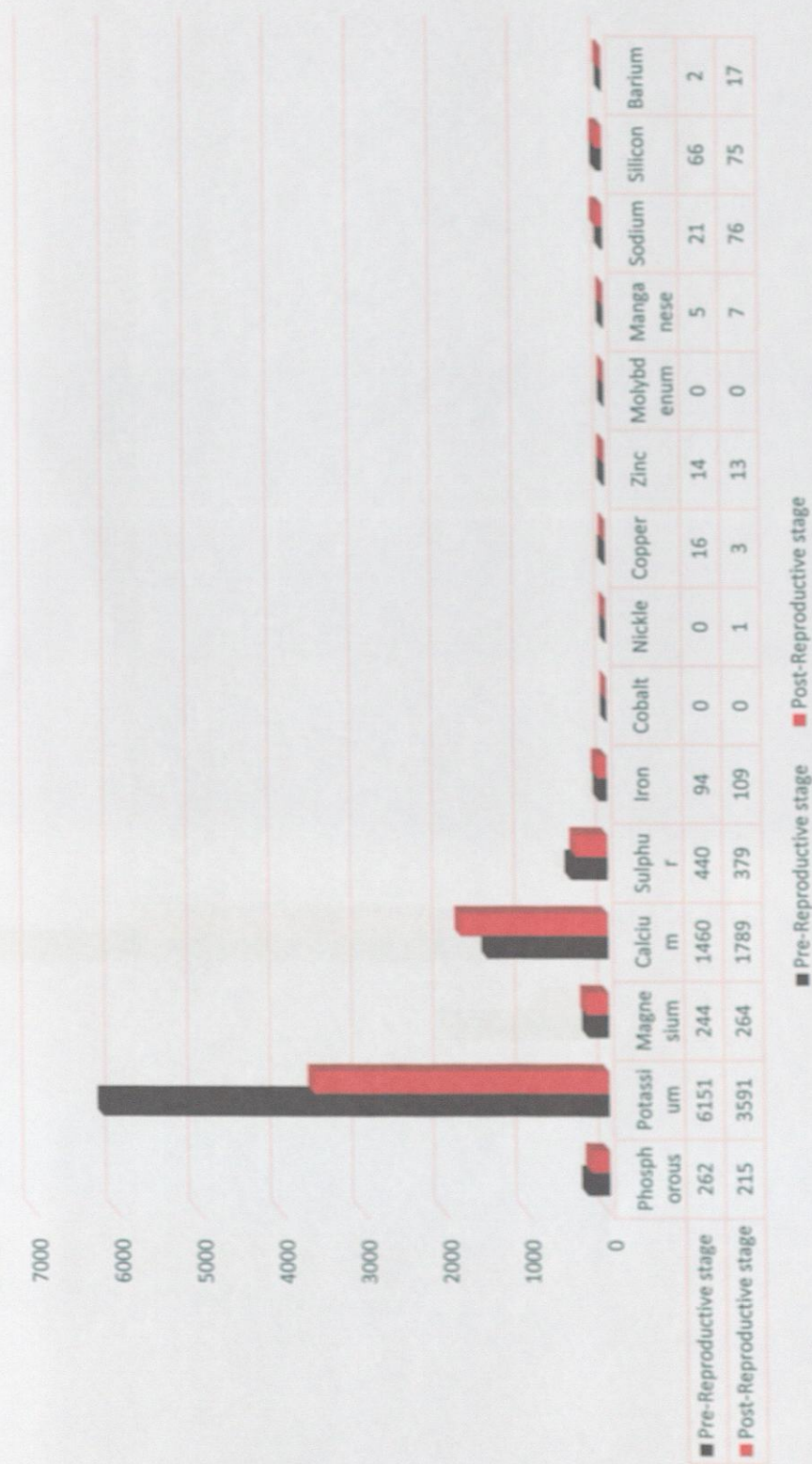


Fig. 18 Macro- Micronutrients and trace element analysis *Andrachne cordifolia*

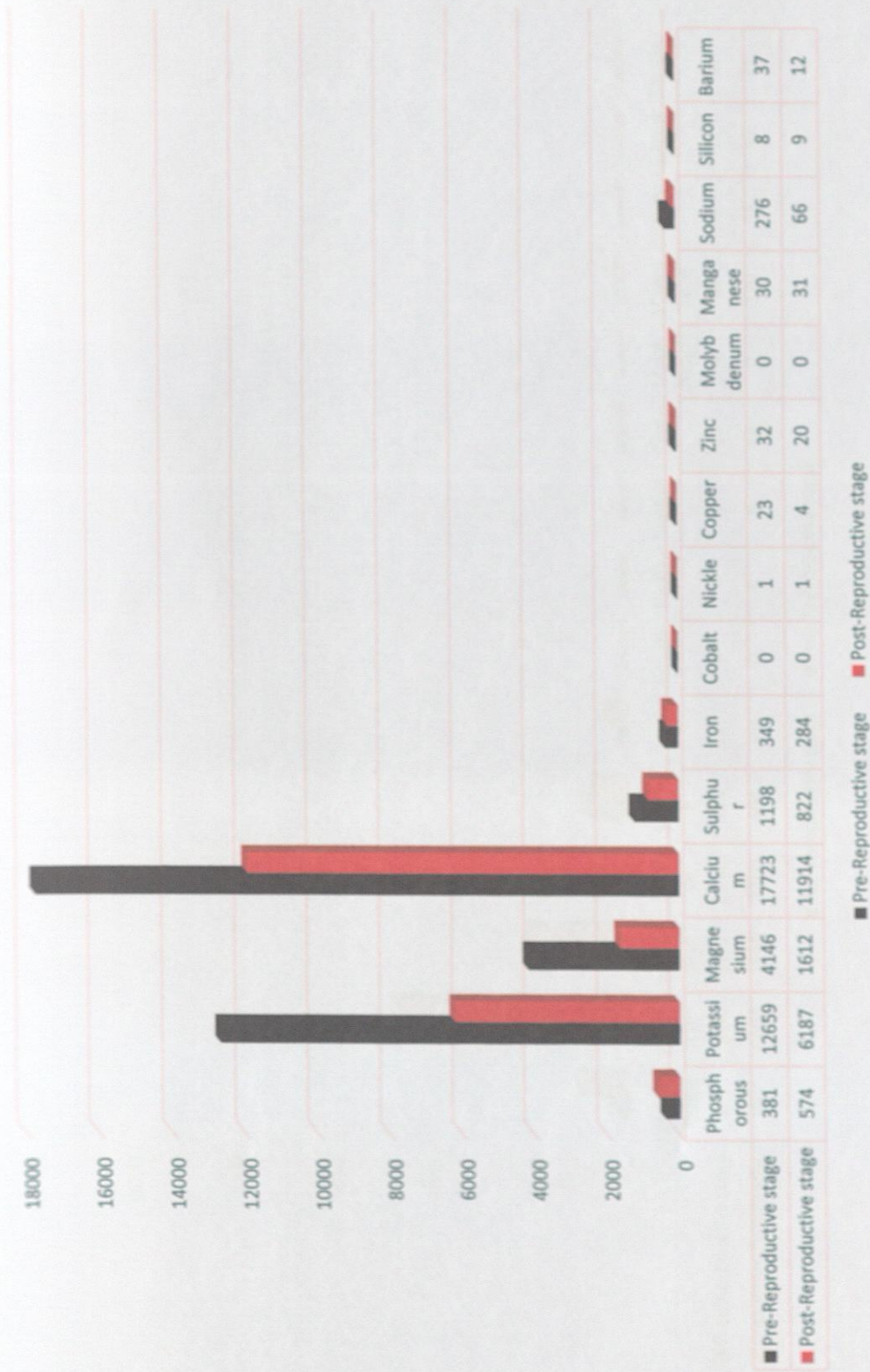


Fig. 19 Macro- Micronutrients and trace element analysis *Quercus baloot*

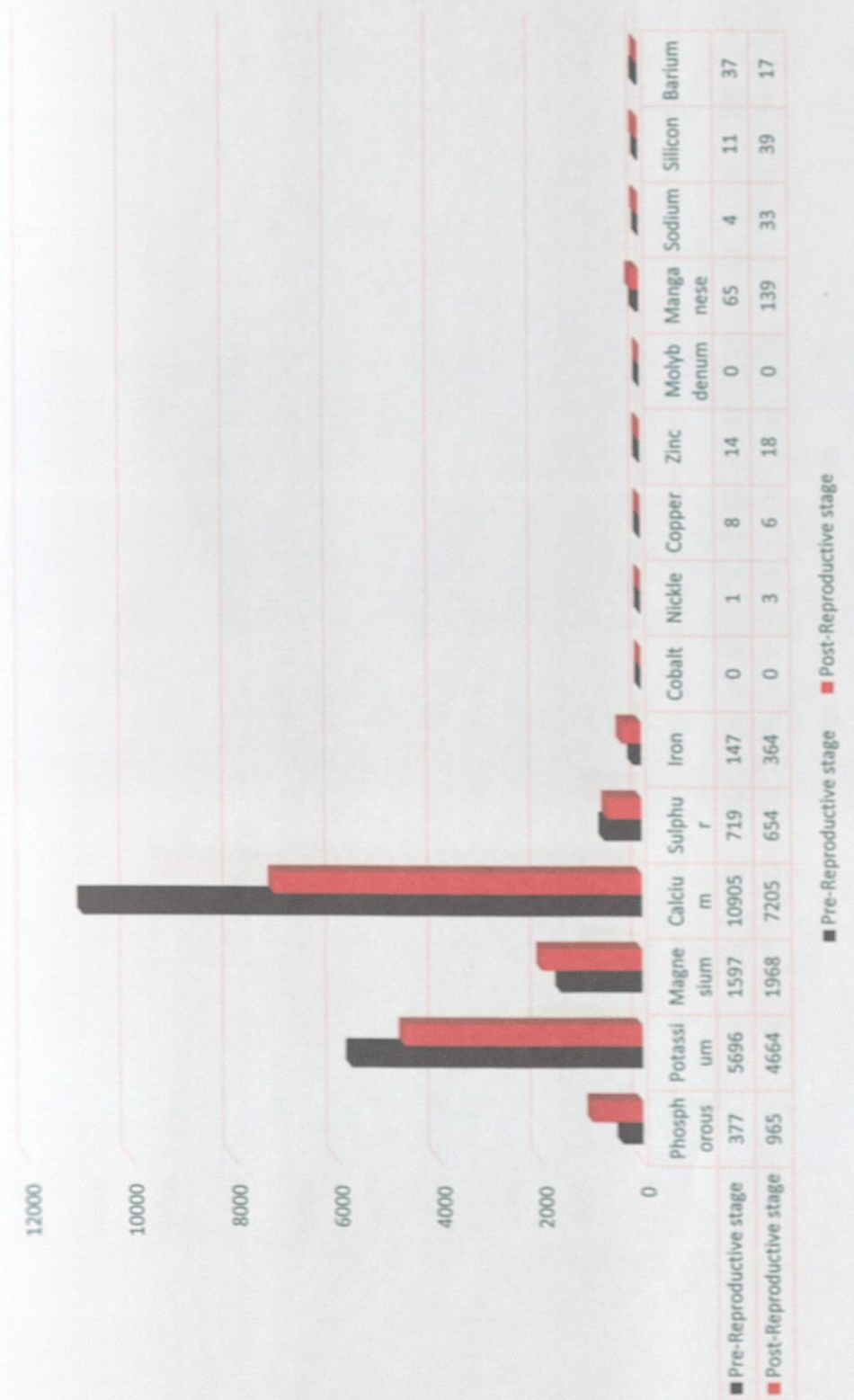


Fig. 20 Macro- Micronutrients and trace element analysis *Indigofera heterantha* var. *heterantha*

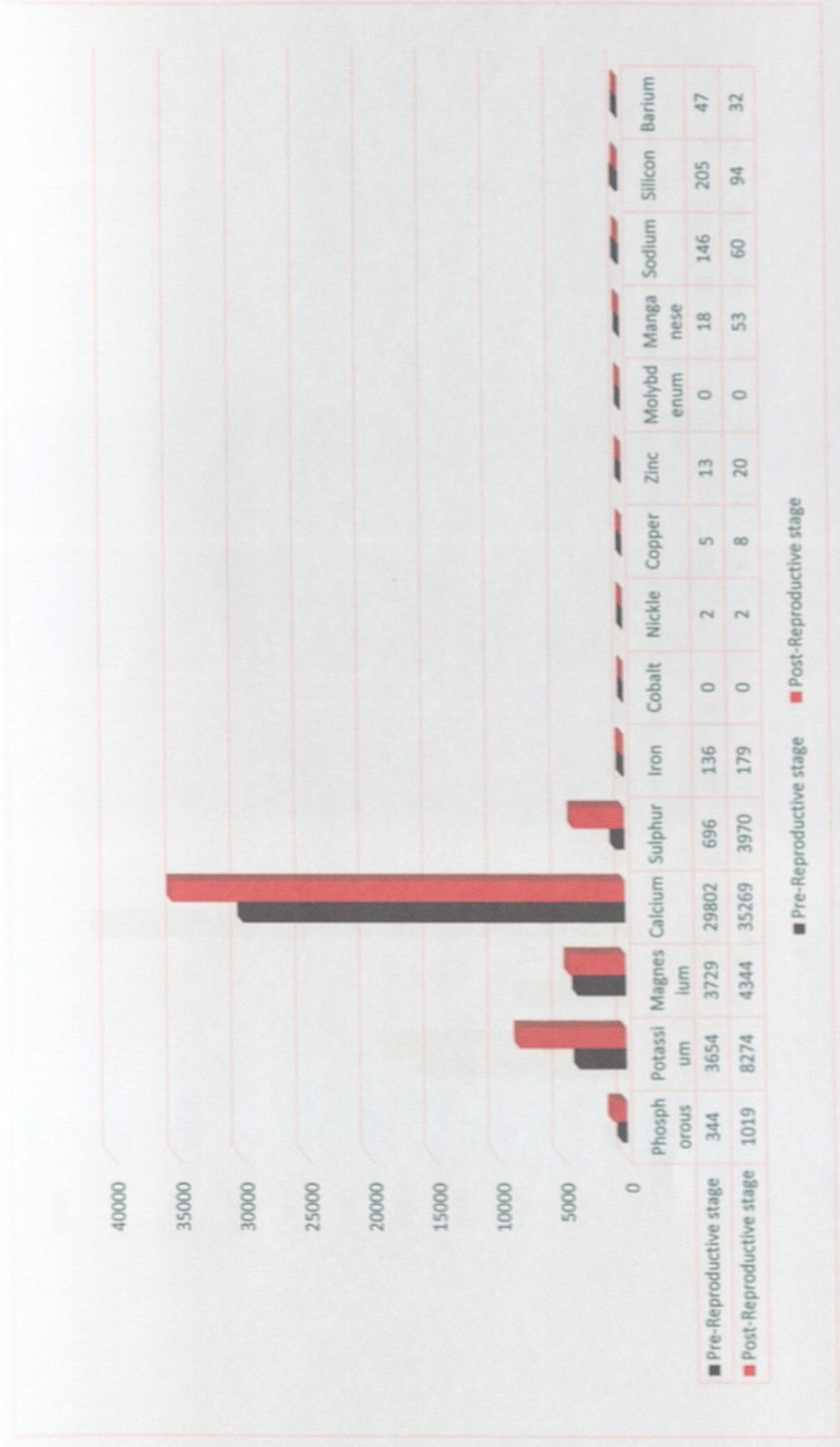


Fig. 21 Macro- Micronutrients and trace element analysis *Cotoneaster nummularia*

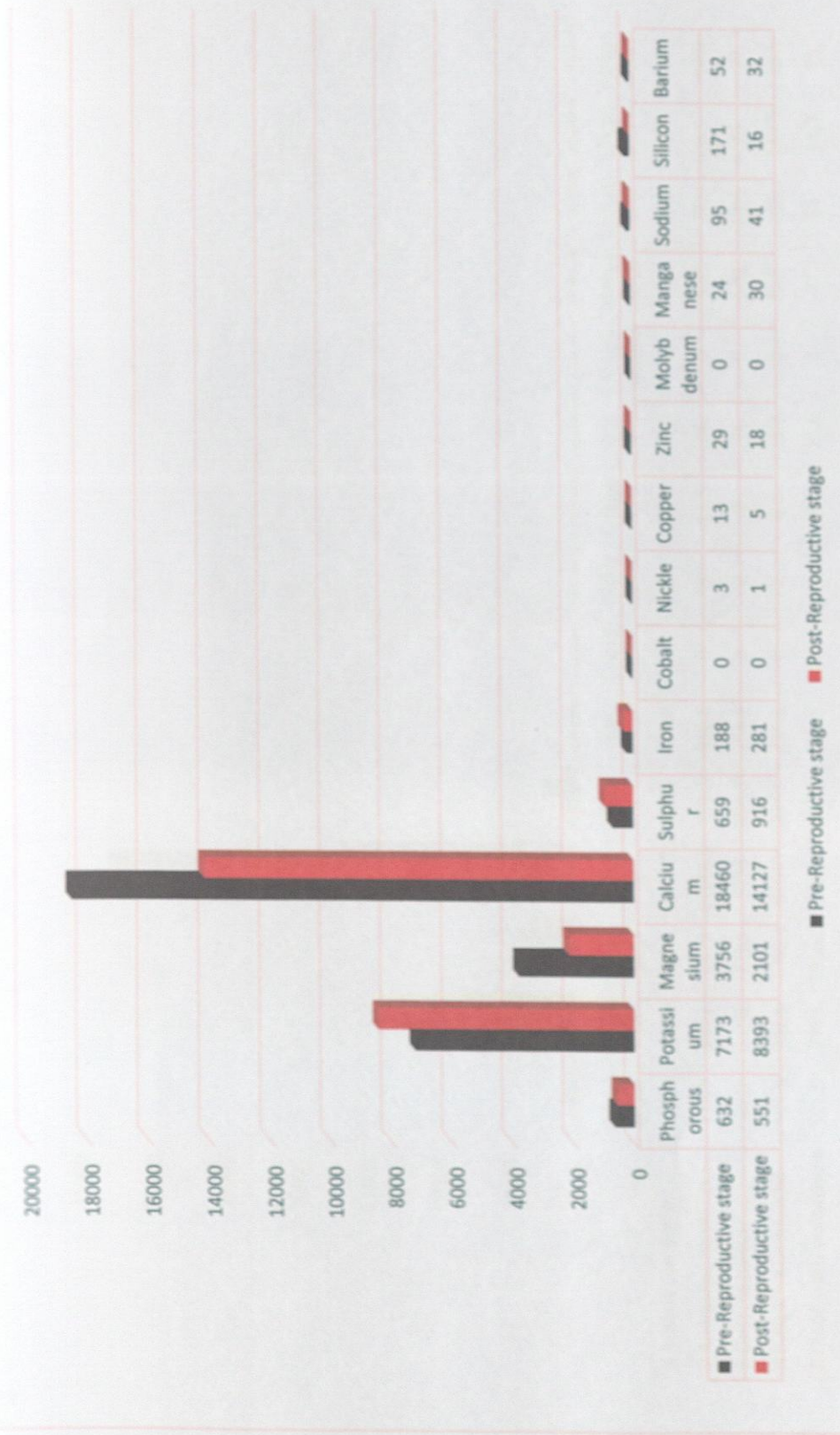
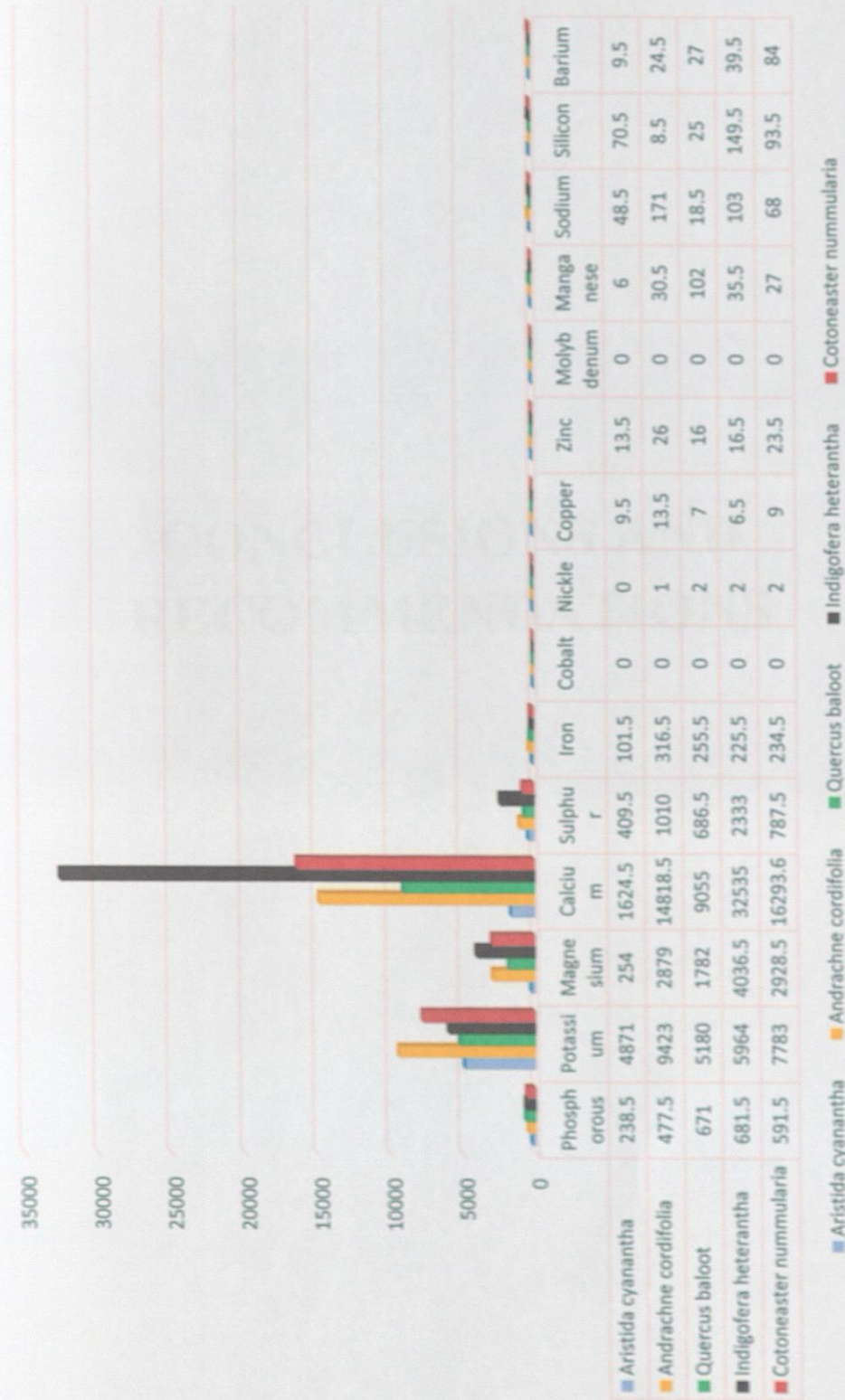


Fig. 22 Mean Values for minerals in all plants analyzed



1. The study was carried out during 1994-1995 in various wetlands in the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
2. The study was carried out in the wetlands of the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
3. On the basis of the study, the following conclusions were drawn: (1) The waterbirds in the wetlands of the Yangtze River Delta, China, are distributed in a patchy manner. (2) The waterbirds in the wetlands of the Yangtze River Delta, China, are distributed in a patchy manner.

CONCLUSIONS AND RECOMMENDATIONS

1. The study was carried out during 1994-1995 in various wetlands in the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
2. The study was carried out in the wetlands of the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
3. On the basis of the study, the following conclusions were drawn: (1) The waterbirds in the wetlands of the Yangtze River Delta, China, are distributed in a patchy manner. (2) The waterbirds in the wetlands of the Yangtze River Delta, China, are distributed in a patchy manner.
4. The study was carried out during 1994-1995 in various wetlands in the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
5. The study was carried out in the wetlands of the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
6. On the basis of the study, the following conclusions were drawn: (1) The waterbirds in the wetlands of the Yangtze River Delta, China, are distributed in a patchy manner. (2) The waterbirds in the wetlands of the Yangtze River Delta, China, are distributed in a patchy manner.
7. The study was carried out during 1994-1995 in various wetlands in the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.
8. The study was carried out in the wetlands of the Yangtze River Delta, China, to study the distribution and abundance of the waterbirds in the wetlands.

Conclusions

1. This study was carried out during 2012-2015 to explore the floristic composition, ethnobotany, edaphology, plant palatability and vegetation structure of Chail valley, District Swat.
2. The study revealed that flora of study area is composed of 104 families, 332 genera and 463 plant species of higher vascular plants. These plants belong to 17 families of monocotyledons represented by 70 species and 84 families of Dicotyledons represented by 384 species. Gymnosperms contributed 9 species belonging to 3 families.
3. On the basis of species richness largest families were Asteraceae, Poaceae, Rosaceae, Lamiaceae, Papilionaceae, Brassicaceae, Boraginaceae and Apiaceae. While on the basis of FIV dominant families were Pinaceae, Fagaceae, Juglandaceae and Ebenaceae among trees; Rosaceae, Papilionaceae, Hamamelidaceae and Berberidaceae among shrubs; Poaceae, Asteraceae, Lamiaceae and Papilionaceae among herbs.
4. Therophytes dominated the landscape followed by hemicryptophytes, nanophanerophytes, geophytes, chamaephytes, mesophanerophytes, megaphanerophytes and microphanerophytes. Based on leaf forms mesophylls were dominant followed by microphylls, nanophylls, leptophylls, macrophylls and megaphylls. There were only two aphyllous plants encountered during this study, which is in line with the climate of the area.
5. Study area is rich in terms of ethnoflora. A total of 174 plants of ethnomedicinal importance were documented which are used as diuretic, carminative, laxative, cardiac tonic, antidiabetic, anthelmintic, expectorant, antipyretic, liver tonic, oral inflammations, nerve tonic and aphrodisiac.
6. Soil texture varied in different monitoring sites from loam to loamy sand to silt loam while pH ranged between 5.2-6 showing podzolic nature of soils, characteristic of this region.
7. Lack of alternative sources of energy compel the local people of locality to extract fuel wood and timber that caused severe deforestation.
8. Study on plant palatability revealed 225 plants were palatable, 32 plants were highly palatable, 83 plants were less palatable and 34 plants were rarely palatable while 89 plants were not palatable.

9. Though area has plenty of palatable plants but area is over grazed. Grazing pressure coupled with deforestation is fast eroding the vegetation cover which may pose a serious threat in years to come.
10. Vegetation study resulted in establishing 15 plant communities, 5 each for trees, shrubs and herbs. On the basis of PC-Ord Ward's cluster analysis there were 3 communities of trees and 4 communities of understory plants.
11. Plant communities varied in physiognomy mainly due to edaphic characteristics and soil macro-micronutrient profile.
12. Titanium concentration was high but within permissible limits. Silver was present in traces.
13. Grazing area need measures to ensure its longevity as palatable plants are under stress.
14. Conservation status of ethnoflora was assessed through IUCN criterion. Improper collection methods and overuse has resulted in putting tremendous stress on ethnoflora. None of the plants came under the dominant category, 107 plants were rare, 42 were rare and 24 were infrequent. One plant was declared as endangered.

Recommendations

1. Reforestation programs need to be initiated in the area to protect and conserve the indigenous floristic wealth. But extreme care in this regard is suggested so that no alien plant species is introduced as it will further increase stress on plants in the locality.
2. Well trained Ecologists should be invited to chart out a plan for conservation of biodiversity in the study area.
3. Proper grazing management be ensured for regeneration of understory plants. Influential elders of the area can play a vital part in protection of climax communities as well as in enforcing moderate and rotational grazing routines.
4. Provision of alternative sources of energy to the locals will reduce pressure on populations of *Pinus* sp. *Cedrus deodara*, *Picea smithiana*, *Abies pindrow* and other tree species. This will in turn reduce the extent of deforestation in the locality.
5. A strict ban on extraction of fuel wood and timber is advocated for next 7 years to protect the floristic wealth and associated fauna.
6. Effective measures are needed to check the soil erosion.
7. Study area is rich in ethnoflora but need of the day is to educate people about proper collection methods and to avoid over use of medicinal plants. Introduction of improved varieties of livestock will elevate economic standards of the people.
8. A balance between human influences, food supply, improved livestock and moderate grazing regimes will be of huge benefit for rangeland sustainability.
9. A healthy nexus of governmental and non-governmental organizations in capacity building, promoting research and framing integrated management plans will improve the socioeconomic status of the people of study area.
10. Timely policies regarding ecotourism will uplift the socioeconomic standards and per capita income of the local inhabitants.
11. Vegetation structure is suggestive that local flora is fighting a war of its survival. Once covered beneath a thick vegetation blanket now bare patches are visible on mountain slopes. In order to protect local ecosystem, long term planning is recommended.

References

- Abbas, Q., R. Qureshi, A. N. Naqvi, S. W. Khan and I. Hussain. 2013. Floristic inventory and ethnobotanical study of Naltar valley (Karakoram Range), Gilgit, Pakistan. *Pak. J. Bot.*, 45(SI): 269-277.
- Abbasi, M. K., M. M. Tahir, A. H. Shah and F. T. Batool. 2009. Mineral nutrient composition of different ecotypes of white clover and their nutrient credit to soil at Rawalakot Azad Jammu and Kashmir. *Pak. J. Bot.*, 41 (1): 41-51.
- Abreu, C. A., M. Cantoni, A. R. Coscione and J. Paz-Ferrero. 2012. Organic Matter and Barium Absorption by Plant Species Grown in an Area Polluted with Scrap Metal Residue. *Applied and Env. Soil Sci.*, Article ID 476821, 7, pages, <http://dx.doi.org/10.1155/2012/476821>
- Adam, F. B, and G. E. Crow. 2010. The Flora and vegetation of timber Island, Lake Winnepesaukee, New Hampshire, U.S.A. *Rhodora*, 112 (950): 156-190.
- Addo-Fordjour, P. S. Obeng. A. K. Anning and M. G. Addo. 2009. Floristic composition, structure and natural regeneration in a moist semi-deciduous forest following anthropogenic disturbances and plant invasion. *Int. J. Biod. & Cons.* 1(2): 021-037.
- Ahmad, E., M. Arshad, M. M. Saeed and M. Ishaque. 2004. Ethnopharmacological survey of some medicinally important plants of Galliyat areas of NWFP, Pakistan. *Asian J. Pl. Sci.*, 3(4): 410-415.
- Ahmad, I., M. Hussain, M. Sajid, A. Ahmad and M. Hameed. 2008. Spatio-temporal effects on association of plant species in Soone valley of Pakistan. *Pak. J. Bot.*, 40 (5): 1865-1876.
- Ahmad, I., M. Ibrar, Barkatullah and N. Ali. 2011. Ethnobotanical study of Tehsil Kabal, Swat District, KPK, Pakistan. *J. Bot.*, V: 2011, ID 368572, 9 pages, doi:10.1155/2011/368572.
- Ahmad, K. S., M. Ahmad, F. Ahmad and B. Sadia. 2016. Edaphic factors as major determinants of plant distribution of Temperate Himalayan grasses. *Pak. J. Bot.*, 48(2): 567-573.
- Ahmad, K., Z. I. Khan, A. Ashfaq, M. Ashraf and S. Yasmin. 2014. Assessment of heavy metal and metalloid levels in Spinach (*Spinacia oleracea* L.) growth in wastewater irrigated agricultural soil of Sargodha, Pakistan. *Pak. J. Bot.*, 46(5): 1805-1810.

- Ahmad, K., Z. I. Khan, M. Ashraf, M. Hussain, M. Ibrahim and E. E. Valeem. 2008. Status of plant diversity at Kufri (Soone Valley) Punjab, Pakistan and prevailing threats therein. *Pak. J. Bot.*, 40 (3): 993-997.
- Ahmad, M. and S. S. Shaukat. A textbook of vegetation ecology. 2012. Abrar sons, Karachi, Pakistan. pp: 302-305. ISBN 978-969-9629-00-6
- Ahmad, M., K. Nazim, M. F. Siddiqui, M. Wahab, N. Khan, M. U. Khan and S. S. Hussain. 2010. Community description of Deodar forests from Himalayan range of Pakistan. *Pak. J. Bot.*, 42(5): 3091-3102.
- Ahmad, M., S. S. Shoukat and D. Khan. 2010. Status of vegetation analysis in Pakistan. *Int. J. Biol. Biotech.*, 7 (3): 147-158.
- Ahmad, M., S. Sultana, S. F. Hadi, T. B. Hadda, S. Rashid, M. Zafar, M. A. Khan, M. P. Z. Khan and J. Yaseen. 2014. An ethnobotanical study of medicinal plants of high mountainous region of Chail Valley, District Swat, Pakistan. *J. Ethnobiol. & Ethnomed.*, 10:36: 1-18.
- Ahmad, M., T. Husain, A. H. Sheikh, S. S. Hussain and M. F. Siddiqui. 2006. Phytosociology and structure of Himalayan forests from different climatic zones of Pakistan. *Pak. J. Bot.*, 38(2): 361-383.
- Ahmad, N., S. Anwar, H. Fazal and B. H. Abbasi. 2013. Medicinal plants used in indigenous therapy by people of Madyan Valley in District Swat, Pakistan. *Int. J. Med. Arom. Plants*, 3(1): 47-54.
- Ahmad, S. S. 2009. Ordination and classification of herbaceous vegetation in Margalla Hills National Park Islamabad Pakistan. *Bio. Div. Cons.*, 2(2): 38-44.
- Ahmad, S. S., A. Wahid and K. F. Akbar. 2010. Multivariate classification and data analysis of vegetation along Motorway (M-2), Pakistan. *Pak. J. Bot.*, 42 (2): 1173-1185.
- Ahmad, S., M. Islam, G. Bano, S. Aslam and S. Koukab. 2009. Seasonal variation in current season and dead biomass of *Chrysopogon aucheri* (Boiss) Stapf in highland Baluchistan. *Pak. J. Bot.*, 41 (2): 519-528.
- Ahmad, S., N. Khan, M. Wahab and K. Nazim. 2010. Vegetation studies of selective graveyards of Upper Swat. *Int. J. Bio. Biotech.*, 7(3): 211-217.
- Ahmad, K., Z. I. Khan, M. Ashraf and A. Ejaz. 2012. Appraisal of temporal variation in soil and forage Iron and Zinc in a pasture under semi-arid environmental conditions. *Pak. J. Bot.*, 44(1): 157-160.

- Ahmed, M., and S. A. Qadir. 1976. Phytosociological studies along the way of Gilgit to Gopis, Yasin and Phunder. *Pak. J. of Fores.*, 26: 93-104.
- Ahmed, M., S. S. Shaukat and F. M. Siddiqui. 2011. A Multivariate analysis of the Vegetation of *Cedrus deodara* forests in Hindukush and Himalayan ranges of Pakistan: Evaluating the structure and dynamics. *Turk. J. Bot.*, 35: 419-438.
- Ahmed, M., T. Hussain, A. H. Sheikh, S.S. Hussain and M. F. Siddiqui. 2006. Phytosociology and structure of Himalayan forests from different climatic zones of Pakistan. *Pak. J. Bot.*, 38: 361-383.
- Aisha, I., M. Y. Ashraf, M. Hussain, M. Ashraf, R. Ahmad and A. Kamal. 2015. Effect of micronutrients (Zn, Cu and B) on photosynthetic and fruit yield attributes of *Citrus reticulata* Blanco var. Kinnow. *Pak. J. Bot.*, 47(4): 1241-1247.
- Ajaib, M., H. Bakhsh and M. F. Siddiqui. 2015. Ethnobotanical studies on herbaceous plants of Tehsil Ahmad Pur East, District Bahawalpur, Pakistan. *Int. J. Biol. Biotech.*, 12(2): 299-308.
- Ajaib, M., S. K. Haider, A. Zikrea and M. F. Siddiqui. 2014. Ethnobotanical studies on herbs of Agra Valley, Upper Kurram Agency, Pakistan. *Int. J. Biol. Biotech.*, 11(1): 71-83.
- Ajaib, M, Z. U Khan, N. Khan and M. Wahab. 2010. Ethnobotanical studies on useful shrubs of District Kotli, Azad Jammu & Kashmir, Pakistan. *Pak. J. Bot.*, 42 (3): 1407-1415.
- Akbar, M., M. Ahmed, A. Hussain, M.U. Zafar and M. Khan. 2011. Quantitative forests description from Skardu, Gilgit and Astore Districts of Gilgit-Baltistan, Pakistan. *FUUAST. J. Bio.* 1:149-160.
- Akhtar, N. and E. Bergmeier. 2015. Species richness, alpha and beta diversity of trees, shrubs and herbaceous plants in the woodlands of Swat, Pakistan. *Pak. J. Bot.*, 47(6): 2107-2113.
- Akhtar, N. and S. Begum. 2009. Ethnopharmacological important plants of Jalala, District Mardan, Pakistan. *Pak. J. Pl. Sci.*, 15 (2): 95-100.
- Akram, M., M. A. Kahlowan and Z. A. Soomro. 2009. Desertification control for sustainable land use in the Cholistan Desert, Pakistan. *Earth & Envrm. Science*, 6: 483-492.
- Alam, N., Z. K. Shinwari, M. Ilyas and M. Zahidullah. 2011. Indigenous knowledge of medicinal plants of Chagharzai Valley, District Buner, Pakistan. *Pak. J. Bot.*, 43(2): 773-780.

- Alam, J. and S. I. Ali. 2010. Contribution to the red list of the plants of Pakistan. *Pak. J. Bot.*, 42: 2967–2971.
- Ali, H. and M. Qaiser. 2010. Contribution to the Red List of Pakistan. A case study of *Astragalus gahiratensis* Ali (Fabaceae-Papilionoideae). *Pak. J. Bot.*, 42 (3): 1523- 1528.
- Ali, H. and M. Qaiser. 2009. The Ethnobotany of Chitral Valley, Pakistan with special reference to medicinal plants. *Pak. J. Bot.*, 41(4): 2009-2041.
- Ali, K., M. Arif, M. T. Jan, T. Yaseen, M. Waqas and F. Munsif. 2015. Biochar: A novel tool to enhance wheat productivity and soil fertility on sustainable basis under wheat-maize-wheat cropping system *Pak. J. Bot.*, 47(3): 1023-1031.
- Ali, K., N. Khan., I. Rahman, H. Ahmad and S. Jury. 2015. Multivariate analysis and vegetation mapping of a biodiversity hotspot in the Hindu Kush Mountains. *Int. J. Advan. Res.*, 3 (6): 990-1006.
- Ali, S. I. 2008. The significance of flora with special reference to Pakistan. *Pak. J. Bot.*, 40(30): 967-971.
- Ali, S., A. Perveen and M. Qaiser. 2015. Vegetation structure, edaphology and ethnobotany of Mahaban and Malka (District Buner) KPK, Pakistan. *Pak. J. Bot.*, 47(SI): 15-22.
- Ali, S. M and R. N. Malik. 2010. Vegetation communities of urban open spaces: Green belts and parks in Islamabad city. *Pak. J. Bot.*, 42 (2): 1031-1039.
- Ali, S. I. and M. Qaiser. 1986. A phytogeographic analysis of the phanerogams of Pakistan and Kashmir. *Proceeding of the Royal society of Edinburgh*, 89B: 89-101.
- Ali, S. I. and M. Qaiser (Eds.). 1995-2015. *Flora of Pakistan* (1-220). Department of Botany, University of Karachi.
- Ali, S.I. and Y.J. Nasir (Eds.). 1989-1992. *Flora of Pakistan*. Islamabad, Karachi.
- Alshammary, S. F. 2008. Effect of saline irrigation on growth characteristics and mineral composition of two local halophytes under Saudi environmental conditions. *Pak. J. Biol. Sciences*, 11 (17): 2116-2121.
- Alsherif, A. E. Ahmad. A. M. and S. M. Rawi. 2013. Floristic composition, life form and chorology of plant life at Khulais Region, Western Saudi Arabia. *Pak. J. Bot.*, 45(1): 29-38.

- Altay, V., I. I. Ozyigit, M. Keskin, G. Demir and I. E. Yalcin. 2013. An ecological study on endemic plant *Polygonum istanbolicum* and its environs. *Pak. J. Bot.*, 45(SI): 455-459.
- Altay, V., I. I. Ozyigit and C. Yarc. 2012. Plant Communities in urban habitats of Istanbul, Turkey. *Pak. J. Bot.*, 44(SI): 177-186.
- Amjad, M., Arshad, M. Shoaib and I. A. Qamar. 2013. Phytosociology of *Pinus-Quercus* Forest Vegetation of Nikyal Hills, District Kotli, Azad Kashmir, Pakistan. *I. J. Agri. Crop Sci. comm., IJACS* 5-24/2952-2960.
- Angassa, A. 2005. The ecological impact of bush encroachment on the yield of grasses in Borana rangeland ecosystem. *Afri. J. Eco.*, 43 (1): 14-20
- Angassa, A. and R. M. T. Baars. 2001. Ecological condition of encroached and non-encroached rangelands in Borana, Ethiopia. *African J. Ecology*, 38 (4): 321-328.
- Antje, B., J. K. Esler, P. Eugene and B. Phoebe. 2003. Species richness and floristic relationships between mesas and their surroundings in southern African Nama Karoo. *Diversity & Distributions*, 9 (1): 43-53.
- Antje, B. 2002. Determinants of inselberg floras in arid Nama Karoo landscapes. *J. Biogeography*, 28 (10): 1211-1220.
- Anyasi, R. and H. Atagana. 2014. Enhancing growth performance of *Chromolaena odorata* in two soil samples by using cow manure as amendment. *Pak. J. Bot.*, 46(5): 1771-1779.
- Arain, M. A., M. Ahmad and M. A. Khan. 2000. Some physicochemical characteristics of soil in sugarcane cultivated areas of Nawabshah, Sindh, Pakistan. *Pak. J. Bot.*, 32(1): 93-100.
- Arenas, P. and G. F. Scarpa. 2007. Edible wild plants of the Chorote Indians, Gran Chaco, Argentina. *Botanical J. Linn. Society*, 153 (1): 73-85.
- Arshad, M., G. Murtaza, M. A. Ali, M. Shafiq, C. Dumat and N. Ahmad. 2011. Wheat growth and phytoavailability of copper and zinc as affected by soil texture in saline-sodic conditions. *Pak. J. Bot.*, 43(5): 2433-2439.
- Arshad, M., A. U. Hussan, M. Y. Ashraf, S. Noureen and M. Moazzam. 2008. Edaphic factors and distribution of vegetation in the Cholistan desert, Pakistan. *Pak. J. Bot.*, 40 (5): 1923-1931.
- Ashraf, R. and T. A. Ali. 2007. Effect of heavy metals on soil microbial community and Mung Beans seed germination. *Pak. J. Bot.*, 39(2): 629-636.

- Asner, G. P., E. N. Broadbent, P. J. C. Oliveira, M. Keller, D.E. Knapp and J. N. M. Silva. 2006. Condition and fate of logged forests in the Brazilian Amazon. *Proc. Nat. Acad. Sci.*, 103: 12947- 12950.
- ATSDR. 1990. Toxicological profile for silver. Atlanta, GA, US Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (TP-90-24).
- Attullah, Wazir. S. M. and A. Farooq. 2010. Ethnobotanical survey of plants of Kurram River beds of District Bannu, Pakistan. *Pak. J. Pl. Sci.*, 16 (1): 25-18.
- Awan, M. R., N.A. Raja and M. Idris. 2001. Cluster analysis of vegetation of Swat District. *Pak. J. Sci. Ind. Res.*, 44 (1): 42-51.
- Badshah, L., F. Hussain and Z. Sher. 2016. Floristic inventory, ecological characteristics and biological spectrum of plants of Parachinar, Kurram Agency, Pakistan. *Pak. J. Bot.*, 48(4): 1547-1558.
- Badshah, L. Hussain. F. and Sher. Z. 2013. Floristic inventory, ecological characteristics and biological spectrum of rangeland, District Tank, Pakistan. *Pak. J. Bot.*, 45(4): 1159-1168.
- Badshah, L., F. Hussain and Z. Sher. 2012. An overview of people plant interaction in rangeland of District Tank, Pakistan. *J. Med. Pl. Res.*, 6(14): 2820-2826.
- Badshah, L., F. Hussain and N. Akhtar. 2010a. Vegetation structure of subtropical forest of Tabai, South Waziristan, Pakistan. *Front. Agri. China*, 4 (2): 232-236.
- Badshah, L., M. Ibrar and F. Hussain. 2010b. An ethnobotanical study on the usage of wild medicinal herbs from Malana hills, Parachinar, Kurram Valley. *J. Biol. Biotech.*, 7 (3): 267-271.
- Badshah, L. and N. Hussain. 2008. Indigenous remedies for women and child diseases in the village Tabai South Waziristan, Pakistan. *Pak. J. Pl. Sci.*, 14 (2): 97-100.
- Badshah, L., F. Hussain, G. Dastagir and T. Burni. 2006. Ethnobotany of fuel wood plants of Ladha, South Waziristan, Pakistan. *Pak. J. Pl. Sci.*, 12 (2): 193-201.
- Baes, C. F. and R. E. Mesmer. 1976. The Hydrolysis of Cations. John Wiley & Sons, New York.
- Bakkenes, M., J. R. Alkemade, F. Ihle, R. Leemans and J.B. Latour. 2002. Assessing effects of forecasted climate change on the diversity and distribution of European higher plants for 2050. *Glo. Change Bio.*, 8 (4): 390.
- Balik J., J. Vostal and P. Tlustos. 1989. Results of TITAVIN tests for chosen crops. *Sbornik VSZ, Praha, Rada A*, 50: 143-155.

- Bano, A., M. Ayub, S. Rashid, S. Sultana and H. Sadia. 2013. Ethnobotany and conservation status of floral diversity of Himalayan range of Azad Jammu and Kashmir, Pakistan. *Pak. J. Bot.*, 45(SI): 243-251.
- Bano, G., M. Islam, S. Ahmad, S. Aslam and S. Koukab. 2009. Seasonal variation in nutritive value of *Chrysopogon aucheri* (Boiss) Stapf, and *Cymbopogon jwarancusa* (Jones) Schult, in highland Balochistan, Pakistan. *Pak. J. Bot.*, 41(2): 511-517.
- Barkatullah, M. Ibrar and F. Hussain. 2009. Ethnobotanical studies of plants of Charkotli Hills Batkhela District Malakand, Pakistan. *Front. Biol. China.*, 4(4): 539-548.
- Batalha, M.A. and F.R. Martins. 2004. Floristic frequency, and vegetation life form spectra of a Cerrado site. *Braz. J. Biol.*, 4(2): 203-209.
- Batalha, M.A. and F.R. Martins. 2002. Life-form spectra of Brazilian Cerrado sites. *Flora, Morphology, Distribution, Functional Ecology of Plants*, 197(6): 452-460.
- Beals, E. W. 1984. Bray-Curtis ordination: an effective strategy for analysis of multivariate ecological data. *Adva. Ecol. Res.*, 14: 1-55.
- Becking, L. G. M. B. 1957. The Role of Hydrogen and Oxygen in the Inorganic Environment. *Acta Biotheoretica.*, 12 (2): 71-80.
- Bhatnagar, H. P. 1965. Soil from different quality Sal (*Shorea robusta*) forests of Uttar Pradesh. *Trop. Ecol.*, 6: 56-62.
- Bhatti, G. R., S. Muqarrab and R. Qureshi. 2001. Floristic study of arid zone (Desert Nara, Region) Sindh, Pakistan. Final Technical Report, PSF Project. No. S-SALU/ENVR (45).
- Blanckaert, I. R. L. Swennen, M. Paredes Flores, R. Rosas Lopez and Lira Saade. 2004. Floristic composition, plant uses and management practices in homegardens of San Rafael Coxactlan Valley of Tehuacan-Cuicatlan, Mexico. *Journal of Arid Environments*. 57(2004): 39-62.
- Bokhari, T. Z., Y. Liu, M. Ahmad, M. F. Siddiqui, Q. Li, Z. Khan and S. A. Malik. 2016. Multivariate analysis of some Pine forested areas of Azad Kashmir, Pakistan. *Pak. J. Bot.*, 48(1): 105-113.
- Bouyoucos, G. J. 1936. Directions for making mechanical analysis of soils by the hydrometer method. *Soil Sci.*, 42: 225-228.

- Brady, N. C. 1990. *The Nature and Properties of Soils*. 10th ed. Macmillan Publishing Co. New York, NY. 621 p
- Bremner, J. M., and C. S. Mulvaney. 1982. Nitrogen - Total. In: *Methods of Soil Analysis* (A. L. Page *et al.*, Ed.). Agronomy Monograph 9, Part 2, 2nd ed. American Society of Agronomy, Madison, WI. pp. 595-624.
- Brereton, A. J., N. M. Holden, D. A. McGilloway and O. T. Carton. 2005. A model describing the utilization of herbage by cattle in a rotational grazing system. *Grass & Forage Sci.*, 60 (4): 367-384.
- Bridges, E. M. 1978. *World soils*. 2d. Ed. Cambridge. Cambridge University Press.
- Brits, J., M. W. V. Rouen and N. V. Rooyen. 2002. Ecological impact of large herbivores on the woody vegetation at selected watering points on the eastern basaltic soils in the Kruger National Park. *Afr. J. Eco.*, 40 (1): 53-60.
- Brown, L. R. and G. J. Bredenkamp. 2004. The use of structural species size classes in the description of the woody vegetation of a nature reserve. *Afri. J. Eco.*, 42 (4): 252-269.
- Cain, S. A. and G. M. Castro. 1959. *Manual of Vegetation analysis*. Harper, NY pp. 325.
- Carvajal, M. and C. F. Alcaraz. 1998. Why is titanium a beneficial element for plants? *Journal of Plant Nutrition*. 21: 655-664.
- Carvalho, D. and I. M. M. Saraiva. 2005. Effects of water stress on the proximate composition and mineral contents of seeds of two lupins (*Lupinus albus* and *Lupinus mutabilis*). *J. Food Quality*, 28 (4): 325-332.
- Chamizo, S., Y. Canton, I. Miralles and F. Domingo. 2012. Biological soil crust development affects physicochemical characteristics of soil surface in semiarid ecosystems. *Soil Biology & Biochemistry*, 49 (2012) 96e105.
- Champion, G. H., S. K. Seth and G. M. Khattak. 1965. *Forest types of Pakistan*. Pakistan forest institute, Peshawar. Pp: 233.
- Chapman, J. L. and M. J. Reiss. 2004. *Ecology: Principles and Applications*. Cambridge University Press. England.
- Changwe, K. and K. Balkwill. 2003. Floristic of the Dunbar Valley serpentinite site, songimvelo game reserve, South Africa. *Botanical J. Linn. Society*, 143 (3): 271-285.

- Cheema, M. A., M. F. Saleem, N. Muhammad, M. A. Wahid and B. H. Baber. 2010. Impact of rate and timing of nitrogen application on yield and quality of Canola (*Brassica napus* L.) *Pak. J. Bot.*, 42 (3): 1723-1731.
- Cherney, J. H. and D. J. R. Cherney. 2005. Agronomic response of cool-Season grasses to low-intensity harvest management and low potassium fertility. *Agron J.*, 97: 1216-1221.
- Chiesa, A. P. R., G. V. Kozloski, L. M. B. Sanchez, L. D. Lima, L. Oliveira, C. J. Harter, G. Fiorentini and R. L. Cadorin. 2008. Age of regrowth as a factor affecting the nutritive value of hay of kikuyu grass (*Pennisetum clandestinum*) offered to lambs. *Grass & Forage Science*, 63 (2): 193-201.
- Chocarro, C., J. Lloveras and R. Fanlo. 2005. Effects of winter grazing on spring production of lucerne under Mediterranean conditions. *Grass & Forage Sci.*, 60 (2): 146-150.
- Cierjack, A. and I. Hensen. 2003. Variation of stand structure and regeneration of Mediterranean holm oak along a grazing intensity gradient. *Vegetation*. 173: 215-23
- Claros, M. P. 2003. Changes in forest structure and species composition during secondary forest succession in the Bolivian Amazon1. *Biotropica*, 35 (4): 450-461.
- Cook, M. E., and H. Morrow. 1995. Anthropogenic Sources of Cadmium in Canada. In National Workshop of Cadmium Transport into Plants (Centres Canadian Network of Toxicology ed.), Ottawa, Ontario, Canada.
- Costa, R. C., F. S. Araujo and L. W. Lima-Verde. 2007. Flora and life-form spectrum in an area of deciduous thorn woodland (Caatinga) in Northeastern, Brazil. *J. Arid Env.*, 68 (2): 237-247.
- Costa, F. R. C. 2006. Mesoscale Gradients of herb richness and abundance in Central Amazonia. *Biotropica*, 38 (6): 711-717.
- Cunningham, A.B. 2001. Applied Ethnobotany: People, Wild Plant Use and Conservation. *Earthscan*. London.
- Curtis, J. T. and R. P. McIntosh. 1950. The interrelation of certain analytic and synthetic phytosociological characters, *Ecology*. 31(3): 435-455.
- Dad, J. M. 2016. Distribution, species diversity and composition of plant communities in relation to various affecting factors in an Alpine grassland at Bandipora, Kashmir. *Pak. J. Bot.*, 48(2): 551-560.

- Dairo, F. A. S and I. G. Adanlawo. 2007. Nutritional Quality of *Crassocephalum crepidioides* and *Senecio bialfrae*. *Pak. J. Nut.*, 6 (1): 35-39.
- Dalle, G., B. L. Maass and J. Isselstein. 2006. Encroachment of woody plants and its impact on pastoral livestock production in the Borana lowlands, Southern Oromia, Ethiopia. *African J. Ecology*, 44 (2): 237-24.
- Dastagir, G., F. Hussain and M. A. Rizvi. 2014. Mineral composition of plants of Zygophyllaceae and Euphorbiaceae. *Pak. J. Bot.*, 46(3): 887-896
- Daur, I. and A. A. Bakhashwain. 2013. Effect of humic acid on growth and quality of Maize fodder production. *Pak. J. Bot.*, 45(SI): 21-25.
- Dave, G. and B. Dave. 2003. Mineral concentration dynamics among 7 northern Great Basin grasses. *Journal of Range Management*, 56 (2): 174-184.
- Delhaize, E. and P. R. Ryan. 1995. Aluminum toxicity and tolerance in plants. *Plant Physiol.*, 107: 315-321.
- Devineau, J. L. and A. Fournier. 2007. Integrating environmental and sociological approaches to assess the ecology and diversity of herbaceous species in a Sudan-type savanna (Bondoukuy, Western Burkina Faso). *Flora, Morphology, Distribution & Finctional ecology of Plants*. 202 (5): 350-370.
- DeWalt, S. J. and J. Chave . 2004. Structure and biomass of four lowland Neotropical Forests:1. *Biotropica*, 36 (1): 7-19.
- Dhankhar, S., S. Ruhil., M. Balhara., S. Dhankhar and A. K. Chhillar. 2011. *Aegle marmelos* (Linn.) Correa: A potential source of phytomedicine. *J. Med. Plants Res.*, 5: 1497-1507.
- Dharani, N., J. I. Kinyamario and J. M. Onyari. 2006. Structure and composition of *Acacia xanthophloea* woodland in Lake Nakuru National Park, Kenya. *African J. Ecology*, 44 (4): 523-530.
- Diaz, S., S. Lavorel, S. McIntyre, V. Falczuk, F. Casanovess, D. G. Milchunas, C. Skarpe, G. Rusch, M. Sternberg, I. Noy-Meir, J. Landsberg, W. Zhang, H. Clarkss and B. D. Campbell. 2006. Plant trait responses to grazing- a global synthesis. *Global Change Bio.*, 12: 1-29.
- Digiovino, P., G. F. Ficetola, L. Bottoni, C. Andreis and E. P. Schioppa. 2010. Ecological thresholds in herb communities for the management of suburban fragmented forests. *Forest Ecology & Management*, 259 (3): 343-349.

- Djaha, K., A. Y. C. Yves, K. K. Edouard, N. G. K. Edouard and A. Kouadio. 2008. Preliminary Floristic Inventory and Diversity in Azagny National Park (Côte D'Ivoire). *Eur. J. Sci. Res.*, 23(4): 537-547.
- Domsch, K. 1984. Effects of pesticides and heavy metals on biological processes in soil. *Plant and Soil*, 76: 367-378.
- Dondeyne, S., A. Wijffels, L. B. Emmanuel, J. Deckers and M. Hermy. 2004. Soils and vegetation of Angai forest: ecological insights from a participatory survey in South Eastern Tanzania. *Afri. J. Eco.*, 42 (3): 198-207.
- Dumon, J. C. and W. H. O. Ernst. 1988. Titanium in plants. *J.Pl. Physio.*, 133, 203-209.
- Durrani, M. J., A. Razaq, S. G. Muhammad and F. Hussain. 2010. Floristic diversity, ecological, characteristics and ethnobotanical profile of plants of Aghberg rangelands, Balochistan, Pakistan. *Pak. J. Pl. Sci.*, 16 (1): 29-36.
- Durrani, M. J., F. Hussain and S. U. Rehman. 2005. Ecological characteristics of plants of Harboi rangeland, Kalat, Pakistan. *J. Trop. & Sub Trop. Bot.*, 13 (2): 130-138.
- Duthie, J. F. 1893. Report on botanical tour in Kashmir, 1892. In: *Bot. Survey India*. (1): 1-18.
- Eilu, G., L. N. H. David and J. M. Kasenene. 2004. Tree species distribution in forests of the Albertine Rift, Western Uganda. *African J. Ecology*, 42 (2): 100-110.
- Eni, D. D., A. I. Iwara and R. A. Offiong. 2012. Analysis of Soil-Vegetation Interrelationships in a South-Southern Secondary Forest of Nigeria. *I. J. Fores. Res.*, <http://dx.doi.org/10.1155/2012/469326>.
- Enujiugha, V. N. 2003. Chemical and functional characteristics of Conophor Nut. *Pak. J. Nutrition*, 2 (6): 335-338.
- Estefan, G., R. Sommer and J. Ryan. 2013. Methods of soil, plant and water analysis. International Center for Agricultural Research in the Dry Areas (ICARDA).
- Fardous, A., K. Ahmad, S. Gondal, Z. A. Khan, A. Ejaz and E. E. Valeem. 2011. Assessment of Iron, Cobalt and Manganese in soil and forage: A case study at a rural livestock farm in Sargodha, Pakistan. *Pak. J. Bot.*, 43(3): 1463-1465.
- Fardous, A., S. Gondal, Z. A. Shah, K. Ahmad, Z. I. Khan, M. Ibrahim, A. Ejaz, W. Ahmad, Samiullah and E. E. Valeem. 2010. Sodium, potassium and magnesium dynamics in soil-plant-animal continuum. *Pak. J. Bot.*, 42(4): 2411-2421.

- Fazal, H., N. Ahmad, A. Rashid and S. Farooq. 2010. A Checklist of phanerogamic flora of Haripur Hazara, Khyber Pakhtunkhwa, Pakistan. *Pak. J. Bot.*, 42 (3): 1511-1522.
- Fleischmann, K., P. J. Edwards, D. Ramseier and J. Kollmann. 2006. Stand structure, species diversity and regeneration of an endemic palm forest on the Seychelles. *African J. Ecology*, 43 (4): 291-301.
- Frances, P. M. and M. Shahroukh. 2006. Forbs diversity and community similarity of kopjes in the Serengeti National Park, Tanzania. *Afri. J. Eco.*, 44 (1): 38-46.
- Francisco, J. C., M. D. L. Estrella, C. Aedo and M. Velayos. 2009. Checklist of Commelinaceae of Equatorial Guinea (Annobón, Bioko and Río Muni). *Botanical J. Linn. Society*, 159 (1): 106-122.
- Garg, A. N., A. Kumar, A. G. C. Nair and A. V. R. Reddy. 2007. Analysis of some Indian medicinal herbs by INAA. *J. Radianalytical & Nuclear Chemistry*, 271 (3): 611-619.
- Gauch, H. G. Jr. and R. H. Whittaker. 1981. Hierarchical classification of community data. *J. Ecolo.*, 69: 135-152.
- Gillani, S. A., Y. Fujii, Z. K. Shinwari, M. Adnan, A. Kikuchi and K. N. Watanabe. 2010. Phytotoxic studies on medicinal plant species of Pakistan. *Pak. J. Bot.*, 42(2): 987-996.
- Gillani, S. S., S. Q. Abbas, Z. K. Shinwari, F. Hussain and K. Nargis. 2003. Ethnobotanical studies of Kurram agency, Pakistan through rural community participation. *Pak. J. Biol. Sci.*, 6 (15): 1368-1375.
- Gimenez, E., M. Melendo, F. Valle, F. G. Mercado and E. Cano. 2004. Endemic flora biodiversity in the south of the Iberian Peninsula: altitudinal distribution, life forms and dispersal modes. *Biodiversity & Conservation*. 13 (14): 2641-2660.
- Golluscio, R. A., M. Oesterheld and M. R. Aguiar. 2005. Relationship between phenology and life form: a test with 25 Patagonian species. *Ecography*, 28 (3): 273-282.
- Gorade, P. D. and M. N. Datar. 2014. Checklist of palatable grass species from Peninsular India. *Not. Sci. Biol.*, 6(4): 441-447.
- Gould, W. A., G. Gonzalez and R. G. Carrero. 2006. Structure and composition of vegetation along an elevational gradient in Puerto Rico. *J. Vegetation Science*, 17: 563-574

- Green, R. H. 1974. A multivariate niche analysis with temporally varying environmental factors, *Ecology*. 55: 73-83.
- Greig-Smith P. 1983. *Quantitative Plant Ecology*, 3rd ed. Oxford: Blackwell Scientific press, p. 359.
- Grillini, C. R. L., L. Orioli, P. Piuissi and W. Kakuru. 2001. Structural analysis of the Chambura Gorge forest (Queen Elizabeth National Park, Uganda). *African J. Ecology*, 38 (4): 295-302.
- Gull, T., Z. Mahmood, F. Anwar, B. Sultana, W. Nouman, S. A. Shahid and M. Z. Iqbal. 2015. Variation of proximate composition and minerals within different parts of *Capparis decidua* (Forssk.) Edgew. as a function of harvesting seasons. *Pak. J. Bot.*, 47(5): 1743-1748.
- Guo, Q.S., X.F. Wang, G. Bar, Y. Kang, M. Hong, S.X. Pei and F.J. Zhang. 2009. Life form spectra, leaf character, and hierarchical-synusia structure of vascular plants in *Thuja sutchuehensis* community. *PubMed*. 20(9): 2057-2062.
- Gunasekaran, S., K. Viswanathan and C. Bandeswaran. 2014. Selectivity and palatability of tree fodders in sheep and goat fed by cafeteria method. *Int. J. Sci. Env. & Tech*, 3(5): 1767-1771.
- Gupta, A., S. P. Josi and R. K. Manhas. 2008. Multivariate analysis of diversity and composition of weed communities of wheat fields in Doon valley India. *Tropical Ecology*. 49(2): 103-112.
- Gutierrez, D., S. Mendoza, V. Serrano, M. Bah, R. Pelz, P. Balderas and F. Leon. 2008. Proximate composition, mineral content, and antioxidant properties of 14 Mexican weeds used as fodder. *Weed Biology & Management*, 8 (4): 291-296.
- Gutkowski, B., Krowiak, M., Niedzwiecka, J. and I. K. Oklejewicz. 2002. Floristic notes from the Dynow foothills (Western Carpathians). *Fragm. F. Geobot. Polonica*, 9: 43-47.
- Gyamtocho, P., J. Noeberger and M. Menzi. 1996. Existing status and potential for sustainable improvement of high altitude rangelands of Bhutan. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress. Salt Lake City, Utah. 195-196.
- Hamid. F. S., T. Ahmad, B. M. Khan, A. Waheed and N. Ahmad. 2006. Effect of soil pH in rooting and growth of Tea cuttings (*Camellia sinensis* L.) at nursery level. *Pak. J. Bot.*, 38(2): 293-300.

- Hamilton, A. C. 2004. Medicinal plants, conservation and livelihoods. *Biodiversity and Conservation*, 13: 1477-1517.
- Hamilton, A. C., A. Cunningham, D. Byarugaba and F. Kayanja. 2000. Conservation in a region of political instability. *Conservation Biology*, 14: 1722-1725.
- Hanson, H. and D. Churchil. 1965. *The Plant Community*. Reinhold. New York. Pp. 219.
- Haq, F., H. Ahmad and Z. Iqbal. 2015. Vegetation description and phytoclimatic gradients of subtropical forests of Nandiar Khuwar catchment District Battagram. *Pak. J. Bot.*, 47(4): 1399-1405.
- Haq, F. U. 2011. Conservation status of the critically endangered and endangered species in the Nandiar Khuwar catchment District Battagram, Pakistan. *International J. Biodiversity & Conservation*, 3 (2): 27-35.
- Haq, F. U., H. Ahmad, M. Alam, I. Ahmad and R. Ullah. 2010. Species diversity of vascular plants of Nandiar Valley Western Himalaya, Pakistan. *Pak. J. Bot.*, 42(S.I.): 213-229.
- Hardison, W. A., J. T. Reid, C. M. Martin and P. G. Woolfolk. 1954. Degree of herbage selection by grazing cattle. *J. Dairy Sc.*, 37:89-102.
- Hazrat, A., J. Shah, S. Ahmad, M. Nisar, A. K. Jan and Sikandar. 2010. Medicinal plants of Usheraï valley, Dir, KPK, Pakistan. *Pak. J. Bot.*, 42 (1): 31-34.
- Heady, H. F. 1964. Palatability of herbage and animal preference. *J. Range Mgmt.* 17:76-82.
- Heady, H. F. and D. T. Turell. 1959. Forage preferences exhibited by sheep with esophageal fistulas. *J. Range Man.*, 12: 28-34.
- Hickman, K. R., D. C. Hartnett, R. C. Cochran and C. E. Owensby. 2004. Grazing management effects on plant species diversity in tall grass prairie. *Rangeland Ecol. & Management*, 57 (1): 58-65.
- Hill, M. O., and H. G. Gauch. 1980. Detrended correspondence analysis, an improved ordination technique. *Vegetatio*, 42: 47-58
- Hirata, M., N. Koga, H. Shinjo, H. Fujita, G. Gintzburger, J. Ishida and A. Miyazaki. 2005. Measurement of above-ground plant biomass, forage availability and grazing impact by combining satellite image processing and field survey in a dry area of north-eastern Syria. *Grass & Forage Sci.*, 60 (1): 25-33.

- Hussain, F., L. Badshah, P. Sanaullah and M. J. Durrani. 2004. Ethnobotany of timber wood species of South Waziristan, Pakistan. *Pak. J. Plant Sci.*, 10(1): 9-16.
- Hussain, F. and L. Badshah. 1998. Vegetation structure of Pirghar Hills South Waziristan, Pakistan. *J. Tropical & Subtropical Bot.*, 6: 187-195.
- Hussain, F. and G. Mustafa. 1995. Ecological studies on some pasture plants in relation to animal use found in Nasirabad Valley, Hunza, Pakistan. *Pak. J. Pl. Sci.*, 1: 255-262.
- Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology. UGC. Islamabad.
- Hussain, K., M. F. Nisar, A. Majeed, K. Nawaz and K. H. Bhatti. 2010. Ethnomedicinal survey for important plants of Jalalpur Jattan, District Gujrat, Punjab, Pakistan. *Ethnobot. Leaflets.*, 14: 807-825.
- Hussain, M. I. and A. Perveen. 2009. Plant biodiversity and phytosociological attributes of Tiko Baran (Khirthar Range). *Pak. J. Bot.*, 41(2): 581-586.
- Ibrar, M., F. Hussain and A. Sultan. 2003. Ethnobotanical studies on plant resources of Ranyal hills, District Shangla, Pakistan. *Pak J Bot.*, 39: 329-337.
- Ilyas, M., R. Qureshi, N. Akhtar, M. Munir and Ziaulhaq. 2015. Vegetation analysis of Kabal valley, District Swat, Pakistan using multivariate approach. *Pak. J. Bot.*, 47(SI): 77-86.
- Ilyas, M., R. Qureshi, M. Arshad and S. N. Mirza. 2013. A preliminary checklist of vascular flora of Kabal Valley, Swat. *Pak. J. Bot.*, 45(2): 605-615.
- Ilyas, M., Z. K. Shinwari and R. Qureshi. 2012. Vegetation composition and threats to montane temperate forest ecosystem of Qalagai Hills, Swat, Khyber Pakhtunkhwa, Pakistan. *Pak. J. Bot.*, 44(SI) 113-122.
- Iram, S., I. Ahmad and D. Stuben. 2009. Analysis of mines and contaminated agricultural soil samples for fungal diversity and tolerance to heavy metals. *Pak. J. Bot.*, 41(2): 885-895.
- Ishtiaq, M., W. Hanif, M. A. Khan, A. Ashraf and A. M. Butt. 2007. An ethnomedicinal survey and documentation of important medicinal folklore food phytonims of flora of Samahni valley, (Azad Kashmir) Pakistan. *Pak. J. Biol. Sci.*, 10 (13): 2241-2256.
- IUCN. 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN. Gland. Switzerland and Cambridge, UK. 2: 30.

- Jabeen, T. and S. S. Ahmad. 2009. Multivariate analysis of environmental and vegetation data of Ayub National Park, Rawalpindi. *Soil & Env.*, 28(2): 106-112.
- Jackson, M. L. 1962. Soil chemical Analysis. Constable & Co., Ltd., 10 London p. 406-407.
- Jan, G., A. Khan, A. Farhatullah, F. G. Jan, M. Ahmad, M. Jan, and M. Zafar. 2011. Ethnobotanical studies on some useful plants of Dir Kohistan valleys, KPK, Pakistan. *Pak. J. Bot.*, 43(4): 1849-1852.
- Jorge, R., M. C. Fandino and R. L. Chazdon. 2005. Vegetation structure, composition, and species richness across a 56-year chronosequence of dry tropical forest on Providencia Island, Colombia. *Biotropica*, 37 (4): 520-530.
- Kamal, M., S. M. Wazir, M. Hassan, M. Subhan, S. U. Khan, A. Muhammad and S. Taj. 2009. Ethnobotanically important plants of District Bannu, Pakistan *Pak. J. Pl. Sci.*, 15 (2): 87-93.
- Kappelle, M., G. Avertin, M. E. Juarez and N. Zamora. 2000. Useful plants within a Campesino community in a Costa Rican montane cloud forest. *Mountain Research & Development*, 20 (2): 162-171.
- Kar, P.K., A.K. Biswal and K.L. Barik. 2010. Floristic composition and biological spectrum of a grassland community of Rangamatia in the District of Mayurbhanj, Odisha. *J. Curr. Sci.*, 15(2): 465-469.
- Karki, J. B., Y. V. Jhala and P. P. Khanna . 2000. Grazing lawns in Terai grasslands, Royal Bardia National Park, Nepal. *Biotropica*, 32 (3): 423-429.
- Karsten, W., S. Miehe and G. Miehe. 2005. Plant communities of the Gobi Gurvan Sayhan National Park (Aymak South Gobi, Mongolia). *Candollea*, 60 (1): 149-205.
- Kennedy, A. D., H. Biggs and N. Zambatis. 2003. Relationship between grass species richness and ecosystem stability in Kruger National Park, South Africa. *African J. Ecology*, 41 (2): 131-140.
- Khan, A., M. Ahmad, M. F. Siddiqui, J. Iqbal and M. Wahab. 2016. Phytosociological analysis of Pine forest at Indus Kohistan, KPK, Pakistan. *Pak. J. Bot.*, 48(2): 575-580.
- Khan, K., Alamgeer, A. Erum, B. Ahmad, M. Akram, M. Aarshad, M. M. Junaid and Saleem. 2009. Ethnobotanical studies from Northern areas of Pakistan. *Pharmacology online*. 1: 328-354.

- Khan, M., and S. Musharaf. 2014. Ethnobotanical Studies on plant resources of Sheikh Maltoon, District Mardan, Pakistan. *Med. Pl. Res.*, 4(5) 35-45.
- Khan, M., F. Hussain and S. Musharaf. 2013. Ethnobotanical profile of Tehsil Takht-e-Nasratti, District Karak, Pakistan. *J. Med. Pl. Res.*, 7(22): 1636-1651.
- Khan, M. and F. Hussain. 2012. Palatability and animal preferences of plants in Tehsil Takht-e-Nasrati, District Karak, Pakistan. *Afri. J. Agri. Res.*, 7(44): 5858-5872.
- Khan, N., A. Fayaz, A. Kishwar and S. Shahid. 2015. Composition, structure and regeneration of dynamics of *Olea ferruginea* Royle forests from Hindukush range Pakistan. *J. Mountain Sci.*, 12(3): 647-658.
- Khan, N. 2012. A community analysis of *Quercus baloot* Griff, forest District Dir, Upper Pakistan. *Afri. J. Plant Sci.*, 6(1): 21-31.
- Khan, N., M. Ahmed., M.F. Siddiqui., S. Bibi and I. Ahmed. 2012. A Phytosociological Study of Forest and Non-Forest Vegetation of District Chitral, Hindukush Range, Pakistan. *FUUAST J. Bio.*, 2(1): 91-101.
- Khan, N., M. Ahmad, M. Wahab, K. Nazim and M. Ajaib. 2010. Phytosociology, structure and physicochemical analysis of soil in *Quercus baloot* Griff. Forest District Chitral, Pakistan. *Pak. J. Bot.*, 42(4): 2429-2441
- Khan, N., M. Ahmed., M. Wahab, M. Ajaib and S. S. Hussain. 2010. Studies along an altitudinal gradient in *Monothea buxifolia* forest District Dir Lower Pakistan. *Pak. J. Bot.*, 42: 3029-3038.
- Khan, S. M., S. Page, H. Ahmad and D. Harper. 2012. Anthropogenic influences on the natural ecosystem of Naran valley in the Western Himalayas. *Pak. J. Bot.*, 44(SI): 231-238.
- Khan, S. U., S. M. Wazir, M. Subhan, M. Zahoor, M. Kamal and S. Taj. 2009. Some of the ethnobotanically important plants of F.R. Bannu, NWFP, Pakistan. *Pak. J. Pl. Sci.*, 15 (1): 81-85.
- Khan, S. W. and S. Khatoon. 2007. Ethnobotanical studies on useful trees and shrubs of Haramosh and Bugrote Valleys in Gilgit northern areas of Pakistan. *Pak. J. Bot.*, 39 (3): 699-710.
- Khan, W., H. Ahmad, F. Haq. M. Islam and F. Bibi. 2012. Present status of moist temperate vegetation of Thandiani forests District Abbottabad Pakistan. *Int. J. Biosci.*, 10(2): 80-88.

- Khan, Z. I., M. Ashraf, N. Ahmad, K. Ahmad and E. E. Valeem. 2009. Availability of nutritional minerals (Cobalt, Copper, Iron, Manganese and Zinc) in pastures of central Punjab for farm livestock. *Pak. J. Bot.*, 41(4): 1603-1609.
- Khan, Z. I., M. Ashraf, E. E. Valeem, K. Ahmad and M. Danish. 2007. Pasture concentration of minerals in relation to the nutrient requirements of farm livestock. *Pak. J. Bot.*, 39 (6): 2183-2191.
- Khan, Z. I., M. Ashraf and E. E. Valeem. 2006a. Forage mineral status evaluation: The influence of pastures. *Pak. J. Bot.*, 38 (4): 1043-1054.
- Khan, Z. I., I. A. Hussain, M. Ashraf, and L. R. McDowell. 2006b. Mineral status of soils and forages in Southwest- ern Punjab-Pakistan: Micro-minerals. *Asian-Australian J. of Ani. Sci.*, 19: 1139-1147.
- Khan, Z. I., A. Hussain, M. Ashraf, E. E. Valeem and I. Javed. 2005. Evaluation of variation in soil and forage Micro-mineral concentrations in semiarid region of Pakistan. *Pak. J. Bot.*, 37(4): 921-931.
- Khan, Z. I., A. Husain, M. Ashraf, E. E. Valeem, M. Y. Ashraf and M. S. Akhtar. 2004. Seasonal variation in soil and forage mineral concentrations in semiarid region of Pakistan. *Pak. J. Bot.*, 36(3): 635-640.
- Kim, Y. S. 2006. Conservation of plant diversity in Korea. *Landscape & Ecological Engineering*, 2 (2): 163-170.
- Kiyani, S. A., A. Masood, A. K. Khan and S. Ambreen. 2007. Distribution of secondary metabolites in plants of Quetta-Balochistan. *Pak. J. Bot.*, 39 (4): 1173-1179.
- Knoop, M. C. and N. O. Smith. 2006. Foraging ecology of roan antelope: key resources during critical periods. *African J. Ecology*, 44 (2): 228-236.
- Krantev, A., R. Yordanova, T. Janda, G. Szalai and L. Popova. 2008. Treatment with salicylic acid decreases the effect of cadmium on photosynthesis in maize plants. *J. of Pl. Phy.* 65: 920-931.
- Kwiatkowski, P. 2002. Floristic notes from the Kaczawskie Mts and Kaczawskie Plateau (Western Sudety Mts, Poland) Part 2. *Fragmenta Floristica et Geobotanica Polonica*, 9: 55-65.
- Laidlaw, M., R. Kitching., K. Goodall., A. Small and N. Stork. 2007. Temporal and spatial variation in an Australian tropical rainforest. *Austral. Ecology*, 32 (1): 10-20.

- Lee, W. G., M. Fenner, A. Loughnan and K. M. Lloyd. 2000. Long-term effects of defoliation: incomplete recovery of a New Zealand alpine tussock grass, *Chionochloa pallens*, after 20 years. *J. Applied Ecology*, 37: 348-355.
- Lefroy, E. C., P. R. Dann, J. H. Wilding, R. N. W. Smith and A. A. McGowan. 1992. Trees and shrubs as source of fodder in Australia. *Agroforestry Systems*, 20: 117-139.
- Leheska, J. M., L. D. Thompson, J. C. Howe, E. Hentges, J. Boyce, J. C. Brooks, B. Shriver, L. Hoover and M. F. Miller. 2008. Effects of conventional and grass-feeding systems on the nutrient composition of beef. *J. Anim. Sci.*, 86: 3575-3585.
- Lehnebach, C. A. 2003. Preliminary checklist of the orchids of Chile. *Botanical J. Linn. Society*, 143 (4): 449-451.
- Li, W., L. Xiao-Jing, M. A. Khan and B. Gul. 2008. Relationship between soil characteristics and halophytic vegetation in coastal region of north China. *Pak. J. Bot.*, 40: 1081-1090.
- Loan, M. I., S. H. Raza, S. Muhammad, M. Naeem and M. Khalid. 2006. Lead content in soil and wheat tissue along roads with different traffic loads in Rawalpindi. *Pak. J. Bot.*, 38(4): 1035-1042.
- Lodhi, A., M. Arshad, F. Azam and M. H. Sajjad. 2009. Changes in mineral and mineralizable N of the soil incubated at varying salinity, moisture and temperature regimes. *Pak. J. Bot.*, 41(2): 967-980.
- Loeser, M. R. R., T. D. Sisk and T. E. Crews. 2007. Impact of grazing intensity during drought in Arizona Grassland. *Conservation Biology*, 21 (1): 87-97.
- Lovett, J. C., A. R. Marshall and J. Carr. 2006. Changes in tropical forest vegetation along an altitudinal gradient in the Udzungwa Mountains National Park, Tanzania. *African J. Ecology*, 44 (4): 478-490.
- Lucas, R. W., T. T. Baker, M. K. Wood, C. D. Allison and D. M. Vanleeuwen. 2004. Riparian vegetation response to different intensities and seasons of grazing. *J. Range Management*, 57 (5): 466-474.
- Luis, C., M. Eurico S. and D. M. Adelia. 2002. Vegetation structure and ecology of the Cufada Lagoon (Guinea-Bissau). *Afr. J. Eco.*, 40 (3): 252-259.
- Macia, M. J. 2004. Multiplicity in palm uses by the Huaorani of Amazonian Ecuador. *Botanical J. Linn. Society*, 144 (2): 149-159.

- Maestre, F. T., M. A. Bradford and J. F. Reynolds. 2006. Soil heterogeneity and community composition jointly influence grassland biomass. *J. Vegetation Sci.*, 17 (3): 261-270.
- Magurran, A. E. 1988. Ecological diversity and measurement. Princeton University Press, Princeton.
- Malik, N. Z. and Z. H. Malik. 2004. Present status of subtropical Chirpine vegetation of Kotli Hills, Azad Jammu and Kashmir. *J. Res. Sci.*, 15 (1): 85-90.
- Malik, R. N., S. Z. Hussain and I. Nazir. 2010. Heavy metal contamination and accumulation in soil and wild plant species from industrial area of Islamabad, Pakistan. *Pak. J. Bot.*, 42(1): 291-301.
- Malik, R. N. and S. Z. Husain. 2008. Linking remote sensing and ecological vegetation communities: a multivariate approach. *Pak. J. Bot.*, 40 (1): 337-349.
- Malik, R. N. and S. Z. Husain. 2006. Classification and ordination of vegetation communities of the Lohibehr reserve forest and its surrounding areas, Rawalpindi, Pakistan. *Pak. J. Bot.*, 38 (3): 543-558.
- Manan, Z., Sirajuddin, A. Razzaq, M. Islam and Ikramullah. 2007. Diversity of medicinal plants in Wari sub division District Upper Dir, Pakistan. *Pak. J. Pl. Sci.*, 13 (1): 21-28.
- Manhas, R. K., L. Singh, H. B. Vasistha and M. Negi. 2010. Floristic diversity of protected ecosystems of Kandi Region of Punjab, India. *New York Science Journal*, 3 (4): 96-103.
- Maoe, A. A., T. M. Hynniewta and M. Sanjappa. 2009. Plant wealth of Northeast India with reference to ethnobotany. *IJTK*, 8 (1): 96-103.
- Mapfumo, E., M. A. Naeth, V. S. Baron, A. C. Dick and D. S. Chanasyk. 2002. Grazing impacts on litter and roots: annual versus perennial forages. *J. Range Management*, 55 (1): 16-22.
- Mapfumo, E., D. S. Chanasyk, V. S. Baron and M. A. Naeth. 2000. Grazing impacts on selected soil parameters under short-term forage sequences. *J. Range Management*, 53 (5): 466-470.
- Mapinduzi, A. L., G. Oba, R. B. Weladji and J. E. Colman. 2004. Use of indigenous ecological knowledge of the Maasai pastoralists for assessing rangeland biodiversity in Tanzania. *African J. Ecology*, 41 (4): 329-336.

- Mark, F. A., J. Kathrine, M. Dickinson, J. Allen, R. Smith and C. C. West. 2001. Vegetation patterns, plant distribution and life forms across the alpine zone in Southern Tierra de Fuego, Argentina. *Austral Eco.*, 26(4): 423-440.
- Marwat, Q. and R. A. Qureshi. 2000. A checklist of the vascular plants found in upper Siran reserved and guzara forests, District Manshera, Pakistan. *Pak. J. Pl. Sci.*, 6 (1-2): 43-57.
- Marwat, S. K., K. Usman, E. A. Khan, S. Ghulam, S. Baloch, A. M. Tauqeer and F. U. Rehman, 2012. Ethnobotanical studies on Dwarf Palm (*Nannorhops ritchieana* (Griff.) Aitchison) and Date Palm (*Phoenix dactylifera* L.) in Dera Ismail Khan, KPK, Pakistan. *American J. Pl. Sci.*, 3, 1162-1168.
- Mathooko, J. M. and S. T. Kariuki. 2000. Disturbances and species distribution of the riparian vegetation of a Rift Valley stream. *Afr. J. Eco.*, 38 (2): 123-129.
- McCune, B. and M. J. Mefford. 2005. Multivariate Analysis of Ecological Data (PCORD Version 5.10. MjM Software Gleneden Beach, Oregon: United State of America.
- McCune, B. and J. B. Grace. 2002. *Analysis of Ecological communities*. 2nd ed. USA
- Meena, K. L. and B. L. Yadav. 2010. Some traditional ethnomedicinal plants of Southern Rajasthan. *IJTK*, 9 (3): 471-474.
- Mendez, E. 2005. The vegetation of the Laguna de Llancanelo Provincial Reserve (Mendoza, Argentina). *Candollea*, 60 (1): 123-148.
- Miah, M. D., H. A. Rashid and M. Y. Shin. 2009. Wood fuel use in the traditional cooking stoves in the rural floodplain areas of Bangladesh: A socio-environmental perspective. *Biomass & Bioenergy*, 33 (1): 70-78.
- Milewski, A. V. and D. Madden. 2006. Interactions between large African browsers and thorny *Acacia* on a wildlife ranch in Kenya. *African J. Ecology*, 44 (4): 515-522.
- Miller, S. M. and R. P. Thompson. 2005. Seasonal patterns of diet composition, herbage intake and digestibility identify limitations to performance of weaker sheep grazing native pasture in the Falkland Islands. *Grass & Forage Sci.*, 60 (4): 356-366.
- Mishra, N.K., R. Singh., S. Ojha and Supreeti. 2012. Phytosociological perspectives of representative herbaceous Genera of common occurrence belonging to family Asteraceae in Grassland ecosystem of Anpara region in District Sonbhadra (U.P.). *Ind. J. L. Sci.*, 2(1): 119-122.

- Mizaraite, D., S. Mizaras and L. Sadauskiene. 2007. Wood fuel supply, costs and home consumption in Lithuania. *Biomass & Bioenergy*, 31 (10): 739-746.
- Mohandass, P. D. and D. Vijayan. 2007. Floristic inventory of woody plants in a tropical montane (shola) forest in the Palni hills of the Western Ghats, India. *Tropical Ecology*, 48 (1): 15-25.
- Mohler, C. L., P. L. Marks and S. Gardescu. 2006. Guide to the plant communities of central finger lakes region. *New York State Agricultural Experiment Station*, pp:7-9.
- Mosugelo, D. K., S. R. Moe, S. Ringrose and C. Nellemann. 2002. Vegetation changes during a 36-year period in northern Chobe National Park, Botswana. *African J. Ecology*, 40 (3): 232-240.
- Motyka, J., B. Dobrzanski and S. Zawadski. 1950. Wstepne badania nad lakami polundnlowowschodnej Lubeiszczyny. *Ann. Univ. M. Curie-Jklowska*, 13: 367-447.
- Munhoz, C. B. R. and J. M. Felfili. 2006. Phytosociology of the herb-subshrub layer in an area of Campo Sujo, Distrito Federal, Brazil. *Acta Bot. Bras.*, ISSN 1677-941X <http://dx.doi.org/10.1590/S0102-3306200600300017>.
- Muoghalu, J. I. and O. O. Okeesan. 2005. Climber species composition, abundance and relationship with trees in a Nigerian secondary forest. *African J. Ecology*, 43 (3): 258-266.
- Musharaf, K., F. Hussain. S. Musharaf. And Imdadullah. 2011. Floristic composition, life form and leaf size spectra of the coal mine area vegetation of Dara Adam Khel, Khyber Pakhtonkhwa, Pakistan. *J. Biod. Env.Sci*, 1(3): 2222-3045.
- Musila, W. M., J. I. Kinyamario and P. D. Jungerius. 2003. Vegetation dynamics of coastal sand dunes near Malindi, Kenya. *African J. Ecology*, 39 (2): 170-177.
- Muthuramkumar, S., N. Ayyappan, N. Parthasarathy, D. Mudappa, T. R. Shakar-Raman, M. A. Selwyn and L. A. Pragason. 2006. Plant community structure in tropical rain forest fragments of Western Ghats, India. *Biotropica*. 38(2): 143-160.
- Nafees, M., M. R. Jan, H. Khan and A. Ali. 2008. Status of soil texture and required associated soil conservation measure of river Swat catchment area, NWFP, Pakistan. *Sarhad J. Agric*. 24(2): 251-259.

- Nafeesa, Z., M. Arshad and M. N. Sarwat. 2007. Phytosociological attributes of different plant communities of Pir-Chinasi hills of Azad Jammu and Kashmir. *I.J. Agri. Biology* 9(4): 565-574.
- Nasir, E. and S. I. Ali (Eds.). 1970-1989. *Flora of Pakistan*, Islamabad, Karachi.
- Nasir, Y. J. and R. A. Rafiq. 1995. Wild flowers of Pakistan. Edited by T. J. Roberts. Oxford University Press, Oxford. New York.
- Nasrullah, M. Nisar, Suliman and Z. Ali. 2012. Ethnobotanical wealth of Jandool valley, Dir Lower, Khyber Pakhtunkhwa. Pakistan. *Int. J. Phytomed.*, 4 (2012) 351-354.
- Nawaz, T., M. Hameed, N. Naz, M. Sajid, A. Ahmad and A. A. Chaudhary. 2010. Impact of fencing on vegetation structure in Lehri and a Jindi sub mountainous open scrub forest. *J. Biol. Biotech.*, 7(3): 227-233.
- Nazarian, H., A. Ghahremani, M. Atri and M. Asad. 2004. Ecological factors affecting parts of vegetation in North Iran (Elika and Duna Watersheds) by employing Eco-Phytosociological method. *Pak. J. Bot.*, 36(1): 41-64.
- Neal, J. E. and B. P. Miller. 2007. Livestock grazing impacts on desert vegetation, Khirthar National Park, Pakistan. *Rangeland Ecology & Management*, 60(6): 680 - 684.
- Nogues, D.B., M.B. Araujo, T. Romdal and C. Rahbek. 2008. Scale effects and human impact on the elevational species richness gradients. *Nature*, 453: 216-219.
- Noor, A. and S. Khatoon. 2013. Analysis of Vegetation pattern and soil characteristics of Astore Valley Gilgit Baltistan. *Pak. J. Bot.*, 45(5): 1663-1667.
- Nyamangara, M.E. and L.R. Ndlovu. 1995. Feeding behaviour, feed intake, chemicals and botanical composition of the diet of indigenous goats raised on natural vegetation in a semiarid region of Zimbabwe. *J. Agri. Sci.*, 124: 455-461.
- Okello, J. and P. Sesgawa. 2007. Medicinal plants used by communities of Ngai Subcounty, Apac District, northern Uganda. *Afr. J. Eco.*, 45(1): 76-83.
- Oliveira, H. 2012. Chromium as an Environmental Pollutant: Insights on Induced Plant Toxicity. *Journal of Botany*, Volume 2012 (2012), Article ID 375843, 8 pages, <http://dx.doi.org/10.1155/2012/375843>.
- Oswalt, S. N., T. J. Brandis and B. P. Dimick. 2006. Phytosociology of vascular plants on an international biosphere reserve: Virgin Islands National Park, St John, US Virgin Islands. *Carr. J. Sci.*, 42(1): 53-66.

- Ozgur, E. and R. Ansin. 2003. The flora of Hatila Valley National Park and its close Environs (Artvin), Turkey. *Turk. J. Bot.*, 27(2003): 1-27.
- Padalia, H., N. Chauhan, M. C. Porwal and P. S. Roy. 2004. Phytosociological observations on tree species diversity of Andaman Islands, India. *Current Sci.*, 87: 799-806.
- Pais I. 1983. The biological importance of titanium. *Journal of Plant Nutrition*, 6: 3-131.
- Patrick, O., O. Joseph and A. B. Cunningham. 2004. Regeneration, density and size class distribution of tree species used for drum making in central Uganda. *Afri. J. Eco.*, 42 (2): 129-136.
- Pavlu, V., M. Hejzman, L. Pavlu, J. Gaisler, P. Hejzmanova-Nezerkova and L. Meneses. 2006. Changes in plant densities in a mesic species-rich grassland after imposing different grazing management treatments. *Grass & Forage Sci.*, 61(1): 42- 51.
- Pearse, I. S., L. M. Porensky, L. H. Yang, M. L. Stanton, L. Bhattacharya, R. Cox, K. Dove, A. Higgins, R. Karban, C. Kamoroff, C. Knight, R. Koch, C. Parker, H. Rollins, K. Tanner and T. Kirk. 2012. Complex Consequences of Herbivory and Interplant Cues in Three Annual Plants. *PLoS ONE* 7(5): e38105. doi:10.1371/journal.pone.0038105
- Peer, T., J. P. Gruber, A. Millinger and F. Hussain. 2007. Phytosociology, structure and diversity of the steppe vegetation in the mountains of Northern Pakistan. *Phytocoenologia*. 37(1): 1- 65.
- Peer, T., A. Millinger. J. P. Gruber and F. Hussain. 2001. Vegetation and altitudinal zonation in relation to the impact of grazing in the steppe lands of the Hindu Kush Range (N. Pakistan). *Phytocoenologia*. 31(4): 477-498.
- Perveen, A., G. R. Sarwar and I. Hussain. 2008. Plant biodiversity and phytosociological attributes of Dureji (Khirthar Range). *Pak. J. Bot.*, 40(1): 17-24.
- Perveen, A. and M. I. Hussain. 2007. Plant biodiversity and phytosociological attributes of Gorakh hill (Khirthar Range). *Pak. J. Bot.*, 39(3): 691-698.
- Peters, H. A. 2007. The significance of small herbivores in structuring annual grassland. *J. Vegetation Science*, 18(2): 175-182.
- Pfister, J.A. and J.C. Malechek. 1986. Dietary selection by goats and sheep in a deciduous woodland of North Eastern Brazil. *J. Range Mang.*, 39: 24-28.

- Phillips, W. A., P. J. Starks, S. Glasgow and S. W. Coleman. 2007. Different methods of estimating crude protein concentration of Bermuda grass pastures for stocker calf production. *Professional Animal Scientist*, 23: 696-701.
- Phillips, O.L. 2003. Habitat association among Amazonian tree species: a landscape scale approach. *J. Ecol.*, 91: 757-775.
- Pichi-Sermolli, R. E. 1948. An index for establishing the degree of maturity in plant communities. *J. Ecology*, 36: 85-90.
- Prakash, K. C. 2005. Indigenous uses, population density and conservation of threatened medicinal plants in protected areas of the Indian Himalayas. *Conservation Biology*, 19 (2): 368-378.
- Qaisar, M., S. Farooq, S. Gilani, N. Wasim, M. A. Kakar, M. Shah and A. Rauf. 2013. Ethnobotanical survey of medicinal plants used in Wazir and Daur tribes of North Waziristan, Pakistan. *Global Veterinaria*, 11(3): 285-292.
- Qasim, M., S. Gulzar, Z. K. Shinwari, I. Aziz and M. A. Khan. 2010. Traditional ethnobotanical uses of halophytes from Hub, Baluchistan. *Pak. J. Bot.*, 42 (3): 1543-1551.
- Qureshi, R. and G.R. Bhatti. 2010. Floristic inventory of Pai forest, Nawab Shah, Sindh, Pakistan. *Pak. J. Bot.*, 42(4): 2215-2224.
- Qureshi, R. 2008. Vegetation assessment of Sawan Wari of Nara desert, Pakistan. *Pak. J. Bot.*, (5): 1885-1895.
- Qureshi, R. and G. R. Bhatti. 2008. Diversity of Micro-habitats and their plant resources in Nara desert, Pakistan. *Pak. J. Bot.*, 40(3): 979-992.
- Qureshi, R. and G. R. Bhatti. 2008a. Ethnobotany of plants used by the Thari people of Nara Desert, Pakistan. *Fitoterapia*, 79(6): 468-473.
- Qureshi, R. and G. R. Bhatti. 2008b. Taxonomy of Scrophulariaceae from Nara Desert, Pakistan. *Pak. J. Bot.*, 40(3): 973-978.
- Qureshi, R. and G. R. Bhatti. 2005. Nara Desert, Pakistan: Part II: Human Life. *Rangelands (USA)*, 27 (5): 32-35.
- Qureshi, R. and G. R. Bhatti. 2006. Floristic list of monocot of Nara Desert, Sindh, Pakistan. *Hamdard Medicus*, 49(4): 63-67.
- Rahim, I. U., J. I. Sultan, M. Yaqoob, H. Nawaz, I. Javed and M. Hameed. 2008. Mineral profile, palatability and digestibility of marginal land grasses of trans-himalayan grasslands of Pakistan. *Pak. J. Bot.*, 40(1): 237-248.

- Randal, D. J. and B. A. Diaz. 2006. Spring-fed wetland and riparian plant communities respond differently to alter grazing intensity. *J. Appl. Ecology*, 43(3): 485-498.
- Rascio, N. and F. Navari-Izzo. 2011. Heavy metal hyper accumulating plants: How and why do they do it? And what makes them so interesting? *Plant Science* 180: 169-181.
- Rashid, A., M. F. Swati, H. Sher. And Muhammad. N. Al Yemeni. (2011). Phytocoeological evaluation with detail floristic appraisal of the vegetation around Malam Jabba, Swat, Pakistan. *Asian Pac J Trop Biomed.*, 1(6): 461-467.
- Raunkiaer, C. 1934. The Life Forms of Plants and Statistical Plants Geography being the collected Papers of C. Raunkiaer. Clarendon press, Oxford.
- Rayan, J. N., R. W. Harvey, D. W. Metge and J. E. Larson. 1997. Transport of bacteriophage PRD1 and silica colloids in a sewage-contaminated aquifer. *Eos, Transactions of the American Geophysical Union* 86, F231. Presented at the Fall Meeting of the American Geophysical Union.
- Raza, W., S. Yousaf, A. Niaz, M. K. Rasheed and I. Hussain. 2005. Subsoil compaction effects on soil properties, nutrient uptake and yield of Maize fodder (*Zea mays* L.). *Pak. J. Bot.*, 37(4): 933-940.
- Rehman, H. U., Z. Masood. S. Saddozai and W. M. Achakzai. 2015. Physicochemical analysis of water and soil from Gomal Zam dam of Khajuri-Kach in South Waziristan Agency of Pakistan, with special reference to their impact on fish growth and survival. *American-Eurasian J. Ari. & Env. Sci.* 15(6): 1182-1185.
- Rehman, S. A. U. and M. Z. Iqbal. 2008. Level of heavy metals in the foliage of naturally growing plants collected from Korangi and Landhi industrial areas of Karachi City, Pakistan. *Pak. J. Bot.*, 40(2): 785-789.
- Rhoades, J.D. 1996. Salinity: Electrical conductivity and total dissolved solids. P. 417-435. In D.L. Sparks (ed.) *Methods of soil analysis: Chemical methods, Part 3*. ASA and SSSA, Madison, WI.
- Richard, L. A. 1954. Diagnoses and improvement of saline and alkali soils. *Agriculture Hand Book*, 60: USDA, USA.
- Rosenthal, G. A. and E. A. Bell. 1979. Naturally occurring, toxic non-protein amino acids. In: G.A. Rosenthal and D.H. Janzen (eds), *Herbivores. Their interaction with secondary plant metabolites*. Academic Press, N.Y. p. 353-385.

- Ross, S. M., J. R. King, J. T. O. Donovan and D. M Spaner. 2005. The productivity of oats and berseem clover intercrops. II. Effects of cutting date and density of oats on annual forage yield. *Grass & Forage Sci.*, 60(1): 87-98.
- Ryan, J., George E. and A. Rashid. Soil and Plant analysis laboratory manual. Second edition. (ICARDA), pp: 7-8.
- Sabir, M., A. Khaliq, R. A. Gardezi and H. Khan. 2003. Nutritive value of mushrooms from Azad Kashmir, Pakistan. *Mycopathology (Pakistan)*, 1(1): 35-38.
- Saglam, C. 2013. A phytosociological study of the forest, shrub, and steppe vegetation of Kizildag and environs (Isparta, Turkey). *Turk. J. Bot.*, 37: 316-335.
- Saima, S., A. A. Dasti, Q. Abbas and F. Hussain. 2010. Floristic diversity during monsoon in Ayubia National Park District Abbottabad Pakistan. *Pak. J. Pl. Sci.*, 16(1): 43-50.
- Saima. S. A. A. Dasti, F. Hussain. S. M. Wazir. and S. A. Malik. (2009). Floristic compositions along an 18-KM long transection in Ayubia National Park District Abbottabad. *Pak. J. Bot.*, 41(5): 2115-2127.
- Sakya, S. R., and A. M. S. Bania. 1998. Natural vegetation of Chandragiri region. *Ecoprint*, 5: 51-55
- Hanson, H. and E. D. Churchill. 1965. *The plant Community*. Reinhold, New York. pp. 219.
- Salminen. R., M. J. Batista, M. Bidovec, A. Demetriades, B. De Vivo, W. De Vos, M. Duris, A. Gilucis, V. Gregorauskiene, J. Halamic, P. Heitzmann, A. Lima, G. Jordan, G. Klaver, P. Klein, J. Lis, J. Locutura, K. Marsina, A. Mazreku, P. J. O'Connor, S. A. Olsson, R. T. Ottesen, V. Petersell, J. A. Plant, S. Reeder, I. Salpeteur, H. Sandström, U. Siewers, A. Steenfelt and T. Tarvainen. 2005. Geochemical Atlas of Europe. Part 1: Background Information, Methodology and Maps. Espoo, Geological Survey of Finland.
- Salvatori, V., F. Eguny, A. K. Skidmore, J. D. Leeuw and H. A. M. van Gils. 2003. The effects of fire and grazing pressure on vegetation cover and small mammal populations in the Maasai Mara National Reserve. *African J. Ecology*, 39(2): 200-204.
- Sardar, A. A. and Z. U. Khan. 2009. Ethnomedicinal studies on plant resources of Tehsil Shakargarh, District Narowal, Pakistan. *Pak. J. Bot.*, 41(1): 11-18.
- Saurav, M. and A. P. Das. 2014. Plant species richness and phytosociological attributes of the vegetation in the cold temperate zone of Darjilling Himalaya, India. *Int. Res. J. Env. Sci.*, 3(10): 47-57.

- Schuür, E.A.G. and P.A. Matson. 2001. Net primary productivity and nutrient cycling across a mesic to wet precipitation gradient in Hawaiian Montane Forest. *Oecologia*, 128: 431-442.
- Seiler, G. J. and L. G. Campbell. 2004. Genetic variability for mineral element concentrations of wild Jerusalem artichoke forage. *Crop Sci.*, 44: 289-292.
- Shah, M. and F. Hussain. 2009. Phytosociological studies of the vegetation of Hayat Abad Peshawar, Pakistan. *Pak. J. Pl. Sci.*, 15(2), 123-128.
- Shah, S. M., and F. Hussain. 2012. Ethnomedicinal plant wealth of Mastuj valley, Hindukush range, District Chitral, Pakistan. *J. Med. Pl. Res.* 6(26), 4328-4337.
- Shah, Z., M. Z. Shah, M. Tariq, H. Rahman, J. Bakht, Amanullah and M. Shafi. 2012. Survey of citrus orchards for micronutrients deficiency in Swat valley of North Western Pakistan. *Pak. J. Bot.*, 44(2): 705-710.
- Shah, Z., H. Rahman, M. A. Shah, M. Iqbal, U. Pervaiz and Amanullah. 2010. Tillage and residue impacts on microbial biomass and soil C and N dynamics under different cropping systems. *Pak. J. Bot.*, 42(3): 1969-1976.
- Shaheen, H., R. Sarwar, S. S. Firdous, M. E. I. Dar, Zahidullah and S. M. Khan. 2015. Distribution and structure of conifers with special emphasis on *Taxus baccata* in Moist temperate forests of Kashmir Himalayas. *Pak. J. Bot.*, 47(SI): 71-76.
- Shaheen, H., Z. Ullah, S. M. Khan and D. M. Harper. 2012. Species composition and community structure of Western Himalayan Moist temperate forests in Kashmir. *Forest Eco. & Management*. 278: 138-145.
- Shaheen, H. and R. A. Qureshi. 2011. Vegetation types of Sheosar lake and surrounding landscape in Deosai plains of North Pakistan, Western Himalayas. *J. Med. Pl. Res.*, 5(4): 599-603.
- Sharma, P., J. C. Rana, U. Devi, S. S. Randhawa and R. Kumar. Floristic diversity and distribution pattern of plant communities along altitudinal gradient in Sangla valley, Northwest Himalaya. 2014. *The Sci. World. J.*, 11 pages. <http://dx.doi.org/10.1155/2014/264878>.
- Sher, Z., F. Hussain and M. Saleem. 2012. Macro-mineral status at three phenological stages of some range shrubs of Gadoon hills, District Swabi, Khyber Pakhtunkhwa, Pakistan. *Pak. J. Bot.*, 44(2): 711-716.
- Sher, Z., F. Hussain and L. Badshah. 2013. Phytosociology of summer vegetation of Sudan Galli hills, District Bagh, Azad Kashmir, Pakistan. *Pak. J. Bot.*, 45(1): 1-9, 2013.

- Sher, Z., Z. Khan and F. Hussain. 2011. Ethnobotanical studies of some medicinal plants of Chagharzai Valley, District Buner, Pakistan. *Pak. J. Bot.*, 43(3): 1445-1452.
- Sher, Z. and Z. U. Khan. 2007. Floristic composition, life form and leaf spectra of the vegetation of Chagharzai Valley, District Buner. *Pak. J. Pl. Sci.*, 13(1): 57 - 66.
- Sher, H., Midrarullah, A. U. Khan, Z. U. Khan, F. Hussain and S. Ahmad. 2003. Medicinal plants of Udigram, District Swat, Pakistan. *Pakistan J. Forestry*, 53(1): 65-74.
- Shinwari, Z. K. 2010. Medicinal plants research in Pakistan. *J. Med. Pl. Res.*, 4(3): 161-176
- Shirazi, M. U., M. T. Rajput, M. A. Khan, M. Ali, S. M. Mujtaba, A. Shereen, S. Mumtaz and M. Ali. 2011. Growth and ions (Na, K, and Cl) accumulating pattern of some *Brassica* genotypes under saline-sodic condition. *Pak. J. Bot.*, 43(6): 2661-2664.
- Siddiqui, M. F., A. Salam, M. Ahmad, M. I. Hussain, J. Iqbal and M. Wahab. 2015. Present state and future trends of Pine forests of Malam Jabba, Swat District, Pakistan. *Pak. J. Bot.*, 47(6): 2161-2169.
- Siddique, M. F., S. S. Shaukat, M. Ahmad, I. A. Khan and N. Khan. 2014. Foliar and soil nutrient distribution in conifer forests of moist temperate areas of Himalayan and Hindukush region of Pakistan: A multivariate approach. *Pak. J. Bot.*, 46(5): 1811-1827.
- Siddiqui, M.F., S.S. Shaukat M. Ahmed, N. Khan and I.A. Khan. 2013. Vegetation environment relationship of conifer dominating forests of moist temperate belt of Himalayan and Hindukush region of Pakistan. *Pak. J. Bot.*, 45 (2): 577-592.
- Siddiqui, M.F., M. Ahmed, S.S. Hussain, S.S. Shaukat and N. Khan. 2011. Vegetation description and current status of moist temperate coniferous forests of Himalayan and Hindukush region of Pakistan. *FUUAST J. Biol.*, 1(2): 99-114.
- Siddiqui, F. M., M. Ahmed, S. S. Shaukat and N. Khan. 2010a. Advance multivariate techniques to investigate vegetation-environmental complex of pine forests of moist area of Pakistan. *Pakistan Journal of Botany*. 42: 267-293.
- Siddiqui, M. F., M. Ahmad, N. Khan and I. A. Khan. 2010. Quantitative description of moist temperate conifer forests of Himalayan region of Pakistan and Azad Kashmir. *Int. J. Biol. Biotech.*, 7(3): 175-85.

- Smit, C., J. D. Ouden and H. Muller-Scharer. 2006. Unpalatable plants facilitate tree sapling survival in wooded pastures. *J. Appl. Ecology*, 43(2): 305-312.
- Smith, T., V. Mlambo, J. L. N. Sikosana, V. Maphosa, I. Mueller-Harvey and E. Owen. 2005. *Dichrostachys cinerea* and *Acacia nilotica* fruits as dry season feed supplements for goats in a semi-arid environment: Summary of a DFID funded project in Zimbabwe. *Animal Feed Science & Technology*, 122(1-2): 149-157.
- Smith, T. M. and R. L. Smith. 2012. *Elements of Ecology*. Pearson Publications.
- Sorensen, T. 1948. A method of establishing groups of equal amplitudes in plant sociology based on similarity of species content and its application to analyze the vegetation of Darnish commons. *Biol. Skr.*, 5: 1-34.
- Soule, M. 1985. What is Conservation Biology? *Bioscience*, 35: 727-734.
- Ssegawa, P. and D. N. Nkuutu. 2006. Diversity of vascular plants on Ssesse islands in Lake Victoria, central Uganda. *Afri. J. Eco.*, 44(1): 22-29.
- Staaland, H., I. Brattbakk, K. Ekern and K. Kildemo. 2006. Chemical composition of reindeer forage plants in Svalbard and Norway. *Ecography*, 6(2): 109-122.
- Starks, P. J., D. Zhao, W. A. Phillips and S. W. Coleman. 2006. Development of canopy reflectance algorithms for real-time prediction of Bermuda grass pastures biomass and nutritive values. *Crop Sci.*, 46: 927-934.
- Starks, P. J., S. W. Coleman and W. A. Phillips. 2004. Determination of forage chemical composition using remote sensing. *J. Range Management*, 57 (6): 635 - 640.
- Stewart, R. R. 1967. Checklist of the plants of Swat State, Northwest Pakistan. *Pak. J. Forest.*, 17(4): 457-528.
- Storeheier, P., V. S. D. Mathiesen, J. C. Tyler, N. I. Schjelderup and M. A. Olsen. 2002. Utilization of nitrogen- and mineral-rich vascular forage plants by reindeer in winter. *J. Agricultural Science*, 139(2): 151-160.
- Sultan, J. I., Inam-ur-Rahim, M. Yaqoob, M. I. Mustafa, H. Nawaz and P. Akhtar. 2009. Nutritional evaluation of herbs as fodder source for ruminants. *Pak. J. Bot.*, 41(6): 2765-2776.
- Sultan, J. I., I. U. Rahim, H. Nawaz and M. Yaqoob. 2007. Nutritive value of marginal land grasses of northern grasslands of Pakistan. *Pak. J. Bot.*, 39(4): 1071-1082.

- Tabanez, A. A. J. and V. M. Viana. 2000. Patch structure within Brazilian Atlantic Forest fragments and implications for conservation. *Biotropica*, 32 (4): 925-933.
- Taj, S., S. M. Wazir, M. Subhan, M. Hassan, S. U. Khan and M. Kamal. 2009. Some of the ethnobotanically important plants of Godi khel & its outskirts hilly areas, District Karak, Pakistan. *Pak. J. Pl. Sci.*, 15(1): 39-43.
- Tardío, J., M. P. D. Santayana and R. Morales. 2006. Ethnobotanical review of wild edible plants in Spain. *Botanical J. Linn. Society*, 152(1): 27-71.
- Tareen R. B., T. Bibi, M. A. Khan, M. Ahmad and M. D. Zafar. 2010. Indigenous knowledge of folk medicine by the women of Kalat and Khuzdar regions of Balochistan, Pakistan. *Pak. J. Bot.*, 42(3): 1465-1485.
- Tarrason, D., J. T. Urruta, F. Ravera, E. Herrera, P. Andres and J. M. ESpelta. 2010. Conservation status of tropical dry forest remnants in Nicaragua: Do ecological indicators and social perceptions tally? *Biodiversity & Cons.*, 19(3): 813-827.
- Tiffany, M. E., L. R. McDowell, G. A. O'Connor, H. Nguyen, F. G. Martin, N. S. Wilkinson and E. C. Cardoso. 2000. Effects of pasture applied biosolids on forage and soil concentrations over a grazing season in north Florida. I. Macrominerals. Crude Protein and In Vitro Digestibility. *Commun. Soil Sci. Pl. Anal.*, 31: 201-203.
- Tripathi, S. and R. P. Shukla. 2007. Effect of clipping and grazing on various vegetational parameters of grassland communities of Gorakhpur, U.P. *Tropical Ecology*, 48(1): 61-70.
- Tug. G. N. and F. Duman. (2010). Heavy metal accumulation in soils around a Salt-lake in Turkey. *Pak. J. Bot.*, 42(4): 2327-2333.
- Tuxill, H. and G. P. Nabhan. 2001. People, Plants and Protected Areas. *Earthscan*. London.
- Ugulu, I., S. Baslar, N. Yorek and Y. Dogan. 2009. The investigation and quantitative ethnobotanical evaluation of medicinal plants used around Izmir Province, Turkey. *J. Med. Pl. Res.*, 3:345-367.
- Urooj, R., S. S. Ahmad, M. N. Ahmad, H. Ahmad and M. Nawaz. 2016. Ordination study of vegetation analysis around wetland area: A case study of Mangla Dam, Azad Kashmir, Pakistan. *Pak. J. Bot.*, 48(1): 115-119.
- USA.

- Wahab, M. 2011. Population dynamics and dendrochronological potential of pine tree species of District Dir Pakistan. Ph.D dissertation. Department of Botany Federal Urdu University Karachi Pakistan.
- Wahab, M., M. Ahmad, N. Khan, and A. M. Sarangzai. 2010. A phytosociological study of Pine forest from District Dir, Pakistan. *J. Biol. Biotech.*, 7(3): 219-226.
- Wahab, M., M. Ahmad and N. Khan. 2008. Phytosociology and dynamics of some pine forests of Afghanistan. *Pak. J. Bot.*, 40(3): 1071-1079.
- Walpole, M. J., N. Moriaso and M. Charles. 2004. Status of the Mara woodlands in Kenya. *Afr. J. Eco.*, 42(3): 180-188.
- Wang, R. Z. 2004. Responses of *Leymus chinensis* (*Poaceae*) to long-term grazing disturbance in the Songnen grasslands of north-eastern China. *Grass & Forage Science*, 59(2): 191-195.
- Ward J. H. 1963. Hierarchical grouping to optimize an objective function. *J. Am. Stat. Assoc.*, 58: 236-244.
- Wardle, D.A. and R. D. Bardgett. 2004. Human-induced changes in large herbivorous mammal density: the consequences for decomposers. *Frontiers in Eco. and the Envi.*, 2, 145-153.
- Wariss, M., H. Ahmad, S. Anjum and K. Alam. 2014. Ethnobotanical Studies of Dicotyledonous Plants of Lal Suhanra National Park, Bahawalpur, Pakistan. *Int. J. of Sci. & Res.*, 3(6): 2452-2460.
- Wassenaar, T. D. and R. J. V. Aarde. 2001. Short-term responses of rehabilitating coastal dune forest ground vegetation to livestock grazing. *Afr. J. Eco.*, 39(4): 329-339.
- Watson, L. H. and N. O. Smith. 2000. Diet composition and habitat selection of eland in semi-arid shrub land. *Afr. J. Eco.*, 38: 130-137.
- Wazir, S. M., A. A. Dasti, S. Saima, J. Shah and F. Hussain. 2008. Multivariate analysis of vegetation of Chapursan Valley: an alpine meadow in Pakistan. *Pak. J. Bot.*, 40(2): 615-626.
- Wazir, S. M., S. Saima, A. A. Dasti and M. Subhan. 2007. Ethnobotanical importance of Salt Range species of District Karak Pakistan. *Pak. J. Pl. Sci.*, 13(1): 29-31.
- Wazir, S. M., A. A. Dasti and J. Shah. 2004. Common medicinal plants of Chapursan Valley, Gojalli, Gilgit Pakistan. *J. Res. Sci.*, 15(1): 41-43.
- White, P. J. and M. R. Broadly. 2003. Calcium in plants. *Annals of Bot.*, 9: 487-511.

- Wu, Tonggui, Wu, M. and Yu, M. 2011. Plant distribution in relation to soil conditions in Hangzhou bay coastal wetlands, China. *Pak. J. Bot.*, 43(5): 2331-2335.
- Yadav, A. S. and S. K. Gupta. 2007. Effect of micro-environment and human disturbance on the diversity of herbaceous species in Sariska Tiger Project. *Tropical Ecology*, 48 (1): 125-128.
- Yadav, S. K. 2010. Heavy metals toxicity in plants: An overview on the role of glutathione and phytochelatins in heavy metal stress tolerance of plants. *South African J. of Bot.*, 76: 167- 179.
- Yalcin, E., M. Kilinc, H.G. Kutbay, A. Bilgin and H. Korkmaz. 2011. Floristic properties of lowland meadows in Central Black Sea Region of Turkey. *Eurasia J Biosci.* 5: 54-63.
- Yuming, Y., W. Kanglin, P. Shengji and H. Jiming . 2004. Bamboo diversity and traditional uses in Yunnan. China. *Mountain Research & Development*, 24 (2): 157-165.
- Zabihullah, N. Akhtar and A. Rashid. 2007. A Checklist of plants in Manzaray Baba Valley Malakand Agency, Pakistan. *Pak. J. Pl. Sci.*, 13(2): 111-117.
- Zahoor, M., S. M. Wazir, A. Muhammad and S. F. Muhammad. 2009. Ethnobotany of some plants from Darra'e Pezo, District Lakki Marwat, Pakistan. *Pak. J. Pl. Sci.*, 15(1): 75-80.
- Zhao, D., P. J. Starks, B. K. Kindiger and C. T. Mackown. 2008. Interspecies variation of forage nitrogen and nonstructural carbohydrate concentrations in perennial cool-season grasses. *Agronomy J.*, 100(3): 1-8.
- Zhang, J. T., and F. Zhang. 2011. Ecological relations between forest communities and environmental variables in the Lishan Mountain Nature Reserve, China. *Afri J. Agri. Res.*, 6: 248-259.
- Zheng, Z., Z. Feng, M. Cao, Z. Li and J. Zhang. 2006. Forest structure and biomass of a tropical seasonal Rain Forest in Xishuangbanna, Southwest China. *Biotropica*, 38(3): 318-327.

