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FLORISTIC AND VEGETATION DIVERSITY OF GADOON HILLS OUTER HIMALAYAS DISTRICT SWABI, PAKISTAN

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Abstract

An ecological study was conducted in summer to record the floristic and vegetation diversity of unexplored Gadoon Hills, Outer Himalayas District Swabi, Pakistan. Vegetation was analyzed using 10 nested, 10-m^2, 5-m^2 and 1-m^2 quadrats respectively for trees, shrubs and herbs in all the sites for determining density, cover and frequency of each recorded species. Floristic composition revealed 107 plant species of 98 genera and 54 families. The vegetation and its component flora is divided altitudinally in to sub-Himalayan semi–evergreen, Himalayan Chir pine and Himalayan Temperate zones, each with its component plant communities. The flora and vegetation exhibited hemicrpto-therophytic life form and nano-mesophillic leaf spectra. Majority of the species were mesophytic (63.55%) and annual with simple leaves. FIV, TIV and Mori index revealed that Asteraceae, Rosaceae, Poaceae, Mimosaceae, Pinaceae, Fagaceae, Lamiaceae and Papilionaceae were the dominant families in the investigated area.SIV identified that the top most species in decreasing order were *Pinus roxburghii*, *Quercus dilatata*, *Acacia catechu* and *Heteropogon contortus.* Of the 13 sites, 12 were heterogeneous. Most of the species occupied Classes I-III. Species diversity (0.05-0.29), species richness (0.89-2.14) and species maturity (42.0-76.67) were generally low in the investigated area. The area is highly degraded with nutrient deficiency owing to deforestation, overgrazing, over-exploitation and soil erosion, which are the major threats to the biodiversity of the area. Trees and shrubs are generally stunted and isolated. The area requires concerted ecological and conservation management efforts for the rehabilitation of the original vegetation with the participation of all stake-holders.

Key words: Floristic & Vegetation Diversity, Outer Himalayas, Gadoon Hills, Swabi, Pakistan.

Introduction

Floristic and vegetation diversity is the ecological outcome of an area resulting from complex and intricate inter-relationships operating among the various biotic and abiotic parts. It presents the overall effect produced by the growth of some or all species in various combinations forming various degrees of grouping called plant communities. Efforts are going on to record the floristic and vegetation diversity of various parts of Pakistan. In the same context, Shah *et al*., (2022) reported 80 plant species of 29 families including 27 dicot families from Jani Khel, Bannu. Khan *et al*., (2022) listed 307 taxa of 94 families from Marghazar Swat. Family Rosaceae, therophytes and microphylls were the dominant components. Rahman *et al*., (2022) recorded 244 plant species within 74 families and 194 genera forming 4 plant communities in the Manoor Valley NW Himalayas. Rahman *et al*., (2021) observed 58 plant species of 32 families in understory layer in degraded Oak forests of Swat. Family Fabaceae, hemicryptophytes and microphylls were dominant in the area. Khan *et al*., (2021) identified 330 species including 277 dicot species with 188 genera and 61 families from remote inaccessible Tirah Valley, Pakistan. Monocots shared 35 species with 25 genera of 9 families. The leading families were Asteraceae, Lamiaceae, Rosaceae and Poaceae. One species representation was observed in 35 families. The Pashat Valley District Bajaur had 385 species within 291 genera and 102 families (Haq & Badshah, 2021). Asteraceae, Poaceae and Papilionaceae were the major families contributing to the flora of the area. Zubair *et al*., (2021) listed 45 species of 34 families from understory forest layer with Asteraceae and Fabaceae as the leading families. Mseddi *et al*., (2021) reported 163 species of 101 genera and 41 families from Salma Mountains. They accepted Asteraceae Brassicaceae and Fabaceae as the largest families. Malik *et al*., (2021) listed 190 species of 128 genera and 53 families from Decigram National Park, Western Kashmir Himalayas. Das *et al*., (2021) identified 945 taxa, 470 genera of 188 families in Great Himalayan National Park in Kullu, Western Himalayas. Biswas *et al*., (2021) enumerated 418 species, 315 genera and 120 families in the Chattogram, Bangladesh. Ou *et al*., (2020) registered 186 species, 147 genera and 76 families in understory vegetation in mixed forest in South China.

Some previous studies (Hussain *et al*., 1993, 1994, 2000, 2015; Durrani *et al.,* 2005; Wazir *et al*., 2008; Sher *et al*., 2014; Shedayi *et al*., 2016; Ilyas *et al*., 2018); and recent studies (Shah *et al*., 2022; Khan *et al*., 2022; Hazrat *et al*., 2020; Hamid *et al*., 2020; Abbas *et al*., 2020, 2021) have mostly reported deteriorated flora, vegetation and loss of habitat in various ecological zones of Pakistan due to overgrazing, deforestation and unmanaged human interferences. The above endeavors advocate that no sincere scientific effort exists on the flora and vegetation diversity of the Gadoon Hills, Outer Himalayas, District Swabi. The only available reference on the floristic enumeration of Gadoon Hills is that of Sher *et al*., (2014). The present study was, therefore, devoted to record the existing ecological status of the rapidly declining plant resources due to socio-economic pressure on these renewable forests. This base line data will be an eye opener for the future workers striving for the improvement of rangeland ecosystems of this neglected area.

Materials and Methods

Location and climate of the investigated area: Gadoon Hills are located between latitudes 34-0' and 34-25' N and longitude 72-9' and 72-40' E. The area is bounded by District Buner on the North-West and Utman merged area on east; and Panjmand-Pabenai-Topi area of the District Swabi. The general altitude varies from 400 m on the eastern boundary to 2250 m at Shah Kot Sar (Mahaban Forest). The climate is sub-tropical and semi-arid in the lower reaches that become temperate in the upper parts. Bulk of the rain and high humidity is received during monsoon. The annual rainfall varies from 60 to 145cm that enhances with increasing altitude towards north. Snow fall occurs at high altitudes. Hot summers are characteristic with June and July as the hottest months with mean maximum temperatures of 40-45^{o}C in the lower parts. Winters are cold with mean monthly temperatures of 4 to 10^{o}C. December and January are the coldest months.

Floristic composition: Floristic and vegetation studies were conducted in 13 representative sites during summer. These sites were selected on the basis of floristic diversity, habitat condition, altitude and physiognomic contrast. Plants within the sampled area were collected, processed and deposited in the Peshawar University Herbarium. The identification of plants and nomenclature follows Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1991; Ali & Qaiser, 1991-2022-continued). The life-form and leaf size spectra were determined after Raunkiaer (1934) and Hussain (1989). Plants encountered within the quadrats were considered for preparing floristic list, which were arranged alphabetically with morpho-ecological characteristics.

Vegetation structure: Vegetation structure was analyzed by using 10 nested, 10-m^2, 5-m^2 and 1-m^2 quadrats respectively for trees, shrubs and herbs in all sites for determining density, cover and frequency of each recorded species. Due to differences in sizes of quadrats, the values were changed to per hectare scale for seeking uniformity. The shrub and herbage cover was estimated using Daubenmire cover Scale (Daubenmire, 1959; Hussain, 1989). For tree, diameter at breast height (1.5m) was measured and converted to basal area (Hussain, 1989) following standard tables. The density, frequency and coverage/basal areas were converted to relative values and summed to obtain importance values (IV) for each species. Due to differences in growth stage some species were recorded as trees and shrubs in the respective layers. However, for the purpose of floristic listing such species were considered once. Since the vegetation was stratified in to tree, shrub and herbaceous strata, therefore, plant communities were named by selecting species with highest importance value in each of these strata. Soil, sampled up to 15 cm depth was analyzed by standard methods (Hussain, 1989; Jackson, 1962) for various physical and chemical features. As evident from literature (Naidu & Kumar, 2016; Madiapevo *et al*., 2017; Hassannejad & Ghafarbi, 2012; Kacholi, 2014; Mori *et al*., 1983) that Family Importance Value (FIV) has been calculated using various parameters and methods. Therefore, based on this variation, FIV was calculated on the basis of number of species and genera (Naidu & Kumar, 2016), Relative diversity (Mori *et al*., 1983), Average density (Kacholi, 2014; Madiapevo *et al*., 2017), total IV (Hassannejad & Ghafarbi, 2012) and Mori's Index (Mori *et al*., 1983) for each family.

Determination of other indices: Similarity index was calculated by using Sorensen's floristic index (Sorensen, 1948) and quantitative index of Motyka *et al*., (1950). Homogeneity/ heterogeneity of the communities were determined by using Raunkiaer's Law of Frequency (Raunkiaer, 1934). Species diversity was calculated by Simpson's index of diversity (Simpson, 1949). Species richness was worked out following Menhinick (1964). Maturity Index of the site/community was obtained by Pichi-Sermolli (1948) method.

Results and Discussion

Floristic composition: Floristic composition, physiognomy and structure of the vegetation depend on successful species with the prevailing local conditions. The dominant species control the structure, function of subordinate and diversity of community (Hussain & Ilahi, 1991). The flora consisted of 107 plant species, 98 genera and 54 families (Tables 1-2). A rich floristic listing of 307 taxa from Marghazar (Khan *et al*., 2022), 244 from Manoor Valley (Rahman *et al*., 2022), 385 species from Pashat Valley (Haq & Badshah, 2021) and 145 species from Dhirkot, AJK (Mumshad *et al*., 2021) are also on record because of more favourable habitat conditions in these areas. Khan *et al*., (2021) identified 330 taxa and 230 genera of 78 families from Tirah Valley. Biswas *et al*., (2021) recorded 418 species of plants with 315 genera 120 families from Chattogram, with hot humid location favouring flora and vegetation. Our researched area is hot and dry supporting poor flora and vegetation. Furthermore, habitat deterioration, over exploitation and easy accessibility to the area has caused loss of plant resources in Gadoon. Pteridophytes had 3 families, 4 genera and 5 species: *Adiantum incisum, A. venustum, Asplenium adiantum, Cetrach dalhousiae* and *Cheilanthus marantae* because of relatively high temperature and low humidity. Pteridophytes have been generally ignored by almost all researches (Khan *et al*., 2022; Khan *et al*., 2020) and this is reason for their poor share in the total flora. Pteridophytes require special shady moist habitats which appear insignificant in a large scale phytodiversity. Pakistan reportedly has 202 species of pteridophytes (Gul *et al*., 2016), which is minor contribution towards the flora of Pakistan.

Table 1. Floristic composition and their eco-morphological features of plants of Gadoon Hills, Outer-Himalayas District Swabi, Pakistan.

S. No.	Families and species	Life form	Leaf size	Leaf persistence	Fl Period	Light requirement	Habitat: Mesic/ wet	Spines	Growth habit	Leaf morphology
	A. Pteridophytes (3 Families; 4 G, 5 Sp)									
1.	**Family Adiantaceae (1 G, 2 sp.)**									
	1. *Adiantum incisum* Forssk.	H	L	E	Spores in spring	Sci	Moist	-	Herb	Compound
	2. *Adiantum venustum* D. Don	H	L	E	Spores in spring	Sci	Moist	-	Herb	Compound
2.	**Family Aspleniaceae (2G, 2 sp)**									
	1. *Asplenium adiantum nigrum*L.	H	L	E	Spores in spring	Sci	Moist	-	Herb	Compound
	2.*Ceterach dalhousiae*(Hk.)C. Chr.	H	L	E	Spores in spring	Sci	Moist	-	Herb	Compound
3.	**Family Pteridaceae (1G, 1 sp)**									
	1. *Cheilanthes marinate* (L.) Domin.	H	L	E	Spores in spring	Sci	Moist	-	Herb	Incised
	B. Gymnosperms (2 Families; 2G, 2 Sp)									
4.	**Family Pinaceae (1G, 1 sp)**									
	1. *Pinus roxburghii* Sargent	MP	L	E	Cones in spring	Hel	Mesic	-	Tree	Simple
5.	**Family Taxaceae (1G, 1 sp)**									
	1. *Taxus wallichiana* Zucc.	MP	N	E	Cones in spring	Hel	Mesic	-	Tree	Simple
	C. Monocotyledons (3 Families, 15 G, 15 Sp.)									
6.	**Family Cyperaceae (2G, 2 sp)**									
	1. *Cyperus niveus* Retz.	H	N	D	Spring	Hel	Moist	-	Herb	Simple
	2. *Fimbristylis dichotoma (*L.) Vahl.	H	N	D	Spring	Hel	Moist	-	Herb	Simple
7.	**Family Liliaceae (1G, 1 sp)**							-		
	1.*Tulipa stellata* Hk.f.	G	Mic	D	Spring	Hel	Mesic	-	Herb	Simple
8.	**Family Poaceae (12 G, 12 sp)**									
	1. *Apluda mutica*L.	H	Mic	D	Spring	Hel	Mesic	-	Herb	Simple
	2. *Aristida adscensionis* L.	H	Mic	D	Spring	Hel	Mesic	-	Herb	Simple
	3. *Avenasativa* L.	Th	Mic	D	Spring	Hel	Mesic	-	Herb	Simple
	4. *Chrysopogonaucheri* (Boiss.)Stapf	H	Mic	E	Spring	Hel	Mesic	-	Herb	Simple
	5. *Cynodon dactylon* (L.) Pers.	H	Mic	E	Spring	Hel	Mesic	-	Herb	Simple
	6. *Dichanthium annulatum* (Forssk.) Stapf.	H	Mic	E	Spring	Hel	Mesic	-	Herb	Simple
	7. *Digitaria sanguinalis* (L.) Scop.	H	Mic	D	Spring	Hel	Wet	-	Herb	Simple
	8. *Heteropogon contortus* (L.) P. Beauv.	H	Mic	E	Spring	Hel	Mesic	-	Herb	Simple
	9. *Imperata cylindrica* (L.)P. Beauv.	H	Mic	E	Spring	Hel	Mesic	-	Herb	Simple
	10. *Phalaris minor* Retz.	Th	Mic	D	Spring	Hel	Mesic	-	Herb	Simple
	11. *Poa annua* L.	Th	Mic	D	Spring	Hel	Mesic	-	Herb	Simple
	12. *Themeda anathera* (Nees) Hack.	H	Mic	E	Spring	Hel	Mesic	-	Herb	Simple
	D. Dicotyledons (46 Families; G ; 85 Sp)									
9.	**Family Acanthaceae (1G, 1 sp)**									
	1. *Justicia adhatoda* L.	Np	Mes	E	Spring/Summer	Hel	Mesic	-	Shrub	Simple
10.	**Family Amaranthaceae (1G, 1 sp)**									
	1. *Achyranthes aspera* L.	H	Mes	D	Spring/Summer	Sci	Mesic	+	Herb	Simple
11.	**Family Apocynaceae (2 G, 2 sp)**									
	1. *Carissa spinarum* auct. non L.	Np	Mes	E	Summer	Hel	Mesic	+	Shrub	Simple
	2. *Rhazya stricta* Dcne.	Ch	Mic	E	Spring/Summer	Hel	Dry	-	Shrub	Simple
12.	**Family Araliaceae (1G, 1 sp)**									
	1. *Hedera helix* L.	Mp (Climber)	Mes	E	Summer	Sci	Mesic	-	Woody climber	Simple

Table 1. (Cont'd.).

S. No.	Families and species	Life form	Leaf size	Leaf persistence	Fl Period	Light requirement	Habitat: Mesic/ wet	Spines	Growth habit	Leaf morphology
13.	**Family Asclepiadaceae (1G, 1 sp)**									
	1.*Calotropis procera (*Wild) R.Br.	Ch	Mes	E	Spring	Hel	Dry	-	Shrub	Simple
14.	**Family Asteraceae (10 G, 10 sp)**									
	1. *Artemisia vulgaris L.*	Ch	L	E	Spring	Hel	Dry	-	Shrub	Incised
	2. *Calendula arvensis L.*	Th	Mes	D	Spring	Hel	Mesic	-	Herb	Simple
	3. *Conyza canadensis* (L.) Cronquist	Th	Mes	D	Spring	Hel	Mesic	-	Herb	Simple
	4. *Echinops echinatus* Roxb.	Th	Mes	D	Spring	Hel	Mesic	+		Simple
	5. *Filago spathulata C*. Presl.	Th	Nano	D	Spring	Hel	Mesic	-	Herb	Simple
	6. *Myriactus wallichii* Less.	Th	Nano	D	Summer	Hel	Moist	-	Herb	Simple
	7. *Saussurea heteromalla (*D. Don.) Hand-Mazz	H	Nano	D	Summer	Hel	Mesic	+	Herb	Simple
	8. *Sonchus asper* L.	Th	Micr	D	Spring/Summer	Sci	Moist	-	Herb	Simple
	9. *Tagetus minuta* L.	Th	Nano	D	Summer	Hel	Mesic	-	Herb	Incised
	10. *Taraxacum officinale* Weber.	Th (biennial)	Nano	D	Summer	Hel	Moist	-	Herb	Incised
15.	**Family Berberidaceae (1G, 1 sp)**									
	1. *Berberis lycium* Royle.	Np	Micro	E	Summer	Hel	Dry	+	Shrub	Simple
16.	**Family Boraginaceae (1G, 1 sp)**									
	1. *Trichodesma indica* (L.) R.Br.	Th	Nano	D	Summer	Sci	Mesic	-	Herb	Simple
17.	**Family Buxaceae (1G, 1 sp)**									
	1. *Sarcococa saligna* (Dcne) Duel	NP	Micr	E	Summer	Sci	Mesic	-	Shrub	Simple
18.	**Family Caprifoliaceae (2 G, 3 sp)**									
	1. *Lonicera hypoleuca* Dcne.	Mp (Climber)	Micro	D	Summer	Hel	Mesic	-	Woody climber	Simple
	2. *Lonicera quinquilacularis* Hardw.	Mp (Climber)	Micro	D	Summer	Hel	Mesic	-	Woody climber	Simple
	3. *Vibernum cotinifolium* D. Don.	Mp	Micro	D	Summer	Hel	Mesic	-	Shrub	Simple
19.	**Family Caryophyllaceae (2 G, 2 sp)**									
	1. *Silene vulgaris* (Moench) Carcke	Th	L	D	Spring/Summer	Sci	Moist	-	Herb	Simple
	2. *Stellaria media* (L.) Cyr.	Th	L	D	Spring/Summer	Sci	Moist	-	Herb	Simple
20.	**Family Celastraceae (1G, 1 sp)**									
	1. *Gymnosporia royleana* Wall ex Lawson	NP	Nano	E	Summer	Hel	Dry	+	Shrub	Simple
21.	**Family Crassulaceae (1G, 1 sp)**									
	1. *Hylotelephium ewersii* (Ledeb.) H. Ohba (*Sedum ewersii* Ledeb.)	H	L	D	Summer	Sci	Moist	-	Herb	Simple
22.	**Family Cucurbitaceae (1G, 1 sp)**									
	1. *Solena amplexicaulis* (Lam.) Gandhi	H	Meso	D	Spring	Hel	Mesic	-	Herb	Simple
23.	**Family Ericaceae (1G, 1 sp)**									
	1. *Rhododendron arborium* Smith.	Np	L	E	Summer	Hel	Mesic	-	Shrub	Simple
24.	**Family Euphorbiaceae (2 G, 3 sp)**							-	Herb	Simple
	1. *Euphorbia hirta* L.	Th	L	D	Summer	Hel	Mesic	-	Herb	Simple
	2. *Euphorbia prostrata* Ait.	Th	L	D	Summer	Hel	Mesic	-	Herb	Simple
	3. *Mallotus philippensis* Muell.	Mp/ Np	Mic	E	Summer	Hel	Mesic	-	Tree	Simple
25.	**Family Fagaceae (1G, 2 sp)**									
	1. *Quercus dilatata* Lindley	MP	Mic	E	Summer	Hel	Mesic	-	Tree	Simple
	2. *Quercus incana* Roxb.	MP	Mic	E	Summer	Hel	Mesic	-	Tree	Simple

Table 1. (Cont'd.).

S. No.	Families and species	Life form	Leaf size	Leaf persistence	Fl Period	Light requirement	Habitat: Mesic/ wet	Spines	Growth habit	Leaf morphology
26.	**Family Flacourtiaceae (1G, 1 sp)**									
	1. *Flacourtia indica* (Burm. f.) Merrill	NP	Mic	D	Summer	Hel	Mesic	-	Shrub	Simple
27.	**Family Gentianaceae (1G, 1 sp)**									
	1. *Gentianodes kurroo* (Royle) Omer, Ali & Qaiser	H	L	D	Summer	Hel	Mesic	-	Herb	Simple
28.	**Family Geraniaceae (1G, 1 sp)**									
	1. *Geranium wallichianum* D. Don. ex Sweet	Th	Nano	D	Summer	Sci	Moist	-	Herb	Incised
29.	**Family Hamamelidaceae (1G, 1 sp)**									
	1. *Parrotiopsis jacquemontiana* Dcne.	MP/NP	Mes	E	Summer	Hel	Mesic	-	Shrub	Simple
30.	**Family Lamiaceae (5 G, 6 sp)**									
	1. *Ajuga bracteosa* Wall. ex Benth.	Th	Nano	D	Summer	Sci	Moist	-	Herb	Simple
	2. *Ajuga parviflora* Benth.	Th	Nano	D	Summer	Sci	Moist	-	Herb	Simple
	3. *Micromeria biflora* (Buch.-Ham. ex D. Don) Benth.	H	Nano	D	Summer	Sci	Moist	-	Herb	Simple
	4. *Origanum vulgare* L.	Ch	Nano	E	Summer	Hel	Mesic	-	Herb	Simple
	5. *Otostegia limbata* Bth.	Ch	Nano	E	Summer	Hel	Mesic	+	Shrub	Simple
	6. *Salvia moocruftiana* Wall. ex Benth	H	Mes	D	Summer	Hel	Mesic	-	Herb	Simple
31.	**Family Malvaceae (2G, 2 sp)**									
	1. *Malva parviflora* L.	Th	Mes	D	Spring/Summer	Hel	Mesic	-	Herb	Simple
	2. *Sida cordata* (Burm.f) Borss-Waalkes	Np	Mes	D	Summer	Hel	Mesic	-	Shrub	Simple
32.	**Family Mimosaceae (3 G, 5 sp)**									
	1. *Acacia catechu* (L.f.) Willd.	MP	L	D	Spring/Summer	Hel	Mesic	+	Tree	Compound
	2. *Acacia modesta* Wall.	MP	L	D	Spring/Summer	Hel	Mesic	+	Tree	Compound
	3. *Acacia nilotica ssp nilotica* (L.) Delile.	MP	L	D	Spring/Summer	Hel	Mesic	+	Tree	Compound
	4. *Albizia lebbeck* (L.) Bth.	MP	L	D	Spring/Summer	Hel	Mesic	-	Tree	Compound
	5. *Mimosa himalayana* Gamble	NP	L	D	Spring/Summer	Hel	Mesic	+	Shrub	Compound
33.	**Family Moraceae (1G, 1 sp) (1G, 1 sp)**									
	1. *Ficus palmata* Forssk.	MP	Meso	D	Summer	Hel	Mesic	-	Tree	Simple
34.	**Family Myrsinaceae (1G, 1 sp)**									
	1. *Myrsine africana* L.	NP	Meso	E	Summer	Hel	Mesic	-	Shrub	Simple
35.	**Family Nyctaginaceae (1G, 1 sp)**									
	1. *Boerhaavia diffusa* L.	H	Meso	E	Summer	Hel	Mesic	-	Herb	Simple
36.	**Family Onagraceae 2 G, 2 sp)**									
	1. *Epilobium brevifolium* D. Don.	Th	Nano	D	Summer	Hel	Mesic	-	Herb	Simple
	2. *Oenothera rosea* Soland.	Th	Nano	D	Summer	Hel	Mesic	-	Herb	Compound
37.	**Family Oxalidaceae (1G, 1 sp)**									
	1. *Oxalis corniculata* L.	Th	Nano	D	Spring/Summer	Sci	Moist	-	Herb	Compound
38.	**Family Papilionaceae (3 G, 3 sp)**									
	1. *Butea monosperma* (Lain.) Taubert.	MP	Meso	D	Spring	Hel	Mesic	-	Tree	Compound
	2. *Indigofera heterantha* L.	NP	L	E	Spring	Hel	Mesic	-	Shrub	Compound
	3. *Medicago polymorpha* L.	Th	L	D	Spring	Hel	Moist	-	Herb	Compound
39.	**Family Plantaginaceae (1 G, 2 sp)**									
	1. *Plantago lanceolata* L.	Th	Nano	D	Spring	Hel	Mesic	-	Herb	Simple
	2. *Plantago major* L.	Th	Meso	D	Spring	Hel	Moist	-	Herb	Simple

Table 1. (Cont'd.).

S. No.	Families and species	Life form	Leaf size	Leaf persistence	Fl Period	Light requirement	Habitat: Mesic/ wet	Spines	Growth habit	Leaf morphology
40.	**Family Polygonaceae (2 G, 2 sp)**									
	1. *Bistorta amplexicaulis* (D. Don) Green	H	Nano	E	Spring	Hel	Moist	-	Herb	Simple
	2. *Rumex dentatus* L.	H	Nano	E	Spring	Hel	Moist	-	Herb	Simple
41.	**Family Primulaceae (1G, 1 sp)**									
	1. *Androsace rotundifolia* Hardw.	H	Nano	E	Spring	Sci	Mesic	-	Herb	Incised
42.	**Family Ranunculaceae (1G, 1 sp)**									
	1. *Delphinium denudatum* Wall. ex Hook. & Thoms	H	L	D	Spring	Sci	Mesic	-	Herb	Incised
43.	**Family Rhamnaceae (2 G, 3 sp)**							-	Herb	
	1. *Sageretia thea* (Osbeck) M.C. Johnston	NP	L	E	Spring	Sci	Mesic	-	Shrub	Simple
	2. *Ziziphus mauritina* Lamb.	MP	Nano	E	Spring/Summer	Hel	Dry	+	Tree	Simple
	3. *Ziziphus nummularia* (Burm. f.) Wight & Arn	NP	Nano	E	Spring/Summer	Hel	Dry	+	Shrub	Simple
44.	**Family Rosaceae (7 G, 7 sp)**									
	1. *Cotoneaster bacillaris* Wall. ex Lindle.	MP/ NP	Nano	E	Spring	Hel	Mesic	-	Tree	Simple
	2. *Duchesnea indica* (Andrews) Focke	H	Nano	D	Spring	Sci	Mesic	-	Herb	Simple
	3. *Fragaria nubicola* (Hook.f.) Lindl. ex Lacaita	H	Nano	D	Spring	Sci	Mesic	-	Herb	Simple
	4. *Potentilla supina* L.	Th	Nano	D	Spring	Sci	Mesic	-	Herb	Simple
	5. *Prunus cornuta* (Wall ex Royle) Steud.	MP	Meso	D	Spring	Hel	Mesic	-	Tree	Simple
	6. *Pyrus pashia* Ham ex. D. Don.	MP	Meso	D	Spring	Hel	Mesic	-	Tree	Simple
	7. *Rosa moschata* non J. Herrm.	NP (Climber)	Meso	D	Spring	Hel	Mesic	+	Woody climber	Compound
45.	**Family Rubiaceae (1G, 1 sp)**									
	1. *Gallium aparine* L.	Th	L	D	Spring	Sci	Mesic	-	Herb	Compound
46.	**Family Sapindaceae (1G, 1 sp)**							-		
	1. *Dodonaea viscosa* (L.) Jacq.	NP	Meso	E	Spring	Hel	Dry	-	Shrub	Simple
47.	**Family Saxifragaceae (1G, 1 sp)**									
	1. *Bergenia ciliata* (Haw) Sternb.	H	Meso	E	Spring	Sci	Moist	-	Herb	Simple
48.	**Family Scrophulariaceae (1G, 1 sp)**									
	1. *Verbascum thapsus* L.	Th (Biennial)	Meso	D	Spring	Hel	Dry	-	Herb	Simple
49.	**Family Simaroubaceae (1G, 1 sp)**									
	1. *Ailanthus altissima* (Mill) Swingle	MP	Meso	D	Spring	Hel	Mesic	-	Tree	Compound
50.	**Family Tiliaceae (1G, 1 sp)**								Herb	
	1. *Grewia optiva* Drummond ex Burret	NP	Meso	D	Summer	Hel	Mesic	-	Shrub	Simple
51.	**Family Ulmaceae (1G, 1 sp)**									
	1. *Celtis caucasica* Willd	MP	Meso	D	Summer	Hel	Mesic	-	Tree	Simple
52.	**Family Urticaceae (1G, 1 sp)**									
	1. *Urtica dioca* L.	Th	Meso	D	Summer	Sci	Moist	-	Herb	Simple
53.	**Family Valerianaceae (1G, 1 sp)**								Herb	
	1. *Valeriana jatamansi* Jones.	H	Meso	D	Summer	Sci	Moist	-	Herb	Simple
54.	**Family Violaceae (1G, 1 sp)**									
	1. *Viola stocksii* Boiss.	H	Meso	D	Summer	Sci	Moist	-	Herb	Simple

Key: **Th:** Therophytes, **Mp:** Megaphanerophytes, **Np:** Nanophanerophytes, **Hc:** Hemicryptophytes,**G:**Geophytes,**Ch:**Chamaephytes,,**Mic:**Microphylls,**Lp:** Leptophylls, **Mes:** Mesophyllus, **Na:** Nanophylls

Table 2. Summary of eco-morphological features of flora of Gadoon Hills, Outer Himalayas, District Swabi, Pakistan

	A. Life form	No. of species	%		E. Habitat form	No. of species	%
1.	Therophytes	30	28.04	1.	Moist	28	26.17
2.	Megaphanerophytes	21	19.03	2.	Mesic	68	63.55
3.	Nanophanerophytes	16	14.95	3.	Dry	11	10.28
4.	Hemicryptophytes	33	30.84				
5.	Chamaephytes	6	5.61		**F. Light relations**	**No. of species**	**%**
6.	Geophytes	1	0.93	1.	Heliophytes	29	27.1
				2.	Sciophytes	78	72.9
	B. Leaf size spectra	**No. of species**	**%**		**G. Leaf persistence**	**No. of species**	**%**
1.	Leptophylls	24	22.43	1.	Evergreen	42	39.25
2.	Nanophylls	30	28.04	2.	Deciduous	65	60.75
3.	Microphylls	25	23.36				
4.	Mesophylls	28	26.17		**H. Spines**	**No. of species**	**%**
				1.	Spiny	13	12.15
	C. Life span	**No. of species**	**%**	2.	Non-spiny	94	87.85
1.	Annual	30	28.04				
2.	Perennial	77	71.96				
					I. Leaf form	**No. of species**	**%**
	D. Habit	**No. of species**	**%**	1.	Simple	81	74.77
1.	Herbs	65	60.75	2.	Compound	19	17.75
2	Shrubs	22	20.56	3.	Incised	8	7.48
3	Trees	17	15.89				
4.	Woody climbers (Lianas)	3	2.80				

Gymnosperms added 2 families, 2 genera and 2 species (*Pinus roxburghii* & *Taxus wallichiana*), which are same as reported in the previous study (Sher *et al*., 2014) from the same location. Ahmad *et al*., 2014; Khan *et al*., (2021) and Mumshad *et al*., (2021) supporting the present findings also reported *Pinus roxburghii* from their investigated sites. Monocots had 15 species within 3 families and 15 genera and. Poaceae with (12 genera &12 species) was the overall leading family. Dicots had 85 species, 77 genera and 46 families (Tables 1-2). Asteraceae with 10 monotypic genera, Rosaceae with 7 monotypic genera; and Lamiaceae with 5 genera and 6 species) were the major families among dicots (Tables 1 & 3). Mimosaceae had 3 genera with 5 species; Papilionaceae had 3 genera; while 9 families had 2 genera. Four families viz: Papilionaceae, Caprifoliaceae, Rosaceae, Euphorbiaceae contained 3 species. Two species were present in 10 families. The remaining 38 families had solitary genus each with single species. The present findings agree with Sher *et al*., (2014), who listed 39 families each with one species from the same area. Like the present findings, one species representation is reported by Khan *et al*., (2021) in 35 families, Meragiaw *et al*., (2021) in 33 families, by Rahman *et al*., (2021) in 22 families, by Huang *et al*., (2020) in 22 families and in 18 families by Haq *et al*., (2021). The present floristic list containing 107 species with 98 genera and 54 families is far lesser than the previously reported 260 plant species with 211 genera and 90 families from the same area (Sher *et al*., 2014). This is because the present listing was strictly confined to the species encountered within the quadrats during summer only; while the previous floristic listing was done of all plants including the cultivated species of the area for all the seasons. Similarly, the floristic composition consisting of 571 species of Mastuj Valley (Hussain *et al*., 2015) also reported plants including cultivated plants for all the seasons. Ali *et al*., (2015) also reported floristic composition of Bunir from the adjoining area. Ahmad *et al*., (2014) also scored 87 species including *Pinus roxburghii* from subtropical pine forest, which agrees with the present study. Families like Asteraceae, Poaceae, Lamiaceae and Papilionaceae emerged as dominant because of high number of species in the present study. This is supported by Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1991; Ali & Qaiser, 1991-2022-continued) and recent studies (Shah *et al*., 2022; Khan *et al*., 2022; Khan *et al*., 2021; Haq & Badshah, 2021; Haq *et al*., 2021; Parveen *et al*., 2021; Mumshad *et al*., 2021; Meragiaw *et al*., 2021; Das *et al*., 2021; Khan *et al*., 2021; Moradipour *et al*., 2020), which also recognized these families as major families in the areas investigated by them.

Biological spectra: Biological spectra consisting of life forms and leaf sizes are important in reflecting the impact of grazing, deforestation and over harvesting of forest resources and habitat features. Life form and leaf size spectra are changeable due to change in climatic and habitat features.

a. Life form spectrum: Tables 1 and 2 depict the various morpho-ecological features of the recorded flora. The dominant life form was hemicryptophytes (30.84%), followed in decreasing order by therophytes (28.04%), megaphanerophytes (19.63%), nanophanerophytes (14.95%), chamaephytes (5.61%) and geophytes (0.93%). Hemicryptophytes are generally common in the open habitats (Rahman *et al.,* 2020, 2021) as observed in the present case. Similar to the present findings; Ghafari *et al.,* (2020) also established hemicryptophytes and therophytes as the dominating life form in rangeland of Iran. Rahman *et al.,* (2021) also regarded hemicryptophytes as the dominant life form in oak forests of Swat. They stated that life form and leaf spectra are indicator of biological interferences, climatic adversaries, grazing and deforestation pressure. The investigated area suffers badly from overgrazing and over harvesting of forests component by the local community. The results are parallel with those of Abbas *et al*., (2021) in this respect. However, many workers reported therophytes, hemicryptophytes and nanophanerophytes (Shah *et al*., 2022; Parveen *et al*., 2021; Haq & Badshah, 2021) as the major life forms in their investigated vegetation, which further strengthen the present findings. Khan *et al*., (2021) also confirmed therophytes and hemicryptophytes as the major contributors to the biological spectrum of Tirah Valley, which agree with the present findings. Das *et al*., (2021) stated that biotic disturbances and dryness promote the percentage of therophytes. They further disclosed that phanerophytes and therophytes contributed 71% of the total life form making phanero-therophytic phytoclimate. Following this concept the present the life form can be designated as hemicrypto-therophytictype as in this case hemicryptophytes and therophytes respectively contributed 58.80% share to the total life form classes. The present findings also in line with Ullah *et al*., (2020), who also observed the dominance of therophytes, nanophanerophytes and megaphanerophytes in vegetation of Lajbouk. Dir Lower. Hazrat *et al*., (2020) held therophytes and nanophenerphytes as the dominants in their studies. The life form in plants of Talash, Dir Lower was thero-phanerophytic that closely follows the trend in the present studies. Strengthening our results, Moradipour *et al*., (2020) also designated hemicryptophytes and therophytes as the major life forms in Mala protected area of Iran.

b. Leaf size spectra: Leaf sizes are reflection of aridity and climatic severity. Plants may be leafless in very hot and dry environment or may generally have smaller leaves to avoid excessive loss of moisture and leaf heating. In the present case, leaf size spectra was composed of nanophyll (28.04%), mesophyll (26.17%), microphyll (23.36%) and leptophyll (22.43%) indicating relatively dry habitat condition. The results agree with the findings of other workers (Haq & Badshah, 2021; Parveen *et al*., 2021; Ullah, 2020), who also designated microphylls followed by nanophylls and mesophyll as the leading leaf classes in their studies. The leaf spectra in the present study have the similar tendency as reported for Shigar Valley (Abbas *et al*., 2020). Rahman *et al*., (2021) stated that microphylls followed by nanophylls were the dominant leaf spectra as the dominant life form in oak forests. Khan *et al*., (2021) also declared nanophylls and microphylls as the leading leaf sizes in the flora of Tirah. The dominance of hemicryptophytes and therophytes coupled with small leaf sizes indicate unfavourable environmental conditions. Owing to over population with immense biotic pressure, the habitat has deteriorated that supports low plant diversity. Badshah *et al*., (2013, 2016), Ahmad *et al*., (2014) and Haq & Badshah (2021) also reported similar life form and leaf size spectra in their investigated areas for similar reasons. The leaf spectra were nano-mesophyllic in the case as both these share 54.21% to the total leaf spectra of the research area.

Life span spectra (longevity): In the present investigation, there were 60.75% herbs, 20.56% shrub, 15.89% tree and 2.8% woody climbers in the flora. Our findings closely agree with Parveen *et al*., (2021), who also recorded 50.5% herbaceous plants, 28% tree and 16.4% shrubby elements in the flora of Shahbaz Garhi, District Mardan. Likewise supporting our findings, Khan *et al*., (2021) also reported that the dominant species in Tirah Valley were annual herbs and perennial herbs, deciduous and heliophytes. Malik *et al*., (2021) reported 137 herb species, 41 shrub and 3 tree species, which agree with the present findings. Meragiaw *et al*., (2021) reported 54% herbs in Won chi, Ethiopia. Ulla *et al*., (2020) identified 55% herb species, which are similar to the present findings. Biswas *et al*., (2021) reported 35% herbaceous elements in the studies. Malik *et al*., (2021) also reported 819 herbaceous species/ha and 102 species/ha of shrubby and 8 species/h of tree in the Dachigam National Park in the Western Himalayas. Das *et al*., (2021) concluded that herbs range from 60% to 95% in different altitudes in Great Himalayan National Park, Western Himalayas. The flora of Lajbouk, Dir Lower contained 13.7 and 31.53% shrubs and tree respectively (Ullah *et al*., 2020), which differed from present case. Hazrat *et al*., (2020) reported the dominance of herbaceous flora (70%) with 34.54% and 63% annual and perennial species in Talash, Dir Lower, coincides with our study. It is obvious that herbaceous flora dominates at high altitudes where shrubs fail to survive. Trees in the stratified forests are always important for as loss of tree layer promotes shrubs that favour the creation of degraded grasslands. The rehabilitation of tree and shrubby vegetation can be encouraged through proper conservation. With respect to life span, there were 71.96% perennial and 28.04% annual species (Table 2). Most of the annuals disappear after completing the life cycle in summer but flush out again during early spring and rainy season.

Habitat forms: The habitat forms are reflection of habitat condition such as aquatic, dry or mesic. Majority of the flora (Table 2) was mesophytic (63.55%), followed by moist (26.17%) and xerophytes (10.28%). Khan *et al*., (2021) also recorded mesic and non-spiny and heliophytic species as major floristic components. This is supportive to the present findings. The flora included 72.9% heliophytes and 27.1 sciophytes. This also supports the adverse nature of the habitat resulting due to openness of the vegetation cover. Sciophytes need cool, shady environment, which is provided by over-story plants. In the present case the stratification is poor and open that discourages the growth of shade loving plants. This is also the reason for the poor occurrence of ferns and pteridophytes in the area. This aspect is further strengthened by the presence of 60.75% deciduous and 39.25% evergreen species in the area. The flora was 87.85% non-spiny.

Leaf morphology: Leaf morphology displayed that the leaves were simple in 74.77%, compound in 17.75% and incised in 7.48% species. Khan *et al*., (2021) also recognized simple-entire leaves and simple-incised leaves as major component of Flora of Tirah, which coincide with the present work. Flora is always controlled by locally operative ecological factors within the major climatic zone. The investigated area falls within the Outer Himalayan zone with moderate temperature, humidity and rainfall. It is easily accessible to human's interferences such as establishment new settlements, deforestation, overharvesting of useful plants, overgrazing that promote soil erosion. Such habitats support mesophytes, heliophytes and deciduous species. Badshah *et al*., (2013), Sher *et al*., (2014), Hussain *et al*., (2015) and Ahmad *et al*., (2016) have reported high state of degradation in their studies, which support the present findings.

Family importance values (FIV): Diversity of species within a family is taken as its importance in the flora and vegetation types. The common easiest index is number of species within a family. However, various workers (Mori *et al*., 1983; Hassannejad & Ghafarbi, 2012; Kacholi, 2014; Madiapevo *et al*., 2017) have applied different indices for determining FIV. We applied 6 different parameters/indices (Table 3) to establish FIV and to compare these indices. Based on number of species, Poaceae (12 sp.), Asteraceae (10 sp.) Rosaceae (7 sp.), Lamiaceae (6 sp.), and Mimosaceae (5 sp.) respectively had high FIV. Abbas *et al*., (2021) also stated both these families to be important in terms number of species and genera. These were followed by Papilionaceae, Caprifoliaceous, Euphorbiaceae and Rhamnaceae, each with 3 species. The next 10 families had 2 species. Relying upon number of genera, Poaceae (12 Genera), Asteraceae (10 Genera), Rosaceae (7 Genera) and Lamiaceae (5 Genera) gathered high FIV. Mimosaceae and Papilionaceae had 3 genera each; and 9 families containing 2 genera were next in order of importance. Considering relative diversity, Poaceae (11.21%), Asteraceae (FIV= 9.35%), Rosaceae (FIV= 6.54%), Lamiaceae (FIV= 5.61%) and Mimosaceae (FIV= 4.67%) gained the importance. Four families: Papilionaceae, Caprifoliaceae, Euphorbiaceae and Rhamnaceae had 2.80% relative diversity. The next 10 (FIV= 1.87%) and 35 families (FIV= 0.93%) were less important. Relatively diversity of the family itself depends upon number of species. Higher the number of species and density, higher will the diversity. In the present case, while considering density h^{-1}, once again Poaceae, followed in decreasing order by Cyperaceae, Plantaginaceae, Oxalidaceae, Lamiaceae, Gentiaceae, Papilionaceae, Adiantaceae, Asteraceae and Aspleniaceae achieved high FIV. In this case density has played the major role in imparting importance to these families.

Table 3. Ten Top most important families based on various parameters/indices.

	Top most 10 important families				
	A. Based on no. of species			**B. Based on no. of genera**	
1.	Poaceae	12	1.	Poaceae	12
2.	Asteraceae	10	2.	Asteraceae	10
3.	Rosaceae	7	3.	Rosaceae	7
4.	Lamiaceae	6	4.	Lamiaceae	5
5.	Mimosaceae	5	5.	Mimosaceae	3
6.	Papilionaceae	3	6.	Papilionaceae	3
7.	Caprifoliaceae	3	7.	9 Families had	2
8.	Euphorbiaceae	3	8.	Remaining families had	1
9.	Rhamnaceae	3			
10.	10 families had	2			
	C. Based on relative diversity (%)			**D. Based on Av Density h^{-1}**	
1.	Poaceae	11.21	1.	Poaceae	42969.2
2.	Asteraceae	9.35	2.	Cyperaceae	20192.3
3.	Rosaceae	6.54	3.	Plantaginaceae	9923.1
4.	Lamiaceae	5.61	4.	Oxalidaceae	7900
5.	Mimosaceae	4.67	5.	Lamiaceae	7687.8
6.	Papilionaceae	2.80	6.	Gentianaceae	3000
7.	Caprifoliaceae	2.80	7.	Papilionaceae	2915.4
8.	Euphorbiaceae	2.80	8.	Adiantaceae	2538.4
9.	Rhamnaceae	2.80	9.	Asteraceae	2538.2
10.	10 families had	1.87	10.	Aspleniaceae	2461.6
	E. Based on total importance value of the family			**F. Based on Mori's Index (%)**	
1.	Poaceae	755.54	1.	Mimosaceae	51.45
2.	Mimosaceae	352.58	2.	Poaceae	47.29
3.	Pinaceae	311.49	3.	Pinaceae	21.72
4.	Fagaceae	306.0	4.	Cyperaceae	18.22
5.	Lamiaceae	202.59	5.	Fagaceae	16.77
6.	Papilionaceae	186.33	6.	Lamiaceae	14.19
7.	Cyperaceae	181.04	7.	Papilionaceae	13.42
8.	Rhamnaceae	134.60	8.	Rosaceae	11.6
9.	Sapindaceae	127.37	9.	Asteraceae	11.6
10.	Oxalidaceae	117.54	10	Plantaginaceae	9.77

Application of Total Importance Values (TIV) as an index, revealed that the 10 top most important families respectively in decreasing order were Poaceae, Mimosaceae, Pinaceae, Fagaceae, Lamiaceae, Papilionaceae, Cyperaceae, Rhamnaceae, Sapindaceae and Oxalidaceae with range of TIV from 755.54 to 117.54 (Table 3). Mori's index (Mori *et al*., 1983) arranged the 10 top most families in declining order as Mimosaceae, Poaceae, Pinaceae, Cyperaceae, Fagaceae, Lamiaceae, Papilionaceae, Rosaceae, Asteraceae and Plantaginaceae with FIV gradually decreasing from 51.45 to 9.77 (Table 3). Families Poaceae, Rosaceae, Papilionaceae, Asteraceae and Lamiaceae are among the largest families in Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1991; Ali & Qaiser, 1991-2022 continued). Although, it was obvious that various indices applied for determining FIV gave different results, yet, it was evident that almost the same 10 (or more) families appeared as important in almost all the cases. Family Poaceae with highest FIV was the top most family in 5 indices (Table 3 A-E) and 2nd in position in Mori's index (Table 3F). The order of importance of Poaceae, Asteraceae, Rosaceae, Lamiaceae, Mimosaceae and Papilionaceae was exactly the same when FIV was based on number of species (Table 3A), genera (Table 3B) and relative diversity (Table 3C). It was interesting to see that Family Asteraceae lost its position in 10 top most families based on Total importance value index. Some minor shifting in the position of families was seen when using total importance value (Table 3E) and Mori index (Table 3F). Pinaceae, Fagaceae, Rhamnaceae and Plantaginaceae were absent in all other indices, but Pinaceae, Fagaceae and Rhamnaceae respectively occupied 3rd, 4th and 8th position when TIV was used. Similarly, Pinaceae, Fagaceae, Rhamnaceae and Plantaginaceae had 3rd, 5th, 7th and 10th position based on Mori's Index. The present study suggests that any one of these indices can be satisfactorily applied for calculating FIV. However, indices calculated by using number of species, genera and TIV are simple, efficient, workable and less time consuming. The findings agree with contemporary workers, who have also established Poaceae, Rosaceae, Asteraceae, Lamiaceae, Apiaceae, Brassicaceae and Papilionaceae as the major families in various studies in different locations due their cosmopolitan nature (Shah *et al*., 2022, Khan *et al*., 2020; Rahman *et al*., 2022; Haq & Badshah, 2021; Zubair *et al*., 2021; Haq *et al*., 2021; Parveen *et al*., 2021; Mumshad *et al*., 2021; Mseddi *et al*., 2021; Das *et al*., 2021; Ullah *et al*., 2020; Abbas *et al*., 2020, 2021; Ali *et al*., 2016).

Species importance value (SIV): SIV (or IVI) was achieved by adding total importance values in all the 13 sites gained by a species (Table 5). SIV varies within the vegetation, community or habitat. Based on SIV, the 14 top most species in decreasing order are: *Pinus roxburghii* (SIV= 303.87), *Quercus dilatata* (SIV= 223.87), *Acacia catechu* (SIV= 176.86), *Heteropogon contortus* (SIV= 161.24), *Fimbristylis dichotoma* (SIV= 153.17), *Themeda anathera* (SIV= 143.46), *Acacia modesta* (SIV= 143.31), *Chrysopogon aucheri* (SIV= 143.19), *Butea monosperma* (SIV= 123.81), *Dodonaea viscosa* (SIV= 115.45), *Oxalis corniculata* (SIV= 111.66), *Micromeria biflora* (SIV= 107.25), *Ziziphus nummularia* (SIV= 94.01) and *Plantago lanceolata* (SIV= 87.13). The SIV of the remaining species was less than 87. It appeared that species with high SIV are generally dominants or have high constancy value or in some cases at a certain point their density was high. *Pinus roxburghii* and *Quercus dilatata* had high SIV in the sub-Himalayan pine region; while *Acacia. modesta* and *A. catechu* had high SIV in the *Acacia* zone. *Dodonaea viscosa* displayed high SIV in *Dodonaea viscosa*-scrub zone. Hayat *et al*., (2021) concluded that IVI of the various recorded species lies in between 3.45 to 177.1 in the reserved forests of Lesser Himalayas. *Pinus wallichiana*, *Cedrus deodara* and *Pistacia integerrama* gathered the highest IVI values. Likewise, Malik *et al*., (2021) regarded *Juniperus wallichiana* (IVI=170.69), *Plectranthus rugosus* (IVI=82.32) and *Indigofera heterantha* (IVI=56.73) as the important species of Dachigam National Park. Kaur *et al*., (2020) reported that IVI varied from 0.26 to 106 (*Chenopodium album*) in the fallow land in central districts of Punjab. Ghafari *et al*., (2020) also considered species scoring highest importance value as the dominant species; those with lowest IVI are rare in the respective area. Moradipour *et al*., (2020) observed that highest SIV in tree and shrub layers was achieved by *Quercus branii* and *Ziziphus nummularia*. In our case species with highest SIV were mostly dominant or sub-dominants.

Vegetation structure: Vegetation structure is the organization of the individuals in space forming a stand. The five levels of vegetation structure are floristic composition, community/stand structure, physiognomy, life form structure and biomass structure. The relationship between vegetation types, elevation, and physico-chemical nature of soil are decisive factors controlling plant diversity. Each community possesses characteristics in physiognomy and structure in time and space (Meragiaw *et al*., 2021). The floristic similarity among sites was based on similarity indices.

Similarity indices: Two types: Sorensen's Floristic similarity and Motyka quantitative Similarity indices were calculated (Table 4) among the 13 sites. Sorensen's Floristic similarity index ranged from zero to 75% among the sites. It showed that sites 3 & 4 and 8 & 9 respectively had 65% and 70.6% similarity. Sites 4 & 5 had 75% similarity. The similarity was up to 60% between sites 1 & 3, 1 & 8, 3 & 5 and 10 & 12. The remaining sites with low similarity were merged. Motyka quantitative similarity further clarified the situation, which varied from zero to 64.5% among the sites. Based on Motyka Similarity index, 64.5% similarity was found between sites 8 & 9, 51.4% similarity between sites 4 & 5 and 45.9% similarity between sites 8 & 10 was achieved. Both these indices showed dissimilarity among most of the sites. Motyka indices further diminished the chances of merging the sites. Therefore, classification of 13 sites was accomplished based on SI indices, visual differences in flora and altitude into 3 major ecological zones. The number of species in each stand varied from 16 to 30, which is less than the species that generally are present in such vegetation zones (Malik & Malik, 2004; Hussain & Ilahi, 1991; Hussain & Shah, 1989; Hussain *et al*., 2000). Das *et al*., (2021) recorded 43.77% as the maximum similarity between communities within the range of 3000-3500 m altitude. This is far less than the recorded similarity in the present case. Khan *et al*., (2020) established 3 plant communities in Guzara forests of Hilkot range Mansehra. Das *et al*., (2021) established 4 clusters of plant communities. There were some major key indicator species in each site that were used along with similarity indices and altitude to identify three major zones along with component plant communities as follows:

The detailed importance values and constancy of species in 13 sites within each major ecological zones and communities are discussed below (Table 5).

A. **Sub-Himalayan *Acacia* zone:** This zone spreads between altitudes 400 to 1350 m. Maximum, minimum and average TIV of species in 13 sites is given in Table 5. There are following three communities within this zone.

1. *Butea -Ziziphus-Themeda* degraded community: *Butea-Ziziphus-Themeda* community was recognized by the dominance of *Butea monosperma* (IV= 103.17) in tree layer in site 1 at an altitude of 400 m (Table 5). *Ziziphus nummularia* (IV=11.04) in the shrub layer with *Themeda anathera* (IV= 29.25) in the herb layer were dominants. *Dodonaea viscosa*, *Maytenus royleanus*, *Justicia adhatoda*, *Myrsine africana, Dichanthium annulatum* and *Heteropogon contortus* were associated species. *Butea* forms a narrow diminishing faint zone in the Himalayan foot hills (Champion *et al.,* 1965). The eroded sandy loam soil has poor nutrient status with 89% calcium contents (Table 6). Champion *et al*., (1965) and Hussain & Ilahi (1991) described this type as indistinct almost non-existing forest type in Pakistan. In the present, case it is the only tree species with 8 species in shrub and 13 in the herb layer with a total of 22 species. *Butea* is also recorded in sites 2 and 6 as isolated individual. The three dominants contributed Total Importance Value (TIV) of 143.46; the remaining species shared a TIV of 156.54. TIV contributed by tree layer was 103.17 (*Butea* only), while shrub and herb layer shared 42.7 and 154.13, respectively (Table 7). Overgrazing and deforestation were the major ecological constraints in this site. The species diversity (0.07), richness (1.53) and maturity (53.81) in this stand were (Table 9) due to degradation of vegetation. Champion *et al*., (1965) described *Butea* forests on flat stiff clayey poorly drained soils. However, no good example of this type is present; but we recorded isolated deformed *Butea monosperma* individuals, as the relics of the past lush green forest of this kind.

2. Sub-Himalayan *Acacia modest* community: Sites 2 and 5 with eroded soil at altitude between 450 to 650 meters (Table 5) were dominated by *Acacia modesta* (IV= 39.67, 96.11) in the tree layer. Both the sites had *Acacia-Dodonaea-Themeda* association. *Dodonaea viscosa* (IV= 14.48, 12.2) and *Themeda* (IV= 29.91, 22.81) are respectively dominants in the shrub and herb layers. The number of species was respectively 26 and 25 in sites 2 and 5. Site 2 had 6 tree, 9 shrub and 11 herb species; whereas site 5 was composed of 2 tree, 7 shrub and 15 herb species. Soils in both the sites (Table 6) were sandy to sandy loam, eroded with up to 2% organic matter, pH 6.78-7.36 and 261 (Site 5) to 413 (Site 2) soluble salts. Calcium contents varied from 49 to 67 in these 2 sites with low micronutrients. The soils of Gadoon hills are nutrient deficient requiring proper management for sustainability. The diversity (0.1), species richness (1.62) and species maturity (46.96) are also low (Table 9).

In site 2, TIV contributed by 3 dominants and remaining species was 84.26 and 215.84, respectively (Table 7). The tree, shrub and herb layers respectively shared T IV of 104.84, 53.29 and 195.16. In site 5, the TIV was 131.12 and 168.88 respectively by 3 dominants and by the remaining species. TIV gained by tree, shrub and herb layers was 106.68, 42.82 and 150.5, respectively. This community was relatively protected. Grazing and browsing were allowed after grass cutting for winter stock. In this site the diversity, richness and maturity of species was respectively 0.08, 1.79 and 46, which points out habitat deterioration (Table 7).

3. Sub-Himalayan *Acacia catechu* community: *Acacia catechu* dominated sites 6 and 7 between altitudes 800-1350 m (Table 5). It had *Acacia catechu-Dodonaea viscosa-Heteropogon* association in site 6. The dominants respectively scored TIV of 52.9, 8.84 and 22.77 in tree, shrub and herb layers. In site 6, the 3 dominants had TIV of 84.15 and the remaining species shared 215.85. Tree, shrub and herb strata respectively shared TIV of 125.23, 32.08 and 142.29 (Table 7). Soils had poor macro and micro nutrient status with phosphorus ranging from 26-30 ppm (Table 6). The *p*H varied from 5.89 to 7.1. Organic matter was 1.1 and 2.6% in sites 6 and 7, respectively. *Acacia modesta, A. nilotica, Myrsine africana, Mallotus phillipinensis, Celtis, Ficus palmata, Carrisa opaca, Justicia adhatoda, Maytenus royleanus*, many forbs and grasses associated in this habitat. Sites 6 had 30 species with 10 tree, 6 shrub and 14 herb species. There was *Acacia catechu-Maytenus-Apluda* community in site 7. There were 3 tree, 3 shrub and 12 herb species making a total of 18 taxa. The TIV of 144.83 and 155.17 was accomplished respectively by 3 dominants and remaining species in stand 7. TIV was 114.0, 26.26 and 159.74 in tree, shrub and herb strata, respectively. The habitat was degraded with exposed soil. The diversity, richness and maturity of stand 6 were respectively, 0.05, 2.14 and 42.22 (Table 9). It was 0.08, 1.51 and 47.22 for site 7. Both sites had disturbed unfavourable habitat condition. *Acacia catechu* forests are rare in this part of Pakistan. They are less valuable than *Acacia modesta.* Champion *et al*., (1965) called this type as Dry Deciduous scrub, which consisted of *Acacia catechu* and other associated species of this zone.

Table 4. Floristic (Sorensen) and Quantitative (Motyka) indices of 13 sites in Gadoon Hills, Outer Himalayas, District Swabi, Pakistan.

Sorensen Similarity Index

Stand No.		1	2	3	4	5	6	7	8	9	10	11	12	13
	Veg type	BZT	ADT	DH	ZH	ADT	ADH	AMA	PBO	PIC	PBP	QPV	QBF	PBPo
1.	BZT	x												
2.	ADT	45.8	x											
3.	DH	57.9	33.3	x										
4.	ZH	47.8	32.0	65.0	x									
5.	ADT	34.8	32.0	55.5	75.0	x								
6.	ADH	30.8	42.9	17.4	26.0	26.0	x							
7.	AMA	30.0	22.7	47.0	33.3	28.6	45.8	x						
8.	PBO	52.0	4.8	18.8	15.0	15.0	17.4	23.5	x					
9.	PIC	20.0	13.6	29.4	23.8	19.0	8.3	27.8	70.6	x				
10.	PBP	10.5	4.8	6.3	10.0	10.0	13.0	5.9	43.8	41.2	x			
11.	QPV	0	0	0	4.8	6.5	8.3	0	5.9	5.6	35.3	x		
12.	QBF	0	0	0	9.3	4.7	4.0	5.4	34.3	32.4	57.2	27.0	x	
13.	PBPo	0	0	0	11.8	3.9	7.0	4.4	14..0	17.8	27.9	31.1	47.8	x

Motyka Similarity Index

Stand No.		1	2	3	4	5	6	7	8	9	10	11	12	13
	Veg type	BZT	ADT	DH	ZH	ADT	ADH	AMA	PBO	PIC	PBP	QPV	QBF	PBPo
1.	BZT	x												
2.	ADT	39.1	x											
3.	DH	34.1	30.2	x										
4.	ZH	29.7	24.1	45.6	x									
5.	ADT	26.9	39.3	36.6	51.4	x								
6.	ADH	26.9	37.8	19.2	27.0	28.2	x							
7.	AMA	17.8	22.7	25.7	20.8	23.9	43.3	x						
8.	PBO	1.4	3.7	12.5	13.1	10.6	13.5	16.2	x					
9.	PIC	11.6	8.8	19.1	17.9	15.5	17.4	13.3	64.5	x				
10.	PBP	4.5	3.2	3.2	7.9	7.8	7.6	2.8	45.9	42.3	x			
11.	QPV	0	0	0	4.7	5.3	8.3	0	4.1	2.8	27.3	x		
12.	QBF	0	0	0	6.0	4.5	1.7	1.9	22.i	20.7	44.0	33.5	x	
13.	PBPo	0	0	0	6.9	3.9	4.2	1.9	10.1	9.7	18.3	14.5	25.7	x

Key to the communities: BZT= *Butea-Ziziphus-Themeda;* **ADT**=*Acacia modesta-Dodonaea-Themeda;* **DH**= *Dodonaea-Heteropogon;* **ZH**= *Ziziphus-Heteropogon;* **ADH**= *Acacia catechu-Dodonaea-Heteropogon;* **AMA**= *Aacacia catechu-Maytenus-Apluda;* **PBO**= *Pinus-Berberis-Oxalis,* **PIC**= *Pinus-Indigofera-Chrysopogon;* **PBP**= *Pinus-Berberis-Plantago;* **QPV**= *Quercus-Parrotiopsis-Viola;* **QBF**= *Quercus-Berberis-Fimbristylis;* **PBPo**= *Prunus-Berberis-Poa.*

Table 5. Total, Max and Min IV, No. of stands with dominance and constancy values of species in 13 sites of Gadoon Hills, Outer Himalayas District Swabi, Pakistan.

S. No.	Plant species	Total IV	Max IV	Min IV	No of stands dominant as			No. of stands present	Constancy class (%)
					Ist	2nd	3rd		
	A. Tree layer								
1.	*Acacia catechu* (L.f.) Willd.	176.86	102.03	21.93	2	-	-	3	II (23.08)
2.	*Acacia modesta* Wall.	143.31	96.11	7.53	2	-	-	3	II (23.08)
3.	*Acacia nilotica* (L.) Delile.	6.51	6.51	6.51	-	-	-	1	I (7.69)
4.	*Ailanthus altissima* (Mill) Swingle	10.45	6.13	4.32	-	-	-	2	II (15.38)
5.	*Albizia lebbeck* (L.) Bth.	2.23	2.23	2.23	-	-	-	1	I (7.69)
6.	*Butea monosperma* Roxb.	123.81	103.17	10.04	1	-	-	3	II (23.08)
7.	*Celtis australis* L.	12.77	7.65	5.12	-		--	2	II (15.38)
8.	*Cotoneaster bacillaris* Wall. ex Lindle.	16.46	16.46	16.46	--	-	-	1	I (7.69)
9.	*Ficus palmata* Forssk.	18.57	15.24	3.33	-	-	-	2	II (15.38)
10.	*Flacourtia indica* (Burm. f.) Merrill	8.4	4.72	3.68	-	-	-	2	II (15.38)
11.	*Grewia optiva* Drum.ex.Burret.	27.2	27.2	27.2	-	-	-	1	I (7.69)
12.	*Lonicera quinquilacularis* Hardw.	36.72	36.72	36.72	-	-	1	1	I (7.69)
13.	*Mallotus philippensis* Muell.	13.24	13.24	13.24	-	-	-	1	I (7.69)
14.	*Parratiopsis jacquemontiana* Dcne	20.87	20.87	20.87	-	-	-	1	I (7.69)
15.	*Pinus roxburghii* Sargent	303.87	105.76	17.46	3	-	-	4	IV (30.76)
16.	*Prunus cornuta* (Wall. ex. Royle) Steud.	40.96	40.96	40.96	-	1	-	1	I (7.69)
17.	*Quercus dilatata* Lindley	223.78	89.47	12.37	2	-	1	6	III (46.15)
18.	*Quercus incana* Roxb.	50.24	22.64	8.15	-	-	3	4	II (30.76)
19.	*Taxus wallichiana* Zucc.	4.12	4.12	4.12	-	-	-	1	I (7.69)
20.	*Vibernum cotinifolium* D. Don.	10.51	10.51	10.51	-	-	-	1	I (7.69)
21.	*Ziziphus maurtiana* Lam.	10.57	10.57	10.57	-	-	-	1	I (7.69)
	B. Shrub layer								
22.	*Acacia modesta* Wall.	4.25	4.25	4.25	-	-	-	1	I (7.69)
23.	*Acacia nilotica* (L.) Delile.	3.98	3.98	3.98	-	-	-	1	I (7.69)
24.	*Berberis lycium* Royle.	46.15	11.84	6.8	-	-	-	5	III (38.46)
25.	*Butea monosperma* Roxb.	4.14	4.14	-	-	-	-	1	I (7.69)
26.	*Calotropis procera* (Wild) R.Br.	5.43	5.43	5.43	-	-	-	-	I (7.69)
27.	*Carissa spinarum* auct. non L.	25.64	15.46	1.9	-	-	-	4	II (23.08)
28.	*Dodonaea viscosa* (L.) Jacq.	115.45	57.31	5.02	1	-	-	7	III (53.85)
29.	*Gymnosporia royleana* Wall	25.12	11.04	2.94		-	-	4	II (23.08)
30.	*Indigofera heterantha* L.	38.04	12.57	3.99	-		-	5	III (34.46)
31.	*Justicia adhatoda* L.	29.17	18.5	3.99	-	-		3	II (23.08)
32.	*Lonicera hypoleuca* Dcne.	5.9	5.9	5.9	-	-	-	-	I (7.69)
33.	*Mallotus philippensis* Muell.	8.92	5.39	3.53	-	-	-	2	II (23.08)
34.	*Mimosa himalayana* Gamble	4.44	2.54	1.9	-	-	-	2	II (23.08)
35.	*Myrsine africana* L.	23.93	9.64	3.88	-	-	-	4	II (30.76)
36.	*Otostegia limbata* Bth.	57.58	34.11	2.83	-	1	-	5	III (38.46)
37.	*Parratiopsis jacquemontiana* Dcne	10.1	10.1	10.1	-	-	-	1	I (7.69)
38.	*Pinus roxburghii* Sargent	7.62	4.29	3.33	-	-	-	2	II (15.38)
39.	*Pyrus pashia* Ham ex. D. Done	3.38	2.26	1.12	-	-	-	2	II (15.38)
40.	*Quercus dilatata* Lindley	17.98	6.08	2.95	-	-	-	4	II (30.76)
41.	*Quercus incana* Roxb.	14	5.96	2.97	-	-	-	3	II (23.08)
42.	*Rhazya stricta* Dcne.	11.41	9.4	2.01	-	-	-	2	II (15.38)
43.	*Rhododenron arborium* Smith.	3.94	3.94	3.94	-	-	-	1	I (7.69)
44.	*Rosa moschata* non J. Herrm.	2.95	2.95	2.95	-	-	-	1	I (7.69)
45.	*Sageretia theezans* (L.) Brongn.	31.55	19.4	5.32	-	-	-	3	II (23.08)
46.	*Sarcococca saligna* (Dcne) Duel	7.27	4.27	3.0	-	-	-	2	II (15.38)
47.	*Ziziphus nummularia* Buem.f. Weight	94.01	41.13	9.24	1	-	-	5	III (30.76)
	C. Herb layer								
48.	*Achyranthes aspera* L.	10.86	5.79	5.07	-	-	-	2	II 15.38)
49.	*Adiantum incisum* Forssk.	12.34	12.34	12.34	-	1	-	1	I (7.69)
50.	*Adiantum venustum* D. Don	37.92	12.34	2.42	-	-	-	4	II (30.76)
51.	*Ajuga bracteosa* Wall. Benth.	15.3	8.67	6.63	-	-	-	2	II (23.08)
52.	*Ajuga parviflora* Benth.	27.88	11.34	8.21	-	-	-	3	II (23.08)
53.	*Androsace rotundifolia* Hardw.	1.33	1.33	1.33	-	-	-	1	I (7.69)
54.	*Apluda mutica* L.	47.66	31.76	15.9	-	-	-	2	II (15.38)
55.	*Aristida adscensionis* L.	35.43	15.61	9.68	-	-		3	II (23.08)

Table 5. (Cont'd.).

S. No.	Plant species	Total IV	Max IV	Min IV	No of stands dominant as			No. of stands present	Constancy class (%)
					Ist	2nd	3rd		
56.	*Artemisia vulgaris* L.	2.21	2.21	2.21	-	-	-	1	I (7.69)
57.	*Asplenium adiantum nigrum* L.	30.1	15.25	3.11			-	3	II (23.08)
58.	*Avena sativa* L.	8.32	8.32	8.32	-	-	-	1	I (7.69)
59.	*Bergenia ciliata* (Haw) Sternb.	15.57	15.57	15.57	-	-	-	1	I (7.69)
60.	*Bistorta amplexicaulis* (D. Don) Green	9.85	9.85	9.85	-	-	-	1	I (7.69)
61.	*Boerhaavia diffusa* L.	25.17	12.19	5.34	-	-	-	3	II (23.08)
62.	*Calendula arvensis* L.	2.42	2.42	2.42	-	-	-	1	I (7.69)
63.	*Ceterach dalhousiae* (Hk.) C. Chr.	16.91	15.57	1.34	-	-	-	2	II(15.38)
64.	*Cheilanthes marantae* (L.) Domin.	12.9	12.9	12.9	-	-	-	1	I(7.69)
65.	*Chrysopogon aucheri* (Boiss.) Stapf	143.19	48.66	12.87	-	1	1	7	III (53.85)
66.	*Conyza canadensis* (L.) Cronquist	12.44	7.6	4.84	-	-	-	2	II (15.38)
67.	*Cynodon dactylon* (L.) Pers.	46.54	15.04	8.94	-	-	-	4	II (30.76)
68.	*Cyperus niveus* Retz.	27.83	13.43	5.47	-	-	-	3	II (23.08)
69.	*Delphinium denudatum* Wall. ex H & T.	7.64	7.64	7.64	-	-	-	1	I (7.69)
70.	*Dichanthium annulatum* (Forssk.) Stapf.	63.12	25.68	5.56	-	-	1	4	II (30.76)
71.	*Digitaria sanguinalis* (L.) Scop.	19.44	19.44	19.44-	-	-	-	1	I (7.69)
72.	*Duchesnea indica* (Andr.) Focke	24.93	13.29	11.64	-	-	-	2	II (15.38)
73.	*Echinops echinatus* Roxb.	14.86	7.6	7.26	-	-	-	2	II (15.38)
74.	*Epilobium brevifolium* Don.	1.34	1.34	1.34	-	-	-	1	I (7.69)
75.	*Euphorbia hirta* L.	56.84	28.6	2.53	-	-	1	5	III (38.46)
76.	*Euphorbia prostrata* Ait.	10.13	10.13	10.13	-	-	-	1	I (7.69)
77.	*Filago spathulata C.* Presl.	6.69	4.86	1.83	-	-	-	2	II (23.08)
78.	*Fimbristylis dichotoma* (L.) Vahl.	153.17	80.67	11.53	-	2	-	6	III (46.15)
79.	*Fragaria vesica* Lindle.ex Hk. f.	1.34	1.34	1.34	-	-	-	1	I (7.69)
80.	*Gallium aparine* L.	27.49	11.34	6.88	-	-	-	3	II (23.08)
81.	*Gentiana kurru* Royle	38.99	18.21	10.61	-	-	-	3	II (23.08)
82.	*Geranium wallichianum* D. Don. ex Sweet	32.57	12.87	10.15	-	-	-	3	II (23.08)
83.	*Hedera helix* L.	13.31	8.36	4.95	-	-	-	2	II (15.38)
84.	*Heteropogon contortus* (L.) P. Beauv.	161.24	36.77	22.77	-	2	4	7	III (53.85)
85.	*Imperata cylindrica* (L.) P. Beauv.	46.53	33.83	12.7	-	-	1	2	II (15.38)
86.	*Malva parviflora* L.	7.64	7.64	7.64	-	-	-	1	I (7.69)
87.	*Medicago polymorpha* L.	19.41	19.41	19.41	-	-	-	1	I (7.69)
88.	*Melothria heterophylla* Cogn.	2.21	2.21	2.21	-	-	-	1	I (7.69)
89.	*Micromeria biflora* (Ham.) Bth.	107.25	15.34	3.71	-	-	-	10	IV (76.92)
90.	*Myriactus wallichii* Less.	1.34	1.34	1.34	-	-	-	1	I (7.69)
91.	*Oenothera rosea* Soland.	1.83	1.83	1.83		-	-	1-	I (7.69)
92.	*Origanum vulgare* L.	7.23	7.23	7.23	-	-	-	1	I (7.69)
93.	*Oxalis corniculata* L.	111.66	43.98	4.34	-	1	1	7	III (53.85)
94.	*Phalaris minor* Retz.	29.27	12.95	5.79	-	-	-	3	II (23.08)
95.	*Plantago lanceolata* L.	87.13	50.7	11.71	-	1	1	4	II (30.76)
96.	*Plantago major* L.	20.75	20.75	20.75	-	-	-	1	I (7.69)
97.	*Poa annua*L.	49.25	49.25	49.25	1	-	-	1	I (7.69)
98.	*Potentilla supina* L.	1.34	1.34	1.34	-	-	-	1	I (7.69)
99.	*Rumex dentatus* L.	17.14	9.72	7.42	-		-	2	II (15.38)
100.	*Salvia moocruftiana* Wall.	1.33	1.33	1.33	-	-	-	1	I (7.69)
101.	*Saussurea heteromalla* (D.Don.) Hand-Mazz	10.13	10.13	10.13	-	-	-	1	I (7.69)
102.	*Sedum ewersii* Ledeb.	5.67	5.67	5.67	-	-	-	1	I (7.69)
103.	*Sida cordata* (Burm.f) Borss-Waalkes	10.94	7.29	3.65	-	-	-	2	II (15.38)
104.	*Silene vulgaris* (Moench)	6.73	6.73	6.73	-	-	-	1	I (7.69)
105.	*Sonchus asper* L.	8.93	8.93	8.93	-	--	-	1	I (7.69)
106.	*Stellaria media* (L.) Cyr.	23.07	8.47	6.34	-	-	-	3	II (23.08)
107.	*Tagetus minuta* L.	7.64	7.64	7.64	-	-	-	1	I (7.69)
108.	*Taraxacum officinale* Weber.	5.48	5.48	5.48	-	-	-	1	I (7.69)
109.	*Themeda anathera* (Nees) Hack.	143.46	29.91	17.74	-	4	1	6	III (46.15)
110.	*Trichodesma indica* (L.) R.Br.	16.68	6.34	4.86	-	-	-	3	II (23.08)
111.	*Tulipa stellata* Hk.f.	23.81	13.23	10.58	-	-	-	2	II (23.08)
112.	*Urtica dioca* L.	3.11	3.11	3.11	-	-	-	1	I (7.69)
113.	*Valeriana jatamansii Jones*.	29.35	14.94	14.41	-	-	-	2	II (15.38)
114.	*Verbascum thapsus* L.	25.82	9.28	4.84	-	-	-	4	II (30.76)
115.	*Viola serpens* Wall.	27.32	27.32	27.32	-	-	-	1	I (7.69)

Table 6. Physico-chemical characteristics of soil of 13 stands/plant communities of Gadoon Hills, Outer-Himalayas, District Swabi, Pakistan

Stands	1	2	3	4	5	6	7	8	9	10	11	12	13
communities	BZT	ADT	DH	ZH	ADT	ADH	AMA	PBO	PIC	PBP	QPV	QBF	PBPo
	A. Physical features												
Exposure	Plains	E	E	S	S	NE	E	E	E	SE	SE	E	Top
Altitude (m)	400	450	500	600	650	800	1350	1750	1850	1950	2050	2100	2250
Texture	SL	SL	S	S	S	SL	SL	S	S	S	SL	SL	SL
OM %	0.69	2.07	2.346	0.517	0.862	1.10	2.6	0.52	2. 35	0.69	0.76	6.55	1.59
pH	5.6	6.78	6.92	7.64	7.36	5.89	7.1	6.41	5.96	5.91	5.65	6.79	5.52
Ec (dsm^{-1})	0.936	0.646	0.297	0.708	0.408	0.936	0.482	0.415	1.2	0.272	0.206	1.924	2.7
TDS (mg/l)	599.04	413.44	190.08	453.12	261.12	599.04	308.48	265.6	768	174.08	131.84	1231.36	1728
	B. Chemical features												
N%	0.034	0.103	0.117	0.026	0.043	0.055	0.129	0.026	0.117	0.034	0.038	0.328	0.079
SAR (mg/l)	1.099	0.787	0.869	1.028	0.973	0.523	1.432	0.989	0.89	0.67	2.163	0.796	0.835
P_2O_5 (ppm)	30	26	30	30	28	29	28	29	30	26	28	28	32
Ca+Mg	0.95	0.50	0.55	0.7	0.55	0.45	0.75	0.60	0.95	0.65	1.0	0.95	0.86
Na	8	5	4	7	5	5	8	5	7	3	8	7	9
Ca	89.112	66.984	30.72	82.056	49.308	165.996	46.008	40.582	109.956	30.768	19.632	136.296	213.936
Mg	16.848	13.716	11.7	10.62	3.48	16.92	16.452	10.56	16.8896	9.36	7.716	18.206	18.336
K	24	15	38	17	6	21	31	35	245	16	6	138	77
Zn	0.071	0.032	0.035	0.021	0.018	0.042	0.037	0.022	0.022	0.019	0.012	0.145	0.089
Cu	0.043	0.033	0.05	0.056	0.03	0.034	0.052	0.042	0.042	0.036	0.034	0.054	0.048
Fe	0.102	0.039	0.209	0.056	0.07	0.063	0.166	0.202	0.127	0.325	0.344	0.476	0.199
Mn	0.068	0.042	1.379	0.029	0.023	0.05	0.562	0.344	0.126	0.057	0.3	0.123	0.168
Pb	0.047	0.014	0.029	0.045	0.036	0.011	0.029	0.02	0.006	0.018	0.007	0.088	0.042
Cd	0.013	0.007	0.016	0.007	0.008	0.003	0.011	0.005	0.003	0.012	0.004	0.012	0.02
Cr	0.051	0.021	0.066	0.003	0.007	0.032	0.075	0.059	0.072	0.052	0.04	0.059	0.63
Ni	T	T	0.025	T	T	T	0.002	T	0.006	T	T	0.017	0.032

Key to the communities is given under Table 4

Table 7. The number of component species and their share in Total Importance Value (TIV) in 13 stands of Gadoon Hills, Outer-Himalayas, District Swabi Pakistan.

Stands communities	1	2	3	4	5	6	7	8	9	10	11	12	13
	BZT	ADT	DH	ZH	ADT	ADH	AMA	PBI	PIC	PBP	QPV	QBF	PBPo
Total species	22	26	16	24	24	30	18	16	18	16	18	19	27
Trees	1	6	-	-	2	10	3	2	2	3	5	3	5
Shrubs	8	9	4	8	7	6	3	3	4	4	3	6	7
Herbs	13	11	12	16	15	14	12	11	12	9	10	10	15
TIV By Dominants	143.46	84.26	94.08	61.82	131.12	84.15	144.15	129.35	166.99	141.29	102.0	178.26	98.59
TIV by remaining species	156.54	215.75	205.92	238.18	168.88	215.85	155.17	170..65	133.01	158.71	198.0	121.74	201.41
TIV by trees	103.17	104.84	-	-	106.68	125.23	114.0	113.44	114.27	123.41	122.72	117.94	115.75
TIV by shrubs	42.7	53.29	110.27	132.5	42.82	32.08	26.26	18.39	23.82	28.57	21.25	45.07	35.33
TIV by herbs	154.13	195.16	189.73	167.5	150.5	142.69	159.74	168.17	161.91	148.02	156.07	146.99	148.92

Key to the communities is given under Table 4

Table 8. Degree of Homogeneity of stands during summer aspect of Gadoon Hills, Outer Himalayas District Swabi.

Stand No.	Associations	Frequency classes					Remarks
		A	B	C	D	E	
1.	*Butea-Ziziphus-Themeda*	0	13	3	2	3	Heterogeneous
2.	*Acacia modesta-Dodonaea-Themeda*	6	8	8	2	2	Heterogeneous
3.	*Dodonaea-Heteropogon*	1	6	5	2	2	Heterogeneous
4.	*Ziziphus-Heteropogon*	4	10	3	3	3	Heterogeneous
5	*Acacia modesta-Dodonaea-Themeda*	6	8	4	3	3	Heterogeneous
6	*Acacia catechu-Dodonaea -Heteropogon*	7	10	9	2	2	Heterogeneous
7.	*Aacacia catechu-Maytenus-Apluda*	4	7	2	3	2	Heterogeneous
8.	*Pinus-Berberis-Oxalis*	1	5	5	1	4	Heterogeneous
9.	*Pinus-Indigofera-Chrysopogon*	2	7	5	1	3	Heterogeneous
10.	*Pinus-Berberis-Plantago*	0	3	7	1	5	Heterogeneous
11.	*Quercus-Parrotiopsis-Viola*	1	1	8	5	2	Heterogeneous
12.	*Quercus-Berberis-Fimbristylis*	2	3	10	2	2	Heterogeneous
13.	*Prunus-Berberis-Poa*	9	8	5	5	-	Homogeneous

Table 9. Species diversity, richness and maturity of the summer and winter plant communitiesof Gadoon Hills, (Himalayas District Swabi, Pakistan.

Stand No.	Community	Species diversity	Species richness	Species maturity
1.	*Butea-Ziziphus-Themeda*	0.07	1.53	53.81
2.	*Acacia modesta-Dodonaea-Themeda*	0.08	1.79	46.00
3.	*Dodonaea-Heteropogon*	0.1	1.31	51.88
4.	*Ziziphus-Heteropogon*	0.1	1.52	47.39
5	*Acacia modesta-Dodonaea-Themeda*	0.1	1.62	46.96
6	*Acacia catechu-Dodonaea-Heteropogon*	0.05	2.14	42.00
7.	*Aacacia catechu-Maytenus-Apluda*	0.08	1.51	47.22
8.	*Pinus-Berberis-Oxalis*	0.13	1.04	64.00
9.	*Pinus-Indigofera-Chrysopogon*	0.12	1.14	55.29
10.	*Pinus-Berberis-Plantago*	0.11	0.92	71.33
11.	*Quercus-Parrotiopsis-Viola*	0.08	1.06	76.67
12.	*Quercus-Berberis-Fimbristylis*	0.29	0.89	61.76
13.	*Prunus-Berberis-Poa*	0.12	1.38	44.40

4. Sub-Himalayan *Dodonaea viscosa* Scrub: Sites 3 and 4 with eastern and southern exposure are examples of degraded *Dodonaea viscosa* scrub. Both these sites are devoid of tree layers representing degraded relics of the original *Acacia* forest in the area. It has almost the same vegetation and edaphic features as listed under *Acacia* type. *Dodonaea-Heteropogon* community was established in site 3 and *Ziziphus-Heteropogon* community in site 4. *Dodonaea viscosa* had IV of 57.31 and *Heteropogon* contributes IV= 36.77 in site 3. There were 16 (4 shrub & 12 herb) species in site 3. The TIV contributed by dominants was 94.08 and 205.92 by the remaining species. TIV contributed by shrub and herb strata was respectively 110.27 and 189.73 (Table 7). Species diversity (0.1), richness (1.52) and maturity (47.39) are low (Table 9).

In site 4, 24 species (8 shrubs & 16 herbs) supported *Ziziphus-Heteropogon* community with *Dodonaea viscosa* as associated component. The two dominants: *Ziziphus nummularia* and *Heteropogon contortus* shared 41.13 and 20.69 IV, respectively. The TIV for the dominants was 61.82 and 238.18 by the remaining species (Table 7). The shrub and herb layer respectively had TIV of132.5 and 167.5. The diversity, richness and maturity indices were respectively 0.1, 1.31 and 51.88 (Table 9).

The removal of *Acacia modesta* and other tree components created *Dodonaea viscosa* scrub which with further degradation shifts to spiny bushy *Ziziphus nummularia* as obvious in the present case. The habitat is sandy, highly eroded with low macro and micro nutrient status (Table 6). Organic matter below the shrub and grass thickets was slightly above 2% while in the open it was deficient. *p*H lies between 6.92-7.64. These finding agree with many workers (Champion *et al*., 1965; Chaghtai & Ghawas, 1976; Hussain & Shah, 1989; Hussain *et al*., 1992,1997), who also reported that the original forest vegetation in the subtropical zone has been replaced with open scrubs and grasslands through deforestation, terrace cultivation, overgrazing and man-made fire.

B. Sub-Himalayan (subtropical) pine zone: This zone spreads from 1750 to 1950 meters in sites 8-10 within the investigated area. It is characterized by the dominance of *Pinus roxburghii* along with *Quercus dilatata, Q. incana, Berberis lyceum, Indigofera heterantha, Pyrus pashia, Chrysopogon aucheri, Duchesnea indica* and *Oxalis corniculata* (Tables 5, 7). Soil is sandy, eroded and infertile due to poor organic matter contents, nitrogen, micronutrients; but with high calcium contents (Table 9). Subtropical pine (*Pinus roxburghii*) is the major vegetation zone in Pakistan between 800 to almost 1500 meters (Hussain & Ilahi, 1991; Champion *et al*., 1965; Beg, 1975). The canopy in the present case is open with scattered species. The 16 species recorded in site 8 (2 tree, 3 shrub & 11 herb) has *Pinus-Berberis-Oxalis* community at 1750 m on eastern exposure. The TIV gathered by 3 dominants and remaining species was 129.35 and 170.65, respectively. The tree, shrub and herb strata attained TIV of 113.44, 23.82 and 161.91, respectively (Table 7). Site 9 with 18 (2 tree, 4 shrub, 12 herb) species sustained *Pinus-Indigofera-Chrysopogon* community at 1850m on south-east aspect. The dominants were *Pinus roxburghii* (IV= 105.76), *Indigofera heterantha* (IV= 12.57) and *Chrysopogon aucheri* (IV= 48.66) (Table 5) respectively in the tree, shrub and herb layers. The 3 dominants contributed TIV of 166.99; and the remaining species added TIV of 133.01. TIV shared by tree, shrub and herb layers was sequentially 114.27, 23.82 and 161.91 (Table 7). *Pinus-Berberis-Plantago* community occupied site 10, which is composed of 16 species including 3 tree, 4 shrub and 9 herb species (Tables 5, 7). The dominants were *Pinus roxburghii* (IV= 79.58) in tree layer, *Berberis lyceum* (IV= 11.01) in shrub stratum and *Plantago lanceolata* (IV=50.7) in the herb layer. The TIV gathered by 3 dominants was 141.29 and 158.71 by the associated species. TIV contributed by tree, shrub and herb layers was respectively 123.41, 28.57 and 148.02 (Table 7). The vegetation is represented only by scattered relic patches especially in protected places. These relics, however, do permit rebuilding original picture of vegetation to a certain extent but they too are under heavy pressure. Trees have been taken over by scrub layer. Elsewhere scrubs too, have been replaced by grassland. Champion *et al*., (1965) reported various combinations such as *Chir-Carissa, Chir-Carissa-Indigofera, Chir-Quercus, Chir-Acacia catechu* and *Chir-Carissa-Flacourtia* in these forests. Almost similar situation was recorded in the present case. The range of diversity was 0.08 to 0.29, richness 0.92 to 1.14 and maturity from 55.29 to 71.33 (Table 9).

C. Himalayan temperate zone: This is the 3rd major zone covering sites 11-13 between altitudes 2050-2250m. It supported three temperate oak forest communities namely: *Quercus- Parrotiopsis- Viola*, *Quercus-Berberis-Fimbristylis* and *Prunus-Berberis-Poa* (Table 5). Besides the dominants, *Quercus incana, Pinus roxburghii, Cotoneaster baccillaris, Taxus wallichiana, Vibernum continifolium, Indigofera heterantha, Lonicera hypoleuca, Sarcoccoca saligna* and many herbaceous plants were also recorded. Oaks are deformed, degraded and stunted. Oaks are slow growing plant that regenerates through seeds. Soils are generally sandy-loam with 0.76 to 6.6% organic matter, high calcium and magnesium contents (Table 6) but deficient in microelements. *Quercus-Parrotiopsis-Viola* community occupies south-east aspect at 2050m in site 11. It was composed of 18 species (5 tree, 3 shrub, and 10 herb species). The dominants were *Quercus dilatata* (IV= 64.58), *Parrotiopsis jacquemontiana* (IV=10.1) and *Viola serpense* (IV=27.32). The TIV respectively gathered by 3 dominants and rest of species was 102.0 and 198.0 (Table 7). TIV of 122.72 was provided by tree layer, 21.25 by shrub strata and 156.03 by herbaceous layer. *Quercus-Berberis-Fimbristylis* community was present in site 12 at 2100 m on eastern exposure (Table 5). The dominants were *Quercus dilatata* (IV= 89.47), *Berberis lyceum* (IV=8.12) and *Fimbristylis dichotoma* (IV=80.67). It had 18 species with 3 tree, 6 shrub and 10 herb species. The total TIV put in by 3 dominants and remaining species was respectively, 178.26 and 121.74. The tree, shrub and herb layers sequentially contributed TIV of 117.94, 35.7 and 146.99 (Table 7). In site 13, *Prunus-Berberis-Poa* community grew at 2250 m at the hill top. It consisted of 5 tree, 7 shrub and 15 herb species totaling to 27 species. *Prunus cornuta, Berberis lyceum* and *Poa annua* respectively had IV of 40.96, 8.38 and 49.25. The 3 dominants and the remaining species gathered TIV of 98.59 and 201.49, respectively. The TIV contribution by tree, shrub and herb strata was 115.75, 35.33 and 148.92 (Table 7). The site was overgrazed and browsed with open canopy. Coventry (1929) reported mixed forest of *Pinus walichiana* and *Quercus incana* in lower temperate zone between 1600-2600 m in the Punjab. Similarly, Champion *et al*., (1965) and Hussain & Ilahi (1991) described lower temperate forests consisting of *Pinus wallichiana* and *Quercus incana* in between 1600-1900 m. Species diversity varied among the sites from 0.08 to 0.29, species richness: 0.89 to1.38 and maturity from 44.4 to 76.67 (Table 9). Mumshad *et al*., (2021) recorded four major plant communities as 1) *Olea-Desmodium-Prunilla* community, 2) *Abies-Zanthoxylum-Pteracanthus* community, 3) *Cedrus-Elaeagnus-Hypericum* community 4) *Alnus-Myrsine–Ranunculus* community in Dhirkot, Azad Kashmir. They stated that soil type, organic matter and altitude primarily controlled community establishment; same was true in the present case. Similarly, Iqbal *et al*., (2021) established 1) *Quercus-Sarcococca-Pinus*, 2) *Iris-Poa-Arenaria* and 3) *Abies-Picea-Viburnum* in Manrai Hills, Swat. Like the present case, all communities were stratified in to tree, shrub and herb layers. They stated that average Species richness (21.38±5.29), Shannon-Wiener (2.56±0.32), Simpson (0.88±0.05) and evenness (0.85±0.06) indices were slightly more than the other similar studies from Pakistan.

Dominants: Some 22 species emerged as overall dominants in various positions in the 13 sites (Table 5). *Pinus roxburghii* was first dominant in 3 sites; *Acacia catechu, A. modesta,* and *Quercus dilatata* were first dominants in 2 sites. Each of the four species: *Butea monosperma, Dodonaea viscosa, Ziziphus nummularia* and *Poi annua* got first dominant status in one of the sites only. Second dominant position was gained by *Themeda anathera* in 4 sites, *Fimbristylis dichotoma* and *Heteropogon contortus* in 2 sites. *Prunis cornuta, Otostegia limbata, Adiantum incisum, Chrysopogon aucheri, Oxalis corniculata* and *Plantago lanceolata* occupied 2nd dominant status in one stand only. *Heteropogon contortus* was 3rd dominant in 4 sites and 2nd dominant in 2 sites. *Quercus incana* achieved 3rd dominant position in 3 sites. *Loonier quinquilocularis, Quercus dilatata, Chrysopogon aucheri, Dichanthium annulatum, Imperata cylindrica, Oxalis corniculata* and *Plantago lanceolata* had 3rd dominant status in one stand. The presence of large number of dominant species in a smaller area show high stage of degradation. Many sporadic species with disturbed habitat have emerged as controlling species. In fact in the lower reaches *Acacia modesta, A. catechu, Dodonaea viscosa, Ziziphus mourtiana, Z. nummularia, Maytenus royleanus. Justice adhatoda* are important species in this situation (Muhammad *et al*., 2016; Hussain & Ilahi, 1991; Champion *et al.*, 1965; Chaghtai & Ghawas, 1976; Hussain & Shah, 1989; Hussain *et al*., 1992,1997), but the degraded habitat, deforestation, settlements and sale of wood outside its habitat has reduced the population and regeneration of the tree and shrubby species. Further severity is caused by overgrazing and fodder collection that has hampered the growth and regeneration of valuable herbaceous species and seedling of woody plants. Fire is also used to clear forest land in favour of cultivation.

Constancy of species: Constancy is the distribution of a species in different sites or stands of the same community types. All the species recorded in the quadrats were classified into 5 constancy classes. It was seen that 50 (43.48%), 57 (49.56%), 7 (6.09%) and 1 (0.87%) species were present in Classes I, II, III and IV, respectively (Table 5). Only *Micromeria biflora* was recorded in 10 sites got place in Class IV. No tree, shrubby species or dominants occupied classes IV and V, which are characteristic of dominants. This speaks of high state of biological and physical degradation of habitat in the area. The dominant tree species were generally isolated with sparse distribution in the investigated area. The presence of high percentage of most species in classes I and II indicates disturbed habitat where sporadic and isolated individuals appear frequently without exerting any physiognomic pressure on the community.

Degree of homogeneity: Of the 13 sites, only site with *Prunus-Berberis-Poa* community was homogenous (Table 8). The remaining 12 sites were heterogeneous, which is attributed to the presence of large number of annuals and sporadic species in the degraded habitat condition owing to deforestation, overgrazing, trampling and soil erosion. Classes A to C contained high percentage of species. The distribution of frequency in 5 classes followed the Raunkiaerian trend. Malik *et al*., (2021) and Kaur *et al*., (2020) used 4 classes: A, B, C and D because Class E was absent with them. Missing class indicates heterogeneity in species diversity. Several factors including presence/ absence of tree layer, floristic composition, habitat features and erosion cause heterogeneity among the communities (Hart & Chen, 2008; Sangar *et al.*, 2008). Open eroded soils are nutrient deficient, moisture exhausted and prone to erosion, which are responsible for the variation among the sites in the current study. Our findings are supported by Malik *et al*., (2021), who also observed heterogeneity in the scrub vegetation of Dachigam National Park, Western Himalayas.

Species diversity, species richness and maturity indices: Species Diversity index is the total number of all species and its relative abundance of each species (Malik *et al*., 2021). The species diversity (Table 9) was maximum (0.29 %) in site 12 supporting *Quercus-Berberis-Fimbristylis* community that gradually declined to the lowest (0.05%) in site 6 with *Acacia-Dodonaea viscosa-Heteropogon* community. The overall species diversity in the area was generally low among the various sites. Species richness ranged from 0.89 (*Quercus-Berberis-Fimbristylis* community) to 2.14 (*Acacia-Dodonaea viscosa-Heteropogon* community) among the sites. The maturity index (Table 9) varied from 42 (Site 6: *Acacia-Dodonaea viscosa- Heteropogon* community) to 76.67 (Site 11: *Quercus-Parrotiopsis-Viola* community). The overall values for these three parameters in 13 sites were discouraging due to disturbed habitat condition. Such situation is caused in area with high human interference followed by erosion and denudation of soil, which is common feature in the investigated area. The present findings are similar to that of Rahman *et al*., (2021, 2022), who also reported significant differences in species richness and Simpson indices among the major groups of vegetation. Malik *et al*., (2021) reported over all species richness of 106/ha.

Conclusions

This study reports 107 plant species of 98 genera and 54 families. There are three major altitudinal vegetation zones: sub-Himalayan semi–evergreen, Himalayan Chir pine and Himalayan Temperate zones each with its component plant communities. The flora and vegetation had hemicrpto-therophytic life form and nano-mesophillic leaf spectra. Majority of the flora was mesophytic (63.55%) and annual with simple leaves. Based on FIV, TIV and Mori index Asteraceae, Rosaceae, Poaceae, Mimosaceae, Pinaceae, Fagaceae, Lamiaceae and Papilionaceae were the dominant families.Based on SIV, the top most species in decreasing order were *Pinus roxburghii*, *Quercus dilatata*, *Acacia catechu* and *Heteropogon contortus.* Of the 13 sites, 12 were heterogeneous. This study also calculated species diversity, species richness and maturity indices. The area is highly degraded with nutrient deficiency due to deforestation, over-exploitation and soil erosion, which are the major threats to the biodiversity of the area. Trees and shrubs are generally stunted and isolated. The area requires concerted ecological and conservation management efforts for the rehabilitation of the original vegetation with the participation of all stake-holders.

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References

Abbas, Z, S.M. Khan, J. Alam, Z. Abideen and Z. Ullah. 2020. Plant communities and anthropo-natural threats in the Shigar Valley, (Central Karakorum) Baltistan-Pakistan. *Pak. J. Bot*., 52(3): 987-994, 2020. DOI: http://dx.doi.org/ 10.30848/ PJB2020-3(5)

Abbas, Z., S.M. Khan, J. Alam, T. Peer, Z. Abideen, R.W. Bussmann and S. Muhammad. 2021. Vegetation dynamics along altitudinal gradients in Shigar Valley (Central Karakorum) Pakistan: zonation, physiognomy, ecosystem services and environmental impacts. *Pak. J. Bot*., 53(5): 1865-1874, 2021. DOI: http://dx.doi.org/10.30848/PJB2021-5 (43)

Ahmad, A, S.N. Mirza and S.M. Nizami. 2014. Assessment of biomass and carbon stocks in coniferous forest of Dir Kohistan, KPK. *Pak. J. Agri. Sci*., 51(2): 345-350; ISSN (Print) 0552-9034, ISSN (Online) 2076-0906. http://www.pakjas.com.pk

Ahmad, S., T.U. Khan, L. Yang, G. Nabi, S. Ullah, T. Burni and Sobia. 2016. Floristic composition and vegetation structure of subtropical pine forest of district Buner, Khyber-Pakhtunkhwa, Pakistan. *J. BioL. Env. Sci*., 9(5): 1-10.

Ali, S., A. Perveen and M. Qaiser. 2015. Vegetation structure, edaphalogy and ethnobotany of Mahaban and Malka (District Buner) KPK, Pakistan. *Pak. J. Bot*., 47(SI): 15-22, 2015.

Ali, S.I. and M. Qaiser.1993-2022: Flora of Pakistan: Families 194-223. Fakhri Printing Press Karachi.

Ali, S.I. and Y. Nasir.1989-1991. Flora of Pakistan: Families 191-193. Fakhri Printing Press Karachi.

Ali, Asghar, L. Badshah, F. Hussain and Z.K. Shinwari. 2016. Floristic composition and ecological characteristics of plants of Chail Valley, District Swat Pakistan. *Pak. J. Bot*., 48(3): 1013-1026.

Badshah, L., F. Hussain and Z. Sher. 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. 2016. Floristic inventory, ecological characteristics and biological spectrum of plants of Parachinar, Kurram Agency, Pakistan. *Pak. J. Bot*., 48(4): 1547-1558.

Beg, A.R. 1975. Wild life types of Pakistan. Pakistan Forest Institute Peshawar.

Biswas, T., S. Dutta, Md. A. Hossain, Md. R. Rahman, S. Hossen and M.K. Hossain. 2021. Floral diversity in the central part of Chattogram city, Bangladesh. *Ecofeminism and Climate Change*, 2(4): 185-197. DOI 10.1108/EFCC-01-2021-0002.

Chaghtai, S.M. and I.H. Ghawas. 1976. The study of the effect of exposure on community set-up in Malakand Pass, N.W.F.P., Pakistan. *Sultania*, 2: 1-8.

Champion, H.G., S.K. Seth and G.M. Khattak. 1965. Forest Types of Pakistan. Pakistan Forest Institute. Peshawar.

Conventry, B.O. 1929.The forest vegetation and evidence of denudation.*Ind. For.Rec*., 14: 49-60.

Das, D.S., D.S. Rawat, D. Maity, S.S. Dash and B.K. Sinha. 2021. Species richness patterns of different life-forms along altitudinal gradients in the Great Himalayan National Park, Western Himalaya, India. *Taiwania,* 65(2): 154-162, 2020 DOI: 10.6165/tai.2020.65.154.

Daubenmire, R.F. 1959. A canopy coverage method of vegetation analysis.*Northwest Sci*., 33: 43-46.

Durrani, M.J., F. Hussain and S. Rehman. 2005. Ecological characteristics of plants of Harboi rangeland, Kalat, Pakistan. *J. Trop.& Subtrop. Bot.*, 13: 130-138.

Ghafari, S., A. Ghorbani, M. Moameri, R. Mostafazadeh, M. Bidarlord and A. Kakehmami. 2020. Floristic diversity and distribution patterns along an elevational gradient in the northern part of the Ardabil Province Rangelands, Iran. 2020. *Mountain Res. & Develop.*, 40(1): R37–R47 https://doi.org/10.1659/MRD-JOURNAL-D-18-00089.1

Gul, A., J. Alam, H. Ahmad and M. Irfan. 2016. An updated checklist of Pteridophytes of District Mansehra, Khyber Pukhtunkhwa-Pakistan. *Plant Sci. Today*, 3(2): 237-247. http://dx.doi.org/10.14719/pst.2016.3.2.220.

Hamid, M., A.A. Khuroo, A.H. Malik, R. Ahmad, C.P. Singh, J. Dolezal and S. M. Haq. 2020. Early evidence of shifts in alpine summit vegetation: a case study from Kashmir Himalaya. *Front. Plant Sci.*, 11: 421. doi: 10.3389/ fpls.2020.00421.

Haq, A. and L. Badshah. 2021. Floristic description and ecological characteristics of the plants of Pashat Valley, Pak-Afghan border, District Bajaur, Pakistan.*Acta Ecologica Sinica,* 41(6): 524-536. https://doi.org/10.1016/ j.chnaes. 2021.03.010.

Haq, S.M., E.S. Calixto, I. Rashid and A.A. Khuroo. 2021. Human-driven disturbances change the vegetation characteristics of temperate forest stands: A case study from Pir Panchal mountain range in Kashmir Himalaya. *Trees, Forests & People,* 6(2021) 100134, 1-9.https://doi.org/ 10.1016/ j.tfp. 2021. 100134.

Hart, S.A. and H.Y.H. Chen. 2008. Fire, logging and over story affect understory abundance, diversity, and composition in boreal forest. *Ecol. Monograph*, 78: 123-140.

Hassannejad, S. and S.P. Ghafarbi. 2012. Introducing new indices for weed flora studies. *Int. J. Agric & Crop Sci*., 4(22): 1653-1659.

Hayat, W., S. Khan, A. Iqbal, S. Ahmad and A.M. Abbasi. 2021. Protection is better than management to maintain tree species: A case study of lesser-Himalayan moist-temperate forests of Pakistan. *Trees, Forests & People*, 6(2021): 1-11, 100149.https://doi.org/10.1016/j.tfp.2021.100149

Hazrat, A., Z. Shah, K. Sher, Z. Ahmad, S. Bibi, G, Rahim, S. Zaman, Z. Fazal, M. Mukhtiar, T. Nowsheen, J. Zada and A. Khan. 2020. Floristic diversity and ecological characteristics of flora of Kharawo Talash, Dir lower, Khyber Pakhtunkhwa, Pakistan. *Biosci. Res.*, 17(2): 681-687. http://dx.doi.org/10.32859/era. 22.30.1-16.

Huang, J., Z. Guo, S. Tang, W. Ren, G. Chu, L. Wang, L Zhao, R. Yu, Y. Xu, Ding and R. Zang. 2020. Floristic composition and plant diversity in distribution areas of native species congeneric with *Betula halophila* in Xinjiang, northwest China. *Nature Conser.*, 42: 1-17. https://doi.org/10.3897/ nature conservation. 42.54735.

Hussain, F. and A. Shah. 1989. Phytosociolgy of vanishing sub tropical vegetation of Swat with special reference to Docut Hills. I: Winter aspect. *Sci. Khyber,* 2: 27-36.

Hussain, F., S.M. Shah, L. Badshah and M.J. Durrani. 2015. Diversity and ecological characteristics of flora of Mastuj Valley, District Chitral, Hindukush Range, Pakistan. *Pak. J. Bot*., 47(2): 495-510.

Hussain, F., A. Shah, I. Ilahi and A.R. Saljoqi. 1992. Phytosociology of the vanishing sub tropical vegetation of Swat with special reference to Docut Hills: II: Spring Aspect. *Sarhad J. Agric*., 8: 185-191.

Hussain, F. and I. Ilahi. 1991. The Ecology and Vegetation of Lesser Himalayas. Jadoon Printing Press, Peshawar. Botany Department, Peshawar University.

Hussain, F., I. Iqbal and M.J. Durrani. 2000. Vegetation studies on Ghalegy hills, Swat. *Pak. J. Pl. Sci*., 6: 1-10.

Hussain, F., M. Ahmed, G. Shaheen and M.J. Durrani. 1994. Phytosociology of the vanishing tropical dry deciduous forests in District Swabi, Pakistan, II: Ordination. *Pak. J. Bot*., 26: 149-160.

Hussain, F., M. Ahmed, M.J. Durrani and G. Shaheen. 1993. Phytosociology of vanishing tropical dry deciduous forests in District Swabi, Pakistan. I: Community Analysis. *Pak. J. Bot*., 25(1): 51-56.

Hussain, F., M. Ilyas and S. Takatsuki. 1997. Plant communities of Girbanre hills Swat District, North-western Pakistan. *Ecol. Rev*. (Japan), 23: 247-260.

Hussain. F. 1989. Field and Laboratory Manual for Plant Ecology. 1989. University Grants Commission, Islamabad. xp 245

Ilyas, M., R. Qureshi, N. Akhtar, Ziaul-Haq and A.R. Khan. 2018. Floristic diversity and vegetation structure of the remnant subtropical broad leaved forest from Kabal Valley, Swat, Pakistan. *Pak. J. Bot*., 50(1): 201-230.

Iqbal, M., S.M. Khan, Z. Ahmad, M. Hussain, S.N. Shah, S. Kamran, F. Manan, Z.U. Haq and S. Ullah. 2021. Vegetation classification of the Margalla foothills, Islamabad under the influence of edaphic factors and anthropogenic activities using modern ecological tools. *Pak. J. Bot.*, 53(5): 1831-1843, 2021. DOI: http://dx.doi.org/ 10.30848/PJB2021-5 (22)1831-1843

Jackson, M.L. 1962. Soil Chemical Analysis.Constable & Co Ltd. London.

Kacholi, D.S. 2014. Analysis of structure and diversity of the Kilengwe forerst in the Morogoro Region, Tanzania.*Int. J. Biodiv.,* http://dx.doi.org/10.1155/2014/ 516840

Kaur, J., R. Sharma and P. Sharma. 2020. Floristic composition and distribution pattern of herbaceous plant diversity in fallow lands of the central districts of Punjab, India. *J. Threatened Taxa*, 12(8): 15864-15880. https://doi.org/ 10.11609/ jott. 5032.12.8.15864-15880

Khan, A., L. Badshah, F. Hussain, K. Aziz, G. Jelani and W. Hussain. 2021. Phytodiversity and Morpho-Ecological Features of Plants of Tirah Valley, District Khyber, Pakistan. *Jordan J. Natu. Hist.*, (JJNH), 8(2): 49-79 - December, 2021.

Khan, K.R., M. Farooq, A.H. Shah, Z. Iqbal, J. Alam, M. Hussain, G.M. Shah, A. Mehmood and N. Bibi. 2020. Floristic composition, community syntaxonomy and ordination of Guzara (unprotected) forests of Hilkot range, District Mansehra, KP, Pakistan. *Proceed. Int. Acad. Ecol. & Environ. Sci.*, 10(1): 8-21.

Khan, M.N., S. Ali, S.A. Razak, A. Zaman, M. Iqbal and S.N. Shah. 2022. Assessment of floristic diversity in the mountain ecosystem of Marghazar Valley, Hindukush Range, Swat, Pakistan. *Biodiversitas*, 23(2): 1000-1013. DOI: 10.13057/biodiv/d230243.

Madiapevo, S.N., J. Makemteu and E. Noumi. 2017. Plant woody diversity of the highest summit forest (1156 m) in the Kala Massif, Western Yaounde. *Int. J. Curr. Res. in Biosciences & Plant Biology,* 4(10): 1-30.

Malik, A.Y., D.P. Singh, M. Yunus, G.A. Bhat, G. Shukla, J.A. Bhat, M.M. Rather and S. Chakravarty. 2021. Diversity and structure of plant assemblages in open scrub vegetation patches of Dachigam National Park at Kashmir Himalayas.*Trees, Forests & People*, 3(2021) 100060. https://doi.org/10.1016/j.tfp.2020.100060

Malik, N.Z. and Z.H. Malik. 2004. Present status of subtropical Chir pine vegetation of Kotli hills, Azad Jammu and Kashmir. *J. Res.*, *(Science),* 15(1): 85-90.

Menhinick, E.F. 1964. A comparison of some species individual diversity indices applied to samples of field insects. *Ecol.*, 45: 839-861.

Meragiaw, M., Z. Woldu, V. Martinsen and B.R. Singh. 2021. Floristic composition and structure of the Kibate Forest along environmental gradients in Wonchi, Southwestern Ethiopia. *J. For. Res*., 32: 2669-2682. https://doi.org/ 10.1007/s11676-021-01305-z

Moradipour, L., H. Pourbabaei and A. Hitami. 2020. Vegetation structure and floristic composition (Case study: Mala Galeh Protected area, Fars Province, Iran). *JPSL,* 10(3): 533-544. http://dx.doi.org/10.29244/jpsl.10.3.533-544.

Mori, S.A., B.M. Boom, A.M. deCarvalino and T.S. dosSantos. 1983. Ecological importance of Myrtaceae in Eastern Brazilian West Forest. *Biotropica*, 15(1): 68-71.

Motyka, J., B. Dobrzanski and S. Zawadski. 1950. *Ann Univ. M. Curie-Sklodowska*, 13: 367-447.

Mseddi, K., A. Alghamdi, M. Abdelgadir, S. Sharawy, M. Chaieb and T. Miller. 2021. Phytodiversity distribution in relation to altitudinal gradient in Salma Mountains – Saudi Arabia. *Global Ecology & Conservation*, 27 e01525. https://doi.org/10.1016/j.gecco.2021.e01525.

Muhammad, Z., N. Khan and A. Ullah. 2016. Quantitative ethnobotanical profile of understory vegetation in *Acacia modesta* (Wall) forests of Malakand Division Pakistan. *Sci., Technol. & Develop.*, 35: 88-93. DOI: 10.3923/ std.2016.88.93.

Mumshad, M., I. Ahmad, S.M. Khan, Abdullah, K. Rehman, M. Islam, M. Islam, S. Sakhi, S. U. Khan, S.G Afridi, S. Shams,S. Azam, I. Ahmad, R. Afza and Z. Ahmad. 2021. Phytoecological studies and distribution pattern of plant species and communities of Dhirkot, Azad Jammu and Kashmir, Pakistan. *PLoS One,* 16(10): e0257493. https://doi.org/10.1371/journal.pone. 0257493.

Naidu, M.T. and O.A. Kumar. 2016. Tree diversity, stand structure and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *J. Asia-Pacific Biodiv.,* 9: 328-334.

Nasir, E. and S.I. Ali. 1970-1989: Flora of Pakistan: Families 1-190. Fakhri Printing Press Karachi.

Ou, Z., S. Pang, Q. He, Y. Peng, X. Huang and W. Shen. 2020. Effects of vegetation restoration and environmental factors on understory vascular plants in a typical karst ecosystem in southern China. *Scientific Reports,* 10: 12011 | https://doi.org/10.1038/s41598-020-68785-7.

Parveen, S., L. Badshah, A. Ullah, S.G. Ali, S.M. Shah, U. Ali, A. Zaman and S.H. Siddiqui. 2021. Phytodiversity and ethnobotanical features of plants of Shahbaz Garhi Mardan, Khyber Pakhtunkhwa, Pakistan. *Ethnobot. Res. & Appl.*, 22: 30.

Pichi-Sermolli, R.E. 1948.An index for establishing the degree of maturity in plant communities.*J. Ecol.*, 36: 85-90.

Rahman, I.U., R.E. Hart, F. Ijaz, A. Afzal, Z. Iqbal, E.S. Calixto, E.F. Abd-Allah, A.A. Alqarawi, A. Hashem, A.F. Al-Arjani, R. Kausar and S.M. Haq. 2022. Environmental variables drive plant species composition and distribution in the moist temperate forests of Northwestern Himalaya, Pakistan. *PLoS One*, 17(2): e0260687.https://doi.org/ 10.1371/ journal.pone.

Rahman, A., N. Khan, K. Ali,R. Ullah, M.E.H. Khan, D.A. Jones and I.U. Rahman. 2021. Plant species classification and diversity of the understory vegetation in oak forests of Swat, Pakistan. *Appl. Sci*., 11(23): 11372; https://doi.org/ 10.3390/app112311372.

Raunkiaer, C. 1934. The Life form and Plants and Statistical Plant Geography. Oxford, Clerendon Press.

Sangar, R., A. Singh and J.S. Singh. 2008. Differential effect of woody plant canopies on species composition and diversity of ground vegetation. A case study.*Trop. Ecol.*, 49: 189-197.

Shah, I, A., L.Badshah, T. Burni, Noor-uluza and I. Ahmad. 2022. Floristic inventory and ecological evaluation of plants of Jani Khel, Bannu, Khyber Pakhtunkhwa, Pakistan. *Pure & Appl. Biol.*, 11(4): 881-89. http://dx.doi.org/ 10.19045/ bspab.2022.110090.

Shedayi, A.A., Ming Xu, F. Hussain, S. Sadia, I. Naseer and S. Bano. 2016. Threatened plant resources: Distribution and ecosystem services in the world's highest elevation park of the Karakorum ranges. *Pak. J. Bot*., 48(3): 999-1012.

Sher, Z., F. Hussain and L. Badshah. 2014. 06. 31: Biodiversity and ecological characterization of the flora of Gadoon Rangeland, District Swabi, Khyber Pukhtunkhwa, Pakistan. *Iran. J. Bot.*, 20(1): 96-108. Tehran.

Simpson, E.H. 1949.Measurment of diversity. *Nature*, 163: 68.

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species contents. Detkong Dansk Vidensk. *Selsk Biol. Skr.*, 5: 1-34.

Ullah, S., A. Rahman1, I. Ullah, M. Ahmad and M. Idrees. 2020. First floristic inventory and biological spectrum of flora of Lajbouk, Dir Lower, Khyber Pakhtunkhawa, Pakistan. *Biosci. Res.*, 17(3): 1633-1642.

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.

Zubair, M., A.S.B. Jamil, A. Hussain, U.L. Haq, A. Hussain, D.M. Zahid, A. Hashem, A.A. Alqarawi and E.F. AbdAllah. 2021. Diversity of medicinal plants among different tree canopies. *Sustainability,* 2021, 13, 2640.https://doi.org/ 10.3390/su 13052640.

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