# ASSESSMENT OF PLANT COMMUNITIES AND IDENTIFICATION OF INDICATOR SPECIES OF AN ECOTONAL FOREST ZONE AT DURAND LINE, DISTRICT KURRAM, PAKISTAN

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**Abstract.** There must be unique indicator vegetation at Ecotonal Zone in the border region of Pakistan and Afghanistan. Keeping this hypothesis in mind the forest zone of District Kurram at Durand Line was ecologically surveyed. Stations were established, GPS readings, environmental gradients were recorded and soil samples were collected. Data was statistically analysed using PC-ORD version-5 and CANOCO version-4.5. Indicator Species Analysis (ISA), constancy and fidelity level were used to find indicator species of communities. Preliminary results showed that study area hosts 195 vascular plant species belonging to 145 genera and 60 families. Cluster Analysis classified vegetation into four plant communities; (a) *Elaeagnus angustifolia-Rosa chinensis-Seriphidium kurramense* (b) *Platanus orientalis-Rosa moschata – Epilobium hirsutum* (c) *Quercus baloot – Jasminum auriculatum-Foeniculum vulgare* (d) *Quercus dilatata-Hedera nepalensis-Calamintha umbrosa*. Nitrogen, Sodium and Potassium were the strongest Physico-chemical factors ($P \leq 0.05$) determining plant communities composition. Interestingly, *Vincetoxicum cardiostephanum* was reported as narrow endemic species. Distinguished indicator species had significant environmental preferences. Variables like grazing and fodder chopping were the major vegetation drivers. Altitude was one of the most important determinants, influencing directly species distribution; Current study could be potentially used elsewhere for vegetation management and conservation strategies.
**Keywords:** *Indicators of Transitional Zone; Kurram Agency at Pak Afghan Border; Edaphic Factors*

## Introduction

The “ecotone” term was coined by Clements (1905) for transition zone and considered it as a basic unit of landscape ecology (Hansen et al., 1992; Casalini et al., 2019), having extremely unique vegetation, sensitive ecosystems and sharp communities boundaries (Walker et al., 2003; Gonçalves and Souza, 2014), due to abrupt environmental changes (Arellano et al., 2017). These characteristics enhanced significance to check competing ecological theories (Neilson, 1991) and especially climate change management (Kupfer and Cairns, 1996; Judi et al., 2018). The sensitivity and mechanisms of response are differentially varied among ecosystems and


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communities (Huang et al., 2016). The ecosystem continuations particularly for food security are indispensable, not merely to mountainous highland but for lowlands ecosystem; particularly who are dependent on these mountains resources (Rasul, 2010; Dolezal et al., 2016)**.** Therefore, understanding plant and environmental variables correlations, highlighting leading threats and conservation managements are the fascinating research field for ecologists and environmentalists (Tavili and Jafari, 2009; Khan et al., 2016).

Vegetation structure and composition are persuaded by numerous natural and anthropogenic activities (Shaheen et al., 2012; Lyu et al., 2017). Thus, ecosystem services quantification and evaluating vegetation distribution and mapping are important for conservation (Biondi, 2011). Vegetation classification into possible plant communities is also a mandatory part of ecosystem ecology, natural resource management and habitats degradation and fragmentation studies (Khan et al., 2015). It would visualise heterogeneity insights of particular vegetation's type (Haq et al., 2015b). Plant ecologists often hypothesized vegetation driving mechanism and environmental gradients (Willig et al., 2003; Haq et al., 2015a). In mountainous region topography and elevation had strong effects on species diversity, richness and community structures (Khan et al., 2015; Ullah et al., 2015). Anthopogenic disturbances may trigger species shifting (Johnstone and Chapin, 2003) and/or probably eliminate forest products (Brown and Johnstone, 2012) and alter ecosystem function (D'Amato et al., 2011). Long-term overgrazing could have legacial effects on plant diversity, biomass production and edaphic factors (Sher et al., 2010; Sternberg et al., 2017). The soil micro and macro nutrients level can significantly affect species richness and communities Byrne et al. (2017) examined plant's responses against precipitational change and concluded comparatively high level sensitivity. Chang et al. (2018) and Skagen et al. (2018) emphasized forest sensitivity and responses against precipitation variation in ecotones over a time scale.

The indicator species identification ultimately helps in management and restoration of natural resources (Ahmad and Khan, 2004; Mashwani et al., 2011). Keeping the hypothesis in mind; there must be unique indicator vegetation at Ecotonal Zone. The current study was designed to evaluate the vegetation and communities, indicator species and to determine whether soil characteristics and/or anthropogenic activities influences on community distribution in the ecotonal zone. The aim was designed with three main objectives; to quantify vegetation of the ecotonal region, to classify vegetation in major communities along the geo-climatic and altitudinal environmental gradients and to assess the indicator species under the influence of disturbances for future generation management. Additionally, current study documented suggestions for the mountainous plant biodiversity conservation under the scenario of continuous anthropogenic activities.

## Material and methods

### *Study area description*

The Kurram Valley is situated in the far West of the Khyber Pukhtunkhwa (KP), Pakistan, projecting like a neck in Afghanistan and touching Pukthia, Nangarhar and Khost provinces on its West. Previously, study are was called as FATA but on 24 May 2018 in 25th Constitutional amendment, has been merged to KP and give it agency status, It lies between 33° 20' to 34° 10' N-latitudes and 69° 50' to 70° 50' E-longitude,


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with a total length of 115 km and covering 3380 km$^2$ area (*Fig. 1*). District Orakzai and Khyber are lies on its East, District Hangu is situated at southeast, while District North Waziristan is bordered at south. “Koh-e-Sufaid” the part of Western Himalayas, situated on its North. The highest known peak is Sikaram with an altitude of 4728 m a.s.l. This mountainous range results high annual average precipitation and hence summers remain pleasant. The valley is relatively dry and mostly represents the dry temperate-type of habitat. Heavy snowfall has been experienced in winter with a freezing temperature (*Fig. 6*). The study area, floristically the part of Western Irano-Turanian region of the Western Himalayan province. Moreover, it gains distinctive position to act as botanical buffer zone between the dry temperate and moist temperate vegetation zones of the Himalayan and Hindu Kush mountainous ranges, respectively. Thus, due to this unique transitional locality, the valley hosts typical vegetation and position in the region. Vegetation is predominated by oak, blue pine, cheer pine forests and chilgoza pine in the extreme border with Afghanistan. Despite of high phytogeographic status factor like; geopolitical conflicts, harsh terrain, long history of Afghan war, low literacy rate and feudal tribal laws divert the concentration of the scientific societies to evaluate the region ecologically. Therefore, project was lunched to evaluate quantitatively.

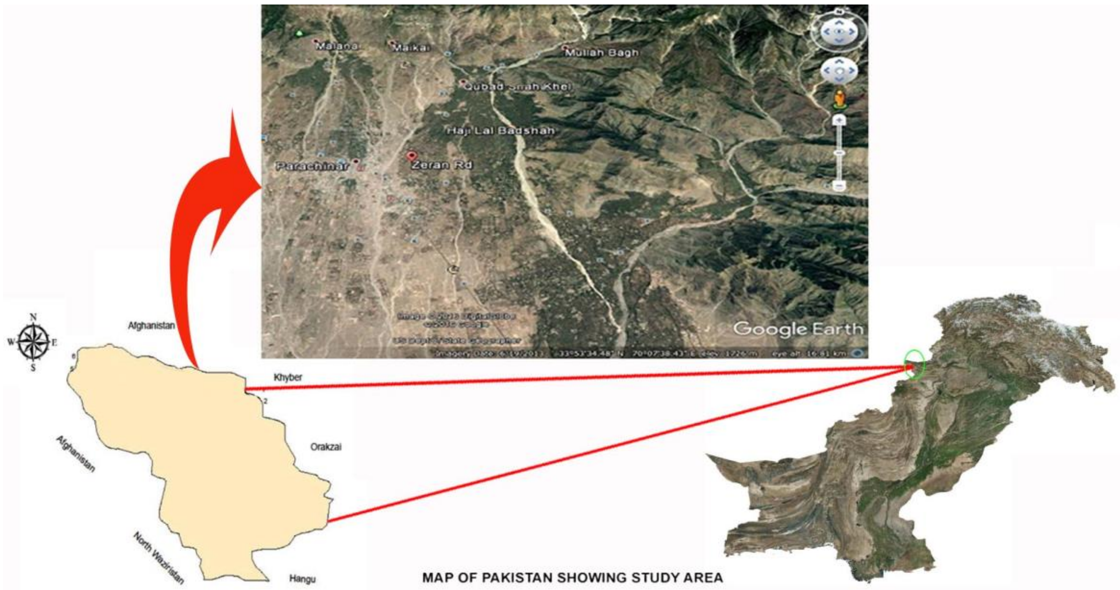


***Figure 1.*** *. Map of the Zeran valley (Border region of Pakistan and Afghanistan).*

### *Field sampling techniques for vegetation quantification*

During the summer season of 2016 to 2017, phytosociological techniques were used for vegetation assessment along edaphic and other related environmental transects (Laurance et al., 2004; Khan et al., 2012). The area was divided into seven different stations on the basis of floristic composition, physiognomy, topography and altitudinal variation (McMahon et al., 2011). Mature and least disturbed vegetation of the study area was focused (Laurance et al., 2004). A mixture of transect and quadrats method was frequently used. Square shape quadrats 1 × 1 m$^2$, 5 × 5 m$^2$ and 10 × 10 m$^2$ for herbs, shrubs and trees respectively were laid in each station. The plant species were collected from respective habit type, vernacular names, family names and other relevant


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information were recorded in the field note books. The collected plant specimens were properly pressed, dried using blotting papers, poisoned and finally mounted on the standard herbarium sheets. All specimens were preserved in the Herbarium of Quaid-I-Azam University, Islamabad, Pakistan for future reference. The specimens were identified with help of the Flora of Pakistan (Ali et al., 1972–2009; Ali and Qaiser, 1986, 1995-2010) and available literatures at Islamabad Herbarium, Quaid-I-Azam University and National Herbarium at National Agriculture Research Centre (NARC), Pakistan. The scientific names of all plant species were confirmed from the plant list website (http://www.theplantlist.org).

The quantitative vegetation attributes i.e., density, cover, frequency and their relative values were recorded. Importance Value Indices of species were also calculated (Curtis and McIntosh, 1950). Various environmental variables like grazing pressure, soil depth and condition, number of stumps, elevation and aspects were recorded with special concentration. Geographical co-ordinates of each site were noted using GPS. The community's names were based on ISA, species constancy and faithfulness.

### *Soil sampling and analyses*

Since the top-soil soil contains greater nutrient concentration ad highest organic matter contents. Mostly roots biomass is accumulated throughout this soil profile (Vallés et al., 2015; Jobbágy and Jackson, 2001). Within each quadrat, soil samples were randomly collected from each microsite, and then mixed accordingly to make a unique pooled. Pebbles and wood pieces were removed. The samples were shad dried, sieved, air dried, grinded and analysed for the selective physico-chemical edaphic factors in a Fauji Fertilizer Company (FFC) limited farm advisory centre, Hasan Abdal, Pakistan. The soil texture was determined by the hydrometer method of particle-size analysis (Day, 1965). The Organic carbon (O.M) contents were analysed via (Nelson and Sommers, 1996) methodology and Nitrogen was measured following the semi-micro Kjeldahl procedure of (Bremner and Mulvaney, 1982). Electric conductivity (E.C) was analysed in saturation extract using (Rhoades, 1982) protocol. Potassium and Phosphorus were analysed according to (Soltanpour, 1985), whilst Sodium was measuerd via (Rhoades and Miyamoto, 1990) methodology.

### *Data statistical analyses*

The data obtained from field work needs to be examined in a statistical framework (Kent and Coker, 2002). It helps ecologists to analyse the effect of environmental factors, vegetation classification and mapping for conservation and management purposes (Anderson et al., 2006). Data of 252 quadrats (84 for each trees, shrubs and herbs species respectively) were alphabetically arranged in MS Excel spread sheet 2010. The utilities of PC-ORD version_5 i.e., Cluster Analysis (CA) and Indicator Species Analysis (ISA) were applied to classify plant communities (Dufrene and Legendre, 1997), analyse distribution pattern and identify indicators species respectively. CA brings stations with similar floristic composition close to each other (Sorensen, 1948; Dalirsefat et al., 2009). The ISA identified indicator plant species with statistical significance ($\leq .05$) of each habitat type, defined by the environmental variable. It also constructed indicator values for each species using Monte Carlo techniques. Each species was evaluated for its ability to categorize among all the treatments of environmental variables and attributed to its suitable habitat type. ISA


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provided suggestions of how well the presence of a species would indicate a specific station or plant community (Dufrene and Legendre, 1997).

Mantel test as a utility of PCORD was used to estimate the strength of the relationship between species and environmental data matrices. These tests help to test hypothesis, whether variation in factors like aspect and elevation etc would have any impact on the diversity of plant species as well as communities qualitatively as well as quantitatively. The naming of plant communities was based on the indicator plant species, having significant P value ≤ 0.05, identified by ISA, as recommended by Dufrêne and Legendre (1997). Beside this, constancy and fidelity level of the characteristics species of the communities were also checked for further authentication of indicator, to use in naming the communities (Malik and Husain, 2006).

### *Ordination analyses for identification of ecological responsible gradients*

Ordination is a multivariate statistical method that summarizes communities data by constructing a low dimensional space in which similar samples and species come closer together along the specific environmental gradients complex and dissimilar ones goes further apart from each other (Gauch, 2010). Keeping the objectives in mind, we analysed plant species data with measured environmental variables in CANOCO (Ter Braak and Barendregt, 1986). Canonical Correspondence Analyses (CCA) is the most meaningful direct ordination gradient technique (Braak, 1988). It is widely used to examine environmental factors influence (Dufrene and Legendre, 1997). The CANOCRAW, utility of CANOCO was used to construct CCA plots of species-environmental and community-environmental variables.

## Results

### *Species diversity and dominant species*

Preliminary findings confirmed total of 195 vascular plant species belongs to 144 genera of 60 Families in the study area (*Table A1* in the *Appendix*). The recorded 195 plant species belong to 144 genera and 60 families (*Table A1*). In which 3 and 5 species belongs pteridophytes and gymnosperms, whilst angiosperms dominating the area with 186 species. Within angiosperms, dicotyledons dominated the region having 160 members whilst 27 species were the representative of monocotyledons (see *Appendix*). The dominant species were evaluated on the basis of the IVI. The lower altitude (1500-2000 m) subtropical evergreen elements like *Olea ferruginea* (7.60%) *and* deciduous Treelets species like *Cotoneaster bacillaris* (3.79) dominated the area. In the middle attitude (2000-2500 m) broad leaved evergreen, *Quercus baloot* (8.63%) found to be dominant whilst at the higher elevational zone (2500-3000 m) moist temperate element and western Himalayan native species *Quercus dilatata* (17.11%) and *Cedrus deodara* (6.37%) forming close gregarious association. The forest thickness was positively correlated whilst species diversity and richness were negatively correlated along the elevational gradient in the study area. The lower xeric elevation was mostly occupied by habitat *Daphne mucronata* (8.58%), *Sophora mollis* (12.17%) and *Berberis lyceum (*7.99%). On the other hand higher elevational zones were dominated by, *Indigofera heterantha, plectranthus rugosus* and Berberis parkeriana by 19.04%, 14.81% and 7.39% of IVI total weightage of 21recorded shrub species. The forest ground flora was dominated by representatives of Poaceae includes; cynodon dactylon (7.73%), *Stipa sibirica* (3.72%), *Setaria pumila* (3.26), *Piptatherum laterale*


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(2.69%), *Apluda mutica* (2.56%), *Agrostis vinealis* (2.11%) with associated species; *Medicago sativa* (6.16%), *Cirsium arvense* (3.91%) Oxalis corniculata (2.71%) and *Viola odorata* (2.44%) in 142 recorded herbs species (*Appendix*). The *V. cardiostephanum* was reported after122 years and confirms their occurance with a rarity in Pakistan. Harsukh, collected for the first time but in non-flowering stage (*Fig. 6C*). Our study re-confirms the occurrence of *V. cardiostephanum* in Pakistan. Its holotype Rechinger 35614 (W) belongs to Afghanistan. Hence, it is a narrow endemic to this ecotonal region of Pak-Afghan border, with a limited distribution; probably less than 100 $km^2$. According to the IUCN red list categories and criteria it has been declared as Critically Endangered species.

### *Community's classification*

The application of PC-ORD version-5 packages with 1,0 data gave rise to Cluster Analyses (CA); precisely divide the plant species into four major communities (*Fig. 2*). The communities' nomenclatures were based on the species constancy, fidelity level and Indicator Species Analyses (ISA). Each indicator species was studied under the influence of environmental variables. The Monte Carlo test result showed that; Nitrogen (N), Sodium (Na), Soil texture (S.T) and altitude played significant role in communities' composition. The Monte Carlo test result shows the strength of the environment-species relationship. The first community; *Elaeagnus angustifolia-Rosa chinensis-Seriphidium kurramense* was found at the lower altitude. The habitat of this community was mostly xeric. The second community; *Platanus orientalis-Rosa moschata-Epilobium hirsutum* found, where mostly agricultural practices were noticed. The third community; *Quercus baloot-Jasminum auriculatum-Foeniculum vulgare* and fourth communities *Quercus dilatata-Hedera nepalensis-Calamintha umbrosa* were found at the high elevation (*Table 1*).

***Table 1.*** *Detail information of the indicator species of the all communities along with fidelity level, constancy classes and Indicator species analyses*

| S No. | Indicator species | Com | Constancy | | F. C. | Var | I.V | P* |
|---|---|---|---|---|---|---|---|---|
| | | | C.C | C% | | | | |
| 1 | *Elaeagnus angustifolia* | 1st | C4 | 68.75 | 72.3 | N | 47 | 0.05 |
| | | | | | | S.T | 46 | 0.01 |
| 2 | *Rosa chinensis* | 1st | C1 | 12.5 | 100 | K | 47 | 0.02 |
| 3 | *Seriphidium kurramense* | 1st | C3 | 43.75 | 100 | N | 49 | 0.04 |
| | | | | | | O.M | 13 | 0.04 |
| 4 | *Platanus orientalis* | 2nd | C2 | 26.09 | 61.02 | Na | 25.8 | 0.0302 |
| 5 | *Rosa moschata* | 2nd | C1 | 8.7 | 67.61 | Na | 66.3 | 0.001 |
| | | | | | | EC | 19.7 | 0.0562 |
| 6 | *Epilobium hirsutum* | 2nd | C1 | 4.35 | 100 | Na | 33.3 | 0.0358 |
| 7 | *Quercus baloot* | 3rd | C2 | 29.17 | 50.52 | pH | 56.1 | 0.0528 |
| 8 | *Jasminum auriculatum* | 3rd | C1 | 12.5 | 100 | pH | 33.3 | 0.0386 |
| 9 | *Foeniculum vulgare* | 3rd | C1 | 4.17 | 100 | Na | 33.3 | 0.032 |
| | | | | | | EC | 20 | 0.0526 |
| 10 | *Quercus dilatata* | 4th | C3 | 52.38 | 100 | K | 33.7 | 0.0196 |
| 11 | *Hedera nepalensis* | 4th | C1 | 4.76 | 100 | ST | 33.3 | 0.0308 |
| 12 | *Calamintha umbrosa* | 4th | C1 | 14.29 | 76.67 | K | 43.9 | 0.011 |
| | | | | | | Na | 32.8 | 0.0196 |

Com = community, C.C = Constancy class, C% = Constancy%, F.C = Fidelity class, Var = Variables, I.V = Indicator Value, P* = significant value


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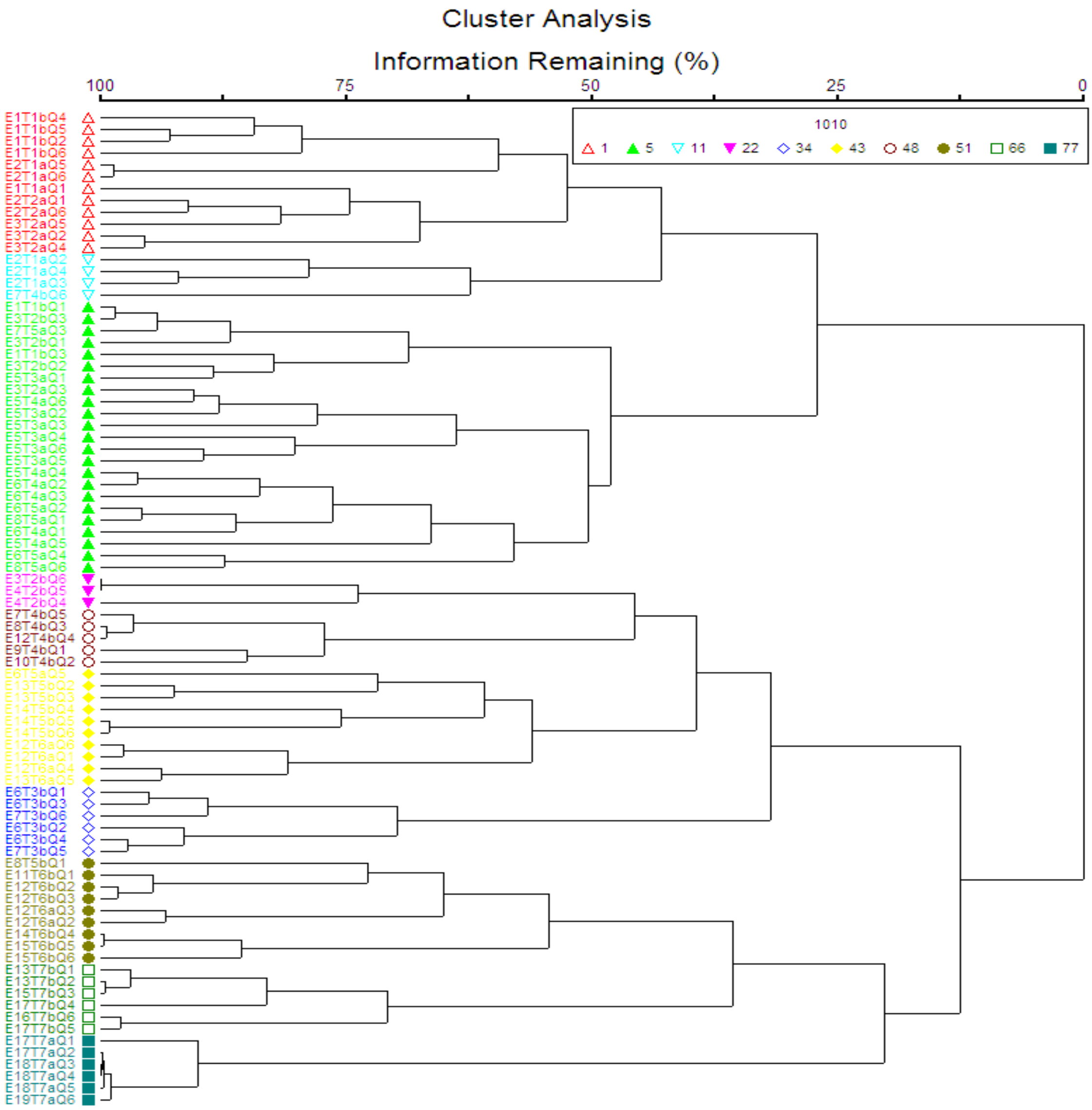


***Figure 2.** Cluster Analysis classifying the study sites into four communities.*

### *1. Elaeagnus angustifolia – Rosa chinensis – Seriphidium kurramense community*

The application of CA and TWCA based on Sorenson Similarity Index, a total of 48 releves clustered in this community. It was found at the elevation range of 1550-1900 m above sea level (a.s.l). The name was given based on significant indicator species (P* value ≤ 0.05) i.e., *Elaeagnus angustifolia*, *Rosa chinensis* and *Seriphidium kurramense* respectively (*Table 1*). Impacts of edaphic factors were also analysed and found that higher Nitrogen and Potassium concentration and medium Organic matter were the most prominent driving environmental variables in determination of these indicator species (*Fig. 5*). Moreover, these species have higher constancy fidelity within this community (*Table 1*). The concentration of N and pH in this community is higher as it comprises of the cultivated land, where use of fertilizers like Di-Ammonium Phosphate (Muthuramkumar et al.), Nitro-Phos (NP) and Potassium sulphate are repeatedly used for higher yields. Based on IVI values the dominant tree species includes *Robinia*


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*pseudoacacia, Punica granatum* and *Populus nigra*. Amongst the shrubby layer *Daphne mucronata* and *Berberis lycium* were the dominant whereas in the herbaceous layer *Cynodon dactylon, Sanguisorba minor* and *Dichanthium annulatum* were reported as dominated species of this community.

Being located at lower elevation numbers of anthropogenic activities i.e., deforestation for fuel and fodder purposes, over grazing and agricultural land expansion are the main threats to the vegetation of this community. It was easily accessible to vicinity of human settlement to utilize the local plant resources. The physio-chemical analyses of this community revealed that pH ranges from 6.8 to 7.8, Nitrogen (0.032-0.87%), Sodium (0.5-1.4 mmolc/100 g), Electrical Conductivity (0.17-0.33 dS/m), Phosphorous (1-4 ppm), Potassium (106-420 ppm) and Organic matter (0.51-1.39%).

*2. Platanus orientalis – Rosa moschata – Epilobium hirsutum community*

This community was found at the middle elevation (1950-2300 m) of the valley. It hosts 84 different quadrats. The characteristic species of tree, shrub and herb layers were *Platanus orientalis*, *Rosa moschata* and *Epilobium hirsutum* respectively. Sodium and EC were the main environmental variables determining the indicator species of this community (*Fig. 5*). We observed that *Rosa moschata* was found in higher while other indicator species observed at a moderate concentration of Sodium and Electrical Conductivity respectively. The indicator species was found with relatively lower constancy level and higher fidelity level within this community (*Table 1*). The other important tree species present were *Populus nigra*, and *Diospyros lotus.* These species were cultivated, therefore gains dominancy in this community as well. Abundant shrub species reported were *Sambucus nigra*, *Rubus fruticosus* and *Indigofera heterantha.* Dominant herbs species were *Medicago sativa* and *Impatiens edgeworthii* in this community.

Agricultural practices were found as the top disturbing elements in this community. Analysing of soil showed that pH ranges from 7.1 to 7.9, Nitrogen (0.043-0.078%), Sodium (0.6-1.5 mmolc/100 g), Electrical Conductivity (0.15-1.18 dS/m), Phosphorous (2-6 ppm), Potassium (84-900 ppm) and Organic matter (0.69-1.25%).

*3. Quercus baloot – Jasminum auriculatum – Foeniculum vulgare community*

Based upon Sorenson index of similarity measurement this community was established relatively at the higher elevation, i.e., 2350-2780 m. Vegetation of this community was dominated by woody plants. Diagrammatic presentation of cluster dendogram show total 72 releves clustered together in this community. The principle indicator species of this community were *Quercus baloot*, *Jasminum auriculatum* and *Foeniculum vulgare.* The important environmental variables responsible for the community establishment were slightly higher pH, moderate Sodium and higher concentration of EC (*Fig. 5*). All the characteristic species of this community show higher level of faithfulness (*Table 1*). This community comprises of a thick forest dominated by ever green tree species i.e., *Quercus semicarpifolia*, *Olea ferruginea* and deciduous tree species like *Celtis caucasica*. *Indigofera heterantha, Plectranthus rugosus* and *Sophora mollis* were the dominant shrubs. *Piptatherum laterale* and *Thymus linearis* were the dominant herb species.

Fodder, fuel wood, chopping and grazing were observed as main anthropogenic activities disturbing the natural vegetation equilibrium. Soil analyses of this community


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indicates that pH ranges from 6.8 to 7.8, Nitrogen (0.048-0.079%), Sodium (0.3-2.4 mmolc/100 g), Electrical Conductivity (0.07-1.33 dS/m), Phosphorous (2-10 ppm), Potassium (42-560 ppm) and Organic matter (0.76-1.26%).

*4. Quercus dilatata – Hedera nepalensis – Calamintha umbrosa community*

This was the community of highest elevation range, that is 2800-3000 m a.s.l. It was represented by 63 quadrats. The analysis inveterate that; *Quercus dilatata*, *Hedera nepalensis* and *Calamintha umbrosa* were the strongest indicator species with a p values < 0.05, under the influence of high Potassium and moderate Sodium concentration (*Fig. 5*). The characteristic species showed high fidelity and moderate constancy level (*Table 1*). This was tree dominating community comprised of the principle indicator of moist temperate vegetation i.e., *Cedrus deodara*, *Quercus baloot* and *Pinus brutia* as dominant tree species. Dominant shrub species were *Indigofera heterantha*, *Plectranthus rugosus* and *Berberis parkeriana*. This community has slightly lower species richness in comparison to the other communities. *Thymus linearis* and *Apluda mutica* were dominating the herbaceous layer of this community.

Soil depth was shallow, due to rugged topography and steep slopes. Higher grazing pressure make this community very prone for soil erosion. Lower temperature prevails throughout the year. These condition results low plant species diversity. Medicinal plant collectors for commercial purposes were the major anthropogenic activities. Large No of stumps were reported as people collect wood for timber and fuel purposes mainly from this elevation range. Physio-chemical analyses revealed pH ranges from 7.2-8, Nitrogen (0.052-0.072%), Sodium (0.-1.4 mmolc/100 g), Electrical Conductivity (0.08-0.28 dS/m), Phosphorous (2-6 ppm), Potassium (60-8690 ppm) and Organic Matter (0.15-1.12%). Due to thick forest layer soil texture of this community was sandy clay loam.

***Direct environmental gradient analyses***

The plant and environmental data treatment via CCA identified the core factors; showing high significant p-value < 0.002. The CCA bi-plot showed that both vegetation variations and communities' variations were mainly driven by; stumps, grazing pressure, Phosphorous, Sodium and Nitrogen (*Table 2*). The CCA ordination procedures for species and communities (*Figs. 3, 4* and *5*) indicated that 1st axis strongly correlated with altitude and partially with pH; the 2$^{nd}$ axis was mainly correlated with stumps (due to immense deforestation), high concentration of sodium and strong EC; 3$^{rd}$ quadrat correlated with high Phosphorous and medium organic matter (O.M) whilst the 4$^{th}$ axis was under the immense grazing pressure (*Figs. 3* and *4*). Similarly stations CCA bi-plot (*Fig. 5*) demonstrated clear reflection of altitudinal and latitudinal gradient complexes of the region. The 1$^{st}$ and 2$^{nd}$ community were clustered at the lower altitude. Moreover, it also describes stations of woody and evergreen vegetation was mostly found at the higher elevation. The physiographic and geomorphologic gradient complexes describes that depth soils and sunlight exposures loving vegetation were frequently distributed at lower parts whilst relatively thin soils an shad loving species favoured the high elevated habitats. The sum of all Eigen value Monte Carlo test were 14.312. The 1$^{st}$ axis eigen value was quite high (0.469), which showed the slope in spreading species along with the axis. The 1$^{st}$ axis cumulative percentage of Species-environment relation was 21.6%


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of total unexplained variance. This value of 4th axis was the highest with 65.1% (*Table 2*).

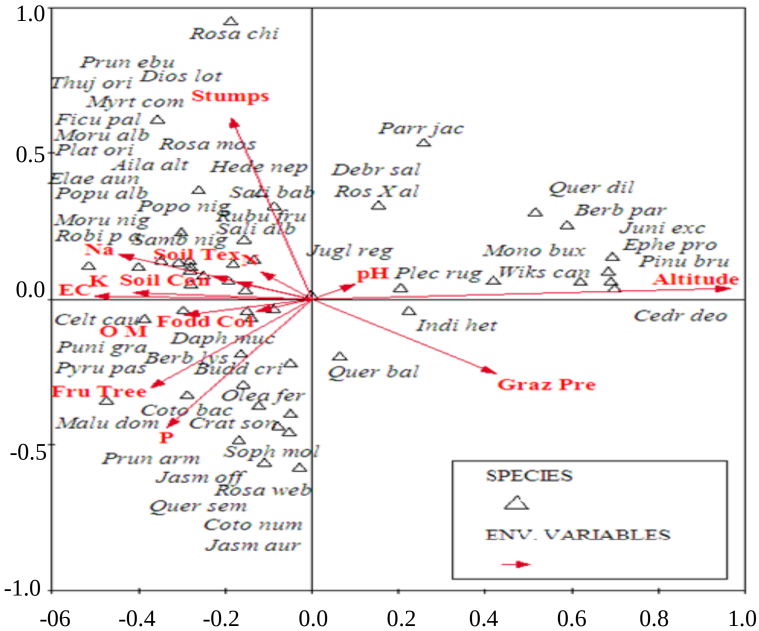


***Figure 3.*** *CCA diagram showing distribution trees and shrubs species along the environmental gradients. P = Phosphorous, Na = Sodium, K = Potassium, OM = Organic Matter, Soil Tex = Soil Texture, N= Nitrogen and EC = Electric Conductivity, Fru tree= Fruit trees, Soi Tex= Soil texture, Graz Pre= Grazing pressure, Soil con= Soil Condition*

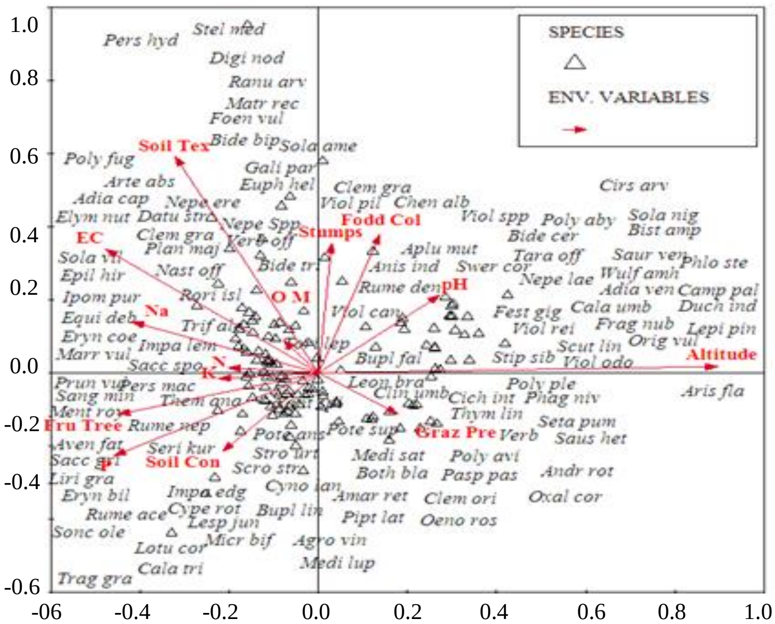


***Figure 4.*** *CCA diagram showing distribution herbs species along the environmental gradients. P = Phosphorous, Na = Sodium, K = Potassium, OM = Organic Matter, Soil Tex = Soil Texture, N = Nitrogen and EC = Electric Conductivity, Fru tree = Fruit trees, Soi Tex = Soil texture, Graz Pre = Grazing pressure, Soil con = Soil Condition*


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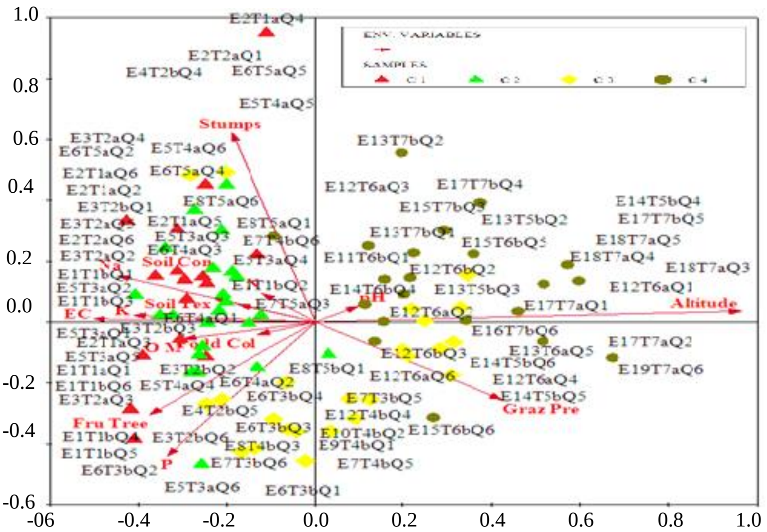


*Figure 5. CCA diagram showing distribution selected stations along the environmental gradients. P = Phosphorous, Na = Sodium, K = Potassium, OM = Organic Matter, Soil Tex = Soil Texture, N = Nitrogen and EC = Electric Conductivity, Fru tree = Fruit trees, Soi Tex = Soil texture, Graz Pre = Grazing pressure, Soil con= Soil Condition, C1 = Community 1st, C2 = Community 2nd, C3 = Community 3rd and C4 = Community 4th*

***Table 2.*** *Summary of the CCA bi-plot four axes of Monte Carlo test for the ecotonal vegetation using IVI data*

| Axes | 1 | 2 | 3 | 4 | Total inertia |
|---|---|---|---|---|---|
| Eigen values | 0.469 | 0.394 | 0.288 | 0.262 | 14.312 |
| Species-environment correlations | 0.903 | 0.880 | 0.909 | 0.836 | |
| | Cumulative percentage | | | | |
| Variance of species data | 3.3 | 6.0 | 8.0 | 9.9 | |
| Species-environment relation | 21.6 | 39.7 | 53.0 | 65.1 | |
| Sum of all eigen values | | | | | 14.312 |
| Sum of all canonical eigen values | | | | | 2.170 |
| Summary of Monte Carlo test (499 permutations under reduced model) | | | Test of significance of all canonical axes | | |
| Eigen value | 0.469 | | Trace | | 2.473 |
| F-ratio | 2.539 | | F-ratio | | 1.675 |
| P-value | 0.002 | | P-value | | 0.002 |

## Discussion

Biological assemblages could evaluate significantly the deteriorative impacts of anthropogenic activities on natural ecosystems (Kusnierz et al., 2015). Ecotones can be differentiated on the bases of the sharpness of their communities (Lloyd et al., 2000). The most appropriate causes are; sharp climatic gradient, elevation, invasion of dominant, steep topography and environmental factor especially human influences (Walker et al., 2003; Casalini, 2017). Results strongly support our hypothesis to have unique indicator vegetation at Ecotonal Zone and edaphological factors affecting community composition. A total of 195 belongs to 60 families of vascular plant species, were reported in varied ecological zones of the valley (*Appendix*). Altitude was one of the most important determinants, influencing directly species distribution; because it governs the micro climate of the habitats (Casalini, 2017; Singh et al., 2009). In the lower altitude (1500-2000 m) subtropical evergreen elements like *Olea ferruginea* (7.60%) in an association with deciduous Treelets species *Cotoneaster bacillaris* (3.79) were recorded as dominated. In the middle attitude (2000-2500 m) broad leaved evergreen species, *Quercus baloot* (8.63%) whilst moist temperate element and western Himalayan native species *Quercus dilatata* (17.11%) and *Cedrus deodara* (6.37%) at the elevation of 2500-3000 m were reported as dominant. *Daphne mucronata* (8.58%), *Sophora mollis* (12.17%) and *Berberis lyceum (*7.99%, sub-tropical indicator) dominated the lower xeric elevation, whilst *Indigofera heterantha* (19.04%,), *plectranthus rugosus* (14.81%) and *Berberis parkeriana* (7.39%) find as dominant shrub species. The herbaceous flora was dominated mostly Poaceae members; cynodon dactylon (7.73%), *Stipa sibirica* (3.72%), *Setaria pumila* (3.26), *Piptatherum laterale* (2.69%), *Apluda mutica* (2.56%), *Agrostis vinealis* (2.11%) along with *Medicago sativa* (6.16%), *Cirsium arvense* (3.91%) Oxalis corniculata (2.71%) and *Viola odorata* (2.44%) in 142 recorded herbs species (*Appendix*). The *V. cardiostephanum* occurrence was reconfirmed after Harsukh (122 years later) and who collected it in non-flowering stage (*Fig. 6C*). We collect it in flowering stage and occupying less than 100 $km^2$, so applying IUCN category and criteria; declared it as its holotype Rechinger 35614 (W) belongs to Afghanistan. Hence, it is a narrow endemic to this ecotonal region of Pak-Afghan border, with a limited distribution; probably less.

The species richness and Diversity Index were optimum at middle elevations (2000-2400 m a.s.l) as compare to the lower (1500-150 m a.s.l), and higher altitudes due to various pressures and xeric conditions at these areas. Reporting moist indicator climatic species like; *Cedrus deodara*, *Indigofera heterantha*, *Bistorta amplexicaulis* and *Trifolium repen* (*Appendix*) in the high elevation is supported by Saima et al. (2009) and Ahmed et al. (2006) studies. The gradual decreasing in species richness along the increasing altitude is considered as a general pattern Shaheen et al. (2011, 2012). Such phenomena of species distribution have also been reported from other mountainous locations using more or less same techniques, i.e., Anderson et al. (2006), Ahmad et al. (2015) and Haq et al. (2017). The micro climatic conditions of the valley vary from sub-tropical to cool temperate zone is in accordance to and Shen et al. (2015) and Zhou et al. (2018). The vegetation of Irano-Toranian and Western Himalayan types for example *Parrotiopsis jacquemontiana* is one of such indicator from the Current location as well. Comparison with previous researches in the adjacent areas indicates similar vegetation zones Khan and Ahmad (2015), Khan et al. (2016) and Haq et al. (2015a).

The multivariate statistical analysis via PCORD V-5 software sorted out the vegetation into 4 plant communities (*Fig. 2*) on the bases of indicator plant species. Approach to the communities naming based on statistical approaches, specifically Indicator Species Analysis in conjunction with fidelity (faithfulness) and constancy measurements of Bergmeier (2002) is one of the technical feature of our finding. The use of indicator species to determine environmental conditions and community types is an emerging technique in vegetation ecology for both theoretical and applied purposes. This use of multispecies environmental or ecological indications instead of single or repetitive indicator has enormously contributed in the bio-indication system and its reliability (Carignan and Villard, 2002; Niemi and McDonald, 2004; Butler et al., 2012;


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Rahman et al., 2019). The characteristic species of each community was confirmed through Indicator Species Analyses, Species fidelity Level and constancy classes. Similar procedure for communities composition were also adopted by Shaheen et al. (2011) Khan et al. (2012), Khan (2012), Ahmad et al. (2016), Bano et al. (2017), Pharswan and Mehta (2010) and Ilyas et al. (2012) in their respective research. Indicator species analyses revealed that Nitrogen, Phosphorous, Sodium, EC and pH were the strongest and significant edaphic factors ($p \leq 0.05$) for the constitutions plant communities and determination of indicator species (*Table 1*). Khan et al. (2016) used the same method with unique results from Thandiani Sub-Forest Division of the Western Himalayas. Soil factors influences over plant distribution in the ecotonal region agreed with the previous studies of El-Keblawy et al. (2015) and Grellier et al. (2014).

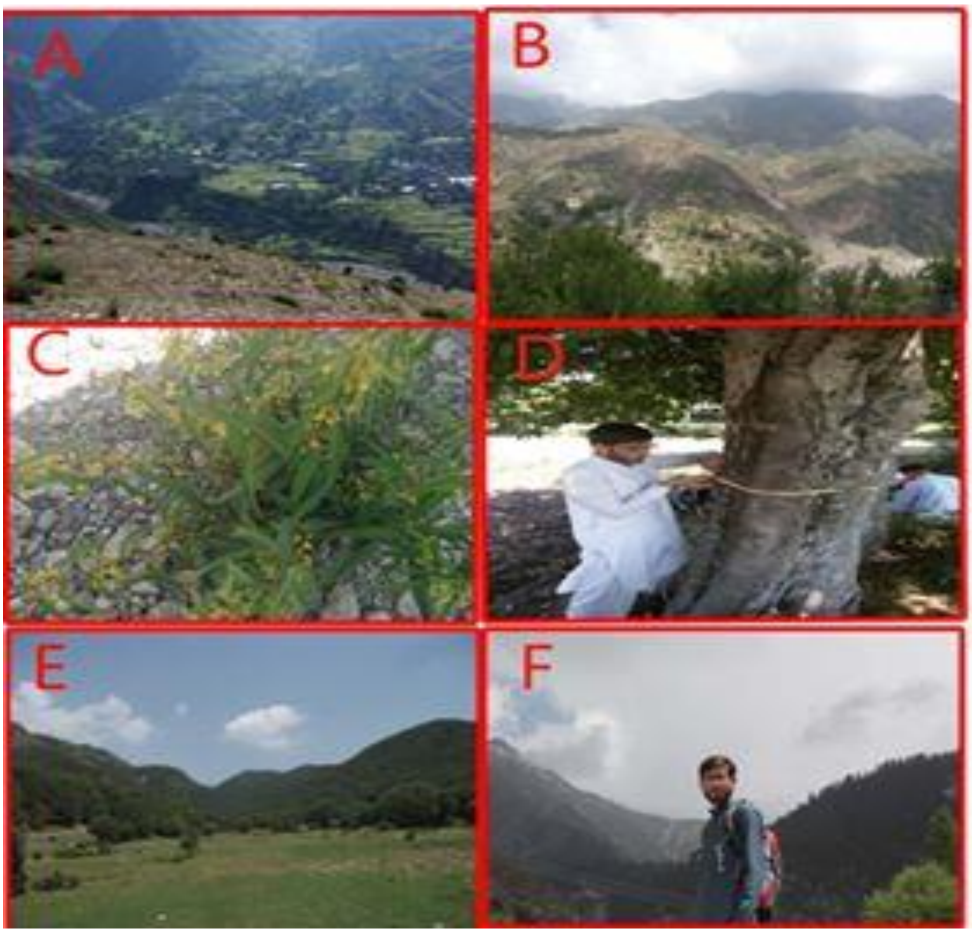


***Figure 6.*** *Pictorial view of the ecotonal region, (A) settlements with agricultural practices, (B) South facing Barren mountains range (C) Vincetoxicum cardiostephanum in flowering stage (D) measuring DBH of Crataegus songarica, (E) Quercus dilatata thick forest and pastures zone, (F) Snow covered high elevated mountains peak*

CANOCO version 4.5 was used to analyse the effect of biotic and abiotic factors on species composition, diversity and community structure (*Figs. 3, 4* and *5*). Use of these Software packages can be seen in the studies of Brown and Bezuidenhout (2005) and Khan et al. (2012b). The elevation, longitude and latitude were responsible for microclimatic variations. Dense vegetation was observed on the north facing slopes as


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compared to south facing slopes in the high elevation of the valley. The environmental gradients like elevation, soil conditions, grazing pressure and soil texture clearly indicates strong impacts on species diversity and composition of the region (*Figs. 4* and *5*; *Table 2*). Soil depth decreases with the high elevation due to steep slopes in areas where soil erodes during rainy seasons. The Organic matter concentration in the lower region (*Figs. 3*, *4* and *5*) is quite high, it was the prime factor retaining higher species diversity and thick vegetation cover, is in accordance to the Casalini (2017) and Bao-Liang et al. (2009) because it is reliable to retain greater humidity and moisture concentration in landform (Pei et al., 2010). Ecologists recommended such ecosystems to support higher biodiversity and combat with climatic challenges. CCA bi-plot also revealed that species were highly sensitive to EC, Phosphorous and sodium (*Fig. 3* and *4*). These findings are in agreements with Khan et al. (2013) and Shaukat et al. (2014). Furthermore, increasing herbaceous vegetation along the elevation gradients indicates the positively correlation with eco-physiological stresses along the increasing altitude. The physiographic elements altitudinal range variations and edaphic factors have great effect on vegetation structure and its distribution pattern (*Fig. 5*). Plant species restricted to a particular habitat due to the availability of their requirements and optimum environmental factors. These factors clearly change the community structure and their distribution from point to point. Now a-days such studies have been adopted by numerous of ecologists and environmentalists to correlate the communities with the environmental factors (Chawla et al., 2008 and Khan et al., 2015).

Amongst the anthropogenic stimuli (counting stumps) repeated fuel-wood chopping is considered the major factor having huge impacts on the structure of the vegetation and results declining and almost disappearance of large old trees (*Fig. 3* and *4*). The most preferred species for fuel wood consumptions includes; *Quercus dilatata, Q. baloot, Olea ferruginea, Morus nigra* and *M. alba*. The greater wood extraction level than the carrying capacity causes a proportional changes in structure and community composition. Moreover, harvesting scenarios also increase ecological impacts. Once they become lost, large gap will be created; so forest fragmentation will be enhanced and probably susceptibility to invasion will be promoted (Rüger et al., 2008); and will inhibit the native seedlings regeneration (Cochrane, 2003). The grazing pressure has negatively affected the species diversity and vegetation structure (*Fig. 3* and *4*), this happen because over grazing can alter soil chemistry and also make it prone for the erosion (Rooney and Waller, 1998). The heavy and uncontrolled grazing and trampling by large amount of cattle on daily by local nomads is alarming situation. For best management legislation, the regeneration patterns and the main governing factors should be addressed (Wangda, 2003). Moreover, subsequent soil erosion and harsh climate during winter season also had catastrophic affect. The dense lush green vegetation of the region are now slowly and steadily replaced by stripped steep ridges, with increasing number of houses, roads and terracing fields. Our finding suggests priorities for the biodiversity conservation via indicator species approaches. Border Area of Afghanistan is geopolitically zone of tension that makes it an Ecotonal territory with rich diversity and must be evaluated taxonomically for probable new species. Recently, ecotones have gained greater attention because also species has narrow ecological amplitude (Silva and Souza, 2018; Corenblit et al., 2011) and expected future climatic changes could affect ecotonal vegetation very strongly (Camarero et al., 2017; Gebrekirstos et al., 2014).


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## Conclusion

The species distribution, communities composition using edaphic and environmental variables contributed valuable information for understanding ecotonal vegetation. We concluded that fragile vegetation of this sensitive region is under tremendous pressure due to diverse anthropogenic activities. It enhanced understanding of phyto-diversity that could potentially lead for conservation, especially in the perspective of anthropogenic impacts. The robustic multivariate statistical tools recognized indicator for micro-climatic and micro-ecological zonation. Results could be improved further if; soil moisture contents studied along the topographical gradient. It will ultimately enhance edaphological and geomorphological role for vegetation management and conservation strategies in landscape ecology. Moreover, presence of endemic species required detail taxonomic and micro-ecological investigation.

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## APPENDIX

***Table A1.*** *Plant check of the ecotonal region, along with a detail of their families, habit and IVI%*

| S/No. | Botanical name | Family | Habit | IVI% | S/No. | Botanical name | Family | Habit | IVI% |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Adiantum capillus veneris* | Pteridaceae | Herb | 0.34 | 99 | *Morus nigra* | Moraceae | Tree | 0.52 |
| 2 | *Adiantum venustum* | Pteridaceae | Herb | 0.77 | 100 | *Myrtus communis* | Myrtaceae | Shrub | 2.38 |
| 3 | *Agrostis vinealis Schreb* | Poaceae | Herb | 2.11 | 101 | *Nasturtium officinale* | Brassicaceae | Herb | 0.16 |
| 4 | *Ailanthus altissima* | Simaroubaceae | Tree | 3.53 | 102 | *Nepeta Spp* | Lamiaceae | Herb | 0.05 |
| 5 | *Amaranthus retroflexus* | Amaranthaceae | Herb | 0.08 | 103 | *Nepeta erecta* | Lamiaceae | Herb | 0.32 |
| 6 | *Amaranthus viridis* | Amaranthaceae | Herb | 0.08 | 104 | *Nepeta laevigata* | Lamiaceae | Herb | 0.46 |
| 7 | *Androsace rotundifolia* | Primulaceae | Herb | 0.27 | 105 | *Oenothera rosea* | Onagraceae | Herb | 1.16 |
| 8 | *Anisomeles indica* | Lamiaceae | Herb | 0.21 | 106 | *Olea ferruginea* | Oleaceae | Tree | 7.60 |
| 9 | *Apluda mutica* | Poaceae | Herb | 2.56 | 107 | *Origanum vulgare* | Lamiaceae | Herb | 0.46 |
| 10 | *Arisaema flavum* | Araceae | Herb | 0.29 | 108 | *Oxalis corniculata* | Oxalidaceae | Herb | 2.71 |
| 11 | *Artemisia absinthium* | Asteraceae | Herb | 0.11 | 109 | *Parrotiopsis jacquemontiana* | Hamamelidaceae | Tree | 1.13 |
| 12 | *Arthraxon prionodes* | Poaceae | Herb | 0.10 | 110 | *Paspalum paspalodes* | Poaceae | Herb | 0.13 |
| 13 | *Avena fatua* | Poaceae | Herb | 0.40 | 111 | *Persicaria hydropiper* | Polygonaceae | Herb | 0.04 |
| 14 | *Berberis lysium* | Berberidaceae | Shrub | 7.99 | 112 | *Persicaria maculosa* | Polygonaceae | Herb | 0.82 |
| 15 | *Berberis parkeriana* | Berberidaceae | Shrub | 7.39 | 113 | *Phagnalon niveum* | Asteraceae | Herb | 0.22 |
| 16 | *Bidens bipinnata* | Asteraceae | Herb | 0.09 | 114 | *Phlomis stewartii* | Lamiaceae | Herb | 1.66 |
| 17 | *Bidens cernua* | Asteraceae | Herb | 0.23 | 115 | *Pinus brutia* | Pinaceae | Tree | 1.37 |
| 18 | *Bidens tripartite* | Asteraceae | Herb | 0.20 | 116 | *Piptatherum laterale* | Poaceae | Herb | 2.69 |
| 19 | *Bistorta amplexicaulis* | Polygonaceae | Herb | 0.43 | 117 | *Plantago lanceolata* | Plantaginaceae | Herb | 2.12 |
| 20 | *Bothriochloa bladhii* | Poaceae | Herb | 1.66 | 118 | *Plantago major* | Plantaginaceae | Herb | 0.15 |
| 21 | *Bromus japonicas* | Poaceae | Herb | 0.38 | 119 | *Platanus orientalis* | Platanaceae | Tree | 1.30 |


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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 22 | *Buddleja crispa* | Buddlejaceae | Shrub | 0.16 | 120 | *Plectranthus rugosus* | Lamiaceae | Shrub | 14.81 |
| 23 | *Bupleurum falcatum* | Apiaceae | Herb | 1.93 | 121 | *Polygala abyssinica* | Polygalaceae | Herb | 0.27 |
| 24 | *Bupleurum linearifolium* | Apiaceae | Herb | 0.10 | 122 | *Polygonum aviculare* | Polygonaceae | Herb | 0.44 |
| 25 | *Calamintha umbrosa* | Lamiaceae | Herb | 0.45 | 123 | *Polygonum plebejum* | Polygonaceae | Herb | 0.24 |
| 26 | *Calanthe tricarinata* | Orchidaceae | Herb | 0.05 | 124 | *Polypogon fugax* | Poaceae | Herb | 0.08 |
| 27 | *Campanula pallida* | Campanulaceae | Herb | 0.36 | 125 | *Popolus nigra* | Salicaceae | Tree | 6.08 |
| 28 | *Cannabis sativa* | Cannabaceae | Herb | 1.38 | 126 | *Populus alba* | Salicaceae | Tree | 0.19 |
| 29 | *Cedrus deodara* | Pinaceae | Tree | 6.37 | 127 | *Potentilla anserina* | Rosaceae | Herb | 0.55 |
| 30 | *Celtis caucasica* | Ulmaceae | Tree | 3.63 | 128 | *Potentilla supina* | Rosaceae | Herb | 0.79 |
| 31 | *Centaurea calcitrapa* | Asteraceae | Herb | 0.08 | 129 | *Prunella vulgaris* | Lamiaceae | Herb | 0.29 |
| 32 | *Centaurea iberica* | Asteraceae | Herb | 0.20 | 130 | *Prunus armeniaca* | Rosaceae | Tree | 0.67 |
| 33 | *Chenopodium album* | Chenopodiaceae | Herb | 0.11 | 131 | *Prunus eburnea* | Rosaceae | Tree | 2.51 |
| 34 | *Cichorium intybus* | Asteraceae | Herb | 0.29 | 132 | *Punica grantum* | Lythraceae | Tree | 5.04 |
| 35 | *Cirsium arvense* | Asteraceae | Herb | 3.91 | 133 | *Pyrus pashia* | Rosaceae | Tree | 0.10 |
| 36 | *Cirsium vulgare* | Asteraceae | Herb | 0.24 | 134 | *Quercus baloot* | Fagaceae | Tree | 8.63 |
| 37 | *Clematis grata* | Ranunculaceae | Herb | 0.41 | 135 | *Quercus dilatata* | Fagaceae | Tree | 17.11 |
| 38 | *Clematis graveolens* | Ranunculaceae | Herb | 0.44 | 136 | *Quercus semecarpifolia* | Fagaceae | Tree | 0.80 |
| 39 | *Clematis orientalis* | Ranunculaceae | Herb | 0.32 | 137 | *Ranunculus arvensis* | Ranunculaceae | Herb | 0.55 |
| 40 | *Clinopodium umbrosum* | Lamiaceae | Herb | 0.58 | 138 | *Ranunculus laetus* | Ranunculaceae | Herb | 0.16 |
| 41 | *Convolvulus arvensis* | Convolvulaceae | Herb | 0.67 | 139 | *Ranunculus repens* | Ranunculaceae | Herb | 0.60 |
| 42 | *Cotoneaster bacillaris* | Rosaceae | Tree | 0.33 | 140 | *Raphanus raphanistrum* | Brassicaceae | Herb | 0.13 |
| 43 | *Cotoneaster nummularia* | Rosaceae | Tree | 3.79 | 141 | *Robinia pseudoacacia* | Fagaceae | Tree | 11.01 |
| 44 | *Crataegus songarica* | Rosaceae | Tree | 0.67 | 142 | *Rorippa islandica* | Brassicaceae | Herb | 0.03 |
| 45 | *Cymbopogon jwarancusa* | Poaceae | Herb | 0.42 | 143 | *Rosa chinensis* | Rosaceae | Shrub | 3.70 |
| 46 | *Cynodon dactylon* | Poaceae | Herb | 7.73 | 144 | *Rosa moschata* | Rosaceae | Shrub | 1.17 |
| 47 | *Cynoglossum lanceolatum* | Boraginaceae | Herb | 0.09 | 145 | *Rosa webbiana* | Rosaceae | Shrub | 0.30 |
| 48 | *Cyperus rotundus* | Cyperaceae | Herb | 0.22 | 146 | *Rosa X alba* | Rosaceae | Shrub | 0.18 |
| 49 | *Daphne mucronata* | Thymelaeaceae | Shrub | 8.58 | 147 | *Rubia cordifolia* | Rubiaceae | Herb | 0.98 |
| 50 | *Datura stramonium* | Solanaceae | Herb | 0.05 | 148 | *Rubus fruticosus* | Rosaceae | Shrub | 4.31 |
| 51 | *Debregeasia salicifolia* | Urticaceae | Shrub | 0.16 | 149 | *Rumex acetosa* | Polygonaceae | Herb | 0.05 |
| 52 | *Dichanthium annulatum* | Poaceae | Herb | 0.45 | 150 | *Rumex dentatus* | Polygonaceae | Herb | 0.67 |
| 53 | *Digitaria nodosa* | Poaceae | Herb | 0.07 | 151 | *Rumex nepalensis* | Polygonaceae | Herb | 0.06 |
| 54 | *Diospyros lotus* | Ebenaceae | Tree | 2.14 | 152 | *Saccharum griffithii* | Poaceae | Herb | 0.07 |
| 55 | *Duchesnea indica* | Rosaceae | Herb | 0.78 | 153 | *Saccharum spontaneum* | Poaceae | Herb | 1.17 |
| 56 | *Elaegnes aungustifola* | Elaeagnaceae | Tree | 3.18 | 154 | *Salix alba* | Salicaceae | Tree | 3.48 |
| 57 | *Elymus nutans* | Poaceae | Herb | 0.09 | 155 | *Salix babylonica* | Salicaceae | Tree | 0.87 |
| 58 | *Ephedra procera* | Ephedraceae | Shrub | 3.40 | 156 | *Sambucus nigra* | Sambucaceae | Shrub | 7.90 |
| 59 | *Epilobium hirsutum* | Onagraceae | Herb | 0.04 | 157 | *Sanguisorba minor* | Rosaceae | Herb | 0.79 |
| 60 | *Equisetum debile* | Equisetaceae | Herb | 0.18 | 158 | *Sauromatum venosum* | Araceae | Herb | 0.16 |
| 61 | *Eragrostis pilosa* | Poaceae | Herb | 0.08 | 159 | *Saussuria heteromalla* | Asteraceae | Herb | 2.41 |
| 62 | *Eragrostis tenella* | Poaceae | Herb | 0.05 | 160 | *Scrophularia striata* | Scrophulariaceae | Herb | 0.44 |
| 63 | *Erigeron bonariensis* | Asteraceae | Herb | 0.21 | 161 | *Scutellaria linearis* | Lamiaceae | Herb | 0.77 |
| 64 | *Erigeron canadensis* | Asteraceae | Herb | 0.98 | 162 | *Seriphidium kurramense* | Asteraceae | Herb | 0.49 |
| 65 | *Eryngium billardieri* | Apiaceae | Herb | 0.14 | 163 | *Setaria pumila* | Poaceae | Herb | 3.26 |
| 66 | *Eryngium coeruleum* | Apiaceae | Herb | 0.11 | 164 | *Solanum americanum* | Solanaceae | Herb | 0.12 |
| 67 | *Euphorbia helioscopia* | Euphorbiaceae | Herb | 0.17 | 165 | *Solanum nigrum* | Solanaceae | Herb | 0.06 |
| 68 | *Festuca gigantea* | Poaceae | Herb | 0.38 | 166 | *Solanum nigrum var. villosum* | Solanaceae | Herb | 0.05 |
| 69 | *Ficus palmata* | Moraceae | Tree | 0.47 | 167 | *Sonchus asper* | Asteraceae | Herb | 0.14 |
| 70 | *Foeniculum vulgare* | Apiaceae | Herb | 0.09 | 168 | *Sonchus oleraceus* | Asteraceae | Herb | 0.29 |
| 71 | *Fragaria nubicola* | Rosaceae | Herb | 0.07 | 169 | *Sophora mollis* | Papilionaceae | Shrub | 12.17 |
| 72 | *Galinsoga parviflora* | Asteraceae | Herb | 0.29 | 170 | *Stellaria media* | Caryophyllaceae | Herb | 0.22 |
| 73 | *Hedera nepalensis* | Araliaceae | Shrub | 0.39 | 171 | *Stipa sibirica* | Poaceae | Herb | 3.72 |
| 74 | *Impatiens edgeworthii* | Balsaminaceae | Herb | 1.50 | 172 | *Strobilanthes urticifolia* | Acanthaceae | Herb | 0.29 |
| 75 | *Impatiens lemannii* | Balsaminaceae | Herb | 0.20 | 173 | *Swertia cordata* | Gentianaceae | Herb | 0.92 |


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|---|---|---|---|---|---|---|---|---|---|
| 76 | *Indigofera heterantha* | Papilionaceae | Shrub | 19.04 | 174 | *Tagetes minuta* | Asteraceae | Herb | 0.77 |
| 77 | *Ipomoea purpurea* | Convolvulaceae | Herb | 1.03 | 175 | *Taraxacum officinale* | Asteraceae | Herb | 0.70 |
| 78 | *Jasminum auriculatum* | Oleaceae | Shrub | 0.24 | 176 | *Themeda anathera* | Poaceae | Herb | 0.15 |
| 79 | *Jasminum officinale* | Oleaceae | Shrub | 0.62 | 177 | *Thuja orientalis* | Cupressaceae | Shrub | 0.59 |
| 80 | *Juglans regia* | Juglandaceae | Tree | 2.73 | 178 | *Thymus linearis* | Lamiaceae | Herb | 5.03 |
| 81 | *Juniperus excelsa* | Cupressaceae | Tree | 0.97 | 179 | *Torilis leptophylla* | Apiaceae | Herb | 1.07 |
| 82 | *Leontopodium brachyactis* | Asteraceae | Herb | 0.08 | 180 | *Tragopogon gracilis* | Asteraceae | Herb | 0.03 |
| 83 | *Lepidium pinnatifidum* | Brassicaceae | Herb | 0.38 | 181 | *Trifolium alexandrianum* | Papilionaceae | Herb | 0.19 |
| 84 | *Lespedeza juncea* | Papilionaceae | Herb | 1.44 | 182 | *Trifolium repens* | Papilionaceae | Herb | 0.76 |
| 85 | *Liriope graminifolia* | Haemodoraceae | Herb | 0.10 | 183 | *Urtica dioica* | Urticaceae | Herb | 0.07 |
| 86 | *Lotus corniculatus* | Papilionaceae | Herb | 0.96 | 184 | *Verbena officinalis* | Verbenaceae | Herb | 0.15 |
| 87 | *Malus domestica* | Rosaceae | Tree | 0.21 | 185 | *Verbena Linn.,* | Verbenaceae | Herb | 0.05 |
| 88 | *Malva neglecta* | Malvaceae | Herb | 0.36 | 186 | Vincetoxicum cardiostephanum | Apocynaceae | Herb | 0.78 |
| 89 | *Marrubium vulgare* | Lamiaceae | Herb | 0.05 | 187 | *Viola canescens* | Violaceae | Herb | 0.70 |
| 90 | *Matricaria recutita* | Asteraceae | Herb | 0.54 | 188 | *Viola odorata* | Violaceae | Herb | 2.44 |
| 91 | *Medicago lupulina* | Papilionaceae | Herb | 0.50 | 189 | *Viola pilosa* | Violaceae | Herb | 0.71 |
| 92 | *Medicago sativa* | Papilionaceae | Herb | 6.16 | 190 | *Viola reichenbachiana* | Violaceae | Herb | 0.14 |
| 93 | *Mentha arvensis* | Lamiaceae | Herb | 0.13 | 191 | *Viola spp.* | Violaceae | Herb | 0.09 |
| 94 | *Mentha longifolia* | Lamiaceae | Herb | 1.52 | 192 | *Wikstroemia canescens* | Thymelaeaceae | Shrub | 4.51 |
| 95 | *Mentha royleana* | Lamiaceae | Herb | 0.54 | 193 | *Wulfeniopsis amherstiana* | Plantaginaceae | Herb | 0.13 |
| 96 | *Micromeria biflora* | Lamiaceae | Herb | 0.09 | 194 | *Xanthium spinosum* | Asteraceae | Herb | 1.91 |
| 97 | *Monotheca buxifolia* | Sapotaceae | Tree | 2.56 | 195 | *Xanthium strumarium* | Asteraceae | Herb | 0.40 |
| 98 | *Morus alba* | Moraceae | Tree | 1.03 | | | | | |


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