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# Land use and land cover modification and its impact on biodiversity and the ecosystem services in District Kurram, Pakistan

[Uso del suelo y modificación de la cobertura terrestre y su impacto en la biodiversidad y los servicios de los ecosistemas en el distrito de Kurram, Pakistán]

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**Abstract:** Modifications of land use and vegetation cover are proceeding faster than ever before in human history, with a considerable reduction in forest cover in biodiversity hotspots. We investigated the land use and vegetation cover changes, their impact on biodiversity in the Kurram District, Pakistan, for 27 years (1989 to 2015). Temporal satellite imagery was processed using a supervised maximum likelihood classification algorithm in ARCGIS 10.1 to elucidate information regarding land use/land cover changes, with conducted structured interviews to obtain the inhabitants' perspectives on their dependence on ecosystems in Kurram, and how their environment is changing. We found that the land under forest cover and rangeland showed a remarkable decrease over the study period. This decline in rangeland and forest cover was a result of the increased of farmland, barren land. The study area is part of a biodiversity, with important medicinal, rare and unique plant species.

**Keywords:** Land use/land cover; Resources exploitation; GIS; Kurram District; Pakistan.

**Resumen:** Las modificaciones del uso de la tierra y la cobertura vegetal están avanzando más rápido que nunca en la historia de la humanidad, con una reducción considerable de la cobertura forestal en los puntos críticos de biodiversidad. Investigamos el uso de la tierra y los cambios en la cobertura vegetal, su impacto en la biodiversidad en el distrito de Kurram, Pakistán, durante 27 años (1989 a 2015). Las imágenes satelitales temporales se procesaron utilizando un algoritmo de clasificación de máxima verosimilitud supervisada en ARCGIS 10.1 para dilucidar información sobre los cambios en el uso del suelo / cobertura del suelo, con entrevistas estructuradas realizadas para obtener las perspectivas de los habitantes sobre su dependencia de los ecosistemas en Kurram y cómo está cambiando su entorno. Descubrimos que la tierra cubierta por bosques y pastizales mostró una disminución notable durante el período de estudio. Esta disminución en los pastizales y la cubierta forestal fue el resultado del aumento de las tierras de cultivo, tierras estériles. El área de estudio es parte de una biodiversidad, con importantes especies de plantas medicinales, raras y únicas.

**Palabras clave:** Uso de la tierra/cobertura de la tierra; Explotación de recursos; GIS; Distrito de Kurram; Pakistán.

## INTRODUCTION

Wherever humans form settlements, they exploit natural resources that help meet their basic needs and change the environment to enhance their living standards (Goldewijk & Ramankutty, 2004; Ramankutty *et al*., 2008). The pace and extent of human-induced alteration in the physical landscape vary with time and space. Rapid growth in population, technological advancement, and overexploitation of natural resources are some of the major driving forces affecting land use and land cover (Serra *et al*., 2008; Abuelaish & Olmedo, 2016). Currently, nearly four percent of the planet is urban land (Yar & Huafu, 2019). The expansion of cities has altered natural landscapes, resulting in various environmental and social issues. These results are expressed in a reduction of natural habitats and native biodiversity (Grimm *et al*., 2008), overexploitation of resources, deterioration of hydrological systems and water (Walsh, 2000; Booth *et al.,* 2004) and air quality (Song *et al*., 2015), variations within the local and geographical environment (Voogt & Oke, 2003; Sánchez-Rodríguez *et al*., 2005; Wilby & Perry, 2006).

Land use and land cover have a significant impact on the functioning of the biophysical set up across the planet (Baskent & Kadiogullari, 2007; Dewan & Yamaguchi, 2009). Urbanization affects biodiversity directly through corporeal progression on land, land use, and human activities within urban areas. Substantive progression changes the topography and can reduce the diversity of native species and modify the habitat conditions needed for their survival. The concerns for biodiversity and ecosystem services depend on different parameters such as taxonomic implications, the spatial analysis scale, and the growth of municipal areas (McKinney, 2008; Tng *et al*., 2012; Ali *et al*., 2021). Studies that endeavour to categorize the impacts of this contemporary and expected urbanization on ecosystem and biodiversity are therefore important for exploring, researching, and testing trends. Additionally, since the health of an ecosystem depends on plant biodiversity, vegetation classification is a prerequisite for ecosystem management and biodiversity conservation.

Pakistan harbors over 6000 species of higher plants (Shinwari, 2010 Jamshed *et al*., 2018). Pakistan's flora is classified into thirteen natural floristic regions, and over 10% of the flora is vulnerable (Kitamura, 1996; Ahmad & Pieroni, 2016). According to Takhtajan (1969) and Good (1947, 1974) Pakistan can be divided into three phytogeographic zones, namely the Saharo-Sindian, Irano-Turranian, and Indian regions. In contrast, Kitamura (1960), Hara (1966), Zohary (1973), and Ali & Qaiser (1986) considered the westernmost region as the Sino-Japanese region of Pakistan (Sarwar & Qaiser, 2012), while Mediterranean and European Siberia regions were recognized by Shinwari (2010). All these areas are home to diverse ecosystems. Additionally, about two-thirds of Pakistan's area is highlands, and the sharp changes in elevation and physiography play substantial roles in plant distribution and regional diversity (Khan & Khatoon, 2008). Preservation of these areas is an essential component of environment change mitigation policies, and this is important to determine vegetation structure (Yalcin *et al*., 2011; Khan *et al.*, 2016; Soelberg & Jager, 2016). Currently, a total of 709 higher plant varieties are considered threatened in Pakistan (Khan *et al*., 2020; Waseem *et al*., 2020) and this local biodiversity is facing tremendous pressure due to urbanization, deforestation, and unsustainable natural assets exploitation (Chaudhary *et al.,* 2017). The loss of biodiversity and species extinction is often irreversible and a severe consequence of anthropogenic changes. Therefore, preserving biodiversity is of paramount importance, and the global recognition of the value of biodiversity and its alarming loss has resulted in the Convention on Biological Diversity (Lashari *et al*., 2020). Pressures on natural vegetation are increasing within space and time. It is recognized that species might play a key role in ecosystems functioning and this perception has led to a fast-growing interest in biodiversity preservation. Additionally, it has driven ecologists to openly debate the relationship between diversity and ecosystem function since the 1980s, leding to the conclusion that anthropogenic effects are causing biodiversity loss (Khan *et al*., 2020).

Actual species extinction is mainly due to human activity, namely land use (conversion of land for settlement, agriculture land expansion, forestry) and degradation, habitat destruction, and fragmentation (climate change and biological invasions). The increases in human population and other associated causes are the major reasons for species decline and extinction (Chowdhury *et al*., 2020).

In the past four decades, geospatial techniques have enabled land-use planners and researchers to better map, assess and monitor land use and land cover alteration (Jensen, 1981; Price *et*

*al*., 1997; Midekisa *et al*., 2017). These contemporary technologies also play a significant role in predicting and examining the changes occurring in land use and land cover (Ahmed *et al*., 2015). One of the primary reasons behind using remotely sensed data is that it has made it feasible to investigate the alterations in land use and land cover changes in comparatively little time, at low cost, and with increased precision (Singh *et al*., 2014). To achieve sustainable land use planning, land managers rely on multi-temporal and multi-sensorial data to monitor ongoing land-use changes (Kumar & Sangwan, 2013).

The nature and the flora of the study area provide essential ecosystem assistance with particular reference to indigenous people's medicinal uses. Ecosystems provide vital support services for human society, such as water and climate regulation, air purification, waste decomposition, soil fertility and regeneration, and the continuation of biodiversity. The complex linkages among the biotic and abiotic components of an ecosystem directly link to human survival. Ecosystem services includes food, pasture, livestock feed, fuelwood, wood and medical products. These eventually promoted industrial, socio-economic and agricultural activities (Zobel *et al*., 2006). Overexploitation of vegetation puts the plant biodiversity in danger. In order to design appropriate systems for the sustainable use of plant resources, it is important to comprehend how traditional plant use affect biodiversity. Our research evaluated the natural vegetation of the Kurram Valley and the valley's vegetation's ecosystem services. The overall purpose was to determine the risk of overuse and loss of plant species.

The current study focused mainly on land-use changes in Khyber Pakhtunkhwa province in northern Pakistan and its social and biological ramifications. The main objectives of the present study were to (a) investigate the spatiotemporal land use and land cover changes over the last three decades and (b) explore the perceptions of inhabitants in the region on how these changes are affecting their way of life.

## MATERIALS AND METHODS

### *Study Area*

Kurram is a recently established tribal area in the province of Khyber Pakhtunkhwa, Pakistan. It is located in a valley with the same name in the northwestern part of the country and is located at 33°20′ to 34°10′ N and 69°50′ to 70°50′ E (Muhammad *et al*., 2019; Ali *et al*., 2020). The Kurram Valley is approximately 115 km long and encompasses about 3380 km$^2$ (Gilani *et al*., 2003; Hussain *et al*., 2018). Afghanistan borders the area in the north, south, and west, North Waziristan in the southeast, Khyber and Orakzai agencies in the northeast, and Hangu District in the east (Figure No. 1).

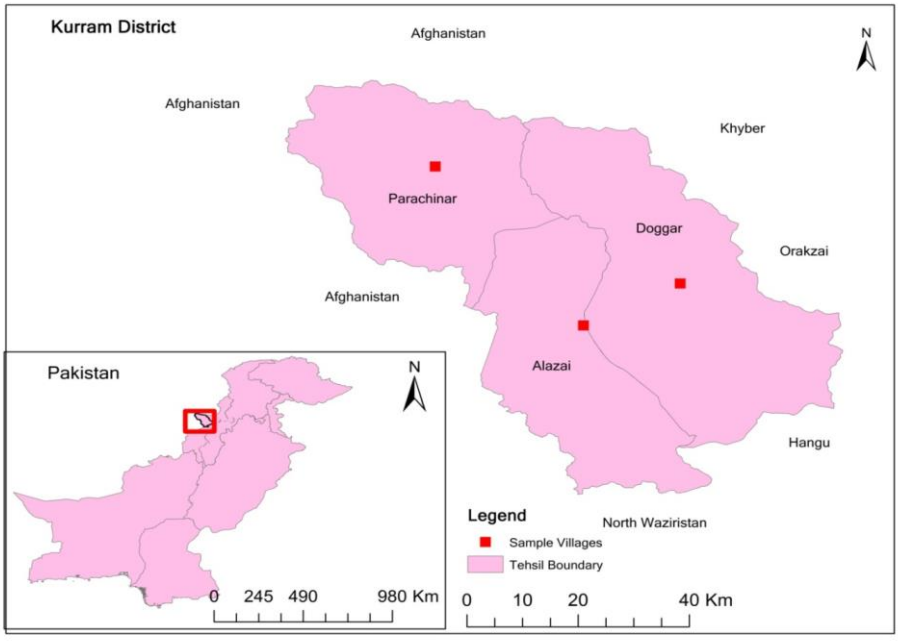


**Figure No. 1**
**Location of the Sample villages and study area**

Physiologically, the vegetation and forests on the slopes Koh-e-Safaid are Sino-Japanese (Hussain *et al*., 2019a). The Kuram River drains the southern part of the Koh-e-Safaid Mountains and enters the Indus Plain north of the Bannu District. The flora of Kurram is diverse consisting of more than 1,100 known higher plants (Aitchison, 1881). The main forest types in Kurram are arid tropical forests and subalpine shrubs (Hussain *et al*., 2013). The main forest types are subtropical dry forests and subalpine shrubs. The dry subtropical zone was found in the southern sector of the study area, and two other types were found in the northern part of the study region. The climate of the Kurram Valley climate varies in the different localities depending on the altitude, from extreme heat to severe cold. In summer, the mean minimum and maximum temperatures range from17-31ºC, with June being the hottest month. In winter, the mean minimum temperature often drops below 0ºC, with frequent snowfalls starting from December and persisting till March. The region experiences dry autumns and winters, and most of the precipitation occurs during the spring and summer seasons, with an average annual rainfall of 848 mm (GOP, 2014).

The valley is heavily populated – from some 448310 in 1989, the population of Kurram rose to 619553 in 2017 (Khattak *et al.*, 2000; Hussain, 2016; Khan *et al*., 2017). The majority of the human population in Kurram belongs to the Pashtun ethnic group and Islam is the main religion (Shia and Sunni). Other indigenous tribes such as the Turi, Bangash, Orakzai, Mangal, Mamozai, Zazai, Ghilzai, Muqbil, Hazara, and Khoshi tribes also live in the region (Ali *et al*. 2019; Hussain *et al*., 2018). Besides local inhabitants, many people who migrated to the region during the Russian and Afghan war (1979-1988) have placed severe pressure on vegetation and land.

Agriculture is the major economic activity in Kurram, and the main crops include beans, peanuts, coarse rice, and tomatoes. However, in the past few decades, agricultural intensification has also led to variations in land use and vegetation cover.

***Remote sensing***

We used remotely sensed data and GIS technologies to examine land use and land cover alteration over the previous three decades (1989-2015). Landsat satellite imageries for the years 1989 and 2015 were downloaded from the United States Geological Survey (USGS) website (USGS, 2019). All the images were validated for geometric accuracy, and all data were projected on WGS 1984, UTM zone 45N, orthorectified, and stitched to create separate 1989 and 2015 orthomosaics for comparison. The remotely sensed data enabled us to calculate the alterations in land use and land cover during the study period. We sampled, stacked, subset, and analyzed spectral bands from 1 to 7 in ArcMap (Mahboob *et al*., 2015). We used a supervised classification method to extort information from Landsat images regarding land use and land cover classes. Supervised classification was more efficient in dealing with the remotely sensed data compared to the unsupervised classification technique. Around 170 training samples were created for every land use type, such as forest, agricultural land, rangeland, barren land, water bodies, and snow cover. The areas under various types of land use and vegetation cover classes were then calculated.

The quantitative and qualitative accuracy assessments of the thematic classification maps in 1989 and 2015 were carried out. The qualitative accuracy evaluation was performed by comparing the visual interpretation techniques with the open-source Google Earth, and the quantitative accuracy evaluation was performed by the standard error matrix (Congalton, 2019). We were using a stratified random sampling technique to collect about 240 reference points for accuracy assessment. We calculated the overall accuracy of the thematic maps in 1989 and 2015, the Kappa coefficient, and users and producers' accuracy. The generated map achieves an overall accuracy of 91%, which is higher than the minimum accuracy of 85% recommended by Anderson *et al*. (1976). The Kappa coefficients were 0.866 (Table No. 1). To graphically represent land use and vegetation cover changes, we generated land use and vegetation cover maps in 1989 and 2015.

***Participatory approach and tools***

An organized approach was made for participatory rural assessment tools, e.g., specific group discussions, resource mapping, transect walks, structured questionnaires to investigate the dependence of people on ecosystems and ecosystem services in the Kurram district in Pakistan. The collected qualitative data were used for comparison with land satellite maps.

***Household survey***

The main purpose of the household survey was to identify and record the inhabitants' views on how the land-use changes affect them among the selected region of the valleys. We conducted interviews on

150 households in the Upper, Lower, and Central Kurram areas. The 150 households were randomly selected from a list of 450 families in three study sites (n=50 households per area), as shown in Table No. 2. Interviewees ranged from 21-75 years old and comprised of 270 men and 40 women. All interviews were only conducted after obtaining oral prior informed consent.

**Table No. 1**
**Accuracy-Assessment Results for the 2015 Land use and Land Cover Modification change map**

| | Class | Agriculture | Rangeland | Barren | Forest Cover | Snow Cover | Water Bodies | Row Total | User Accuracy (%) | Producer's accuracy (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Classified map** | Agriculture | 15 | 8 | 0 | 0 | 0 | 0 | 23 | 81 | 61.5 |
| | Rangeland | 10 | 115 | 2 | 0 | 0 | 0 | 128 | 92.3 | 98.4 |
| | Barren | 0 | 0 | 36 | 0 | 0 | 0 | 36 | 85.5 | 94.1 |
| | Forest Cover | 0 | 0 | 0 | 12 | 0 | 0 | 12 | 90 | 90 |
| | Snow Cover | 0 | 0 | 0 | 0 | 10 | 0 | 10 | 100 | 100 |
| | Water bodies | 0 | 0 | 0 | 0 | 0 | 13 | 13 | 100 | 100 |
| | Column Total | 25 | 123 | 38 | 12 | 10 | 13 | 222 | | |

**Overall accuracy = 91.88%, Kappa coefficient = 0.867**

Interviews were based on a structured survey aimed at collecting information on the interviewees' perceptions regarding their dependency on different ecosystems for ecosystem services and their perspective on how the effects of land use and vegetation cover modification on these ecosystem services. Following the early methodology Bernard (2002) and (Berlin & Berlin, 2005) with minor changes, detailed structured and semi-structured interviews and group discussions was performed with specific questions were asked to document the effect of land use vegetations with local flora and fauna. Our interviews, therefore, focused on the interviewee's (i) reliance of the local inhabitants on ecosystem services for the source of revenue, (ii) perception on state of land use and land cover modification, and (iii) long term changes over the flow of goods and services derived from the forest, agricultural land, rangeland, barren land, water bodies, and snow cover. The average time per interview was 35-40 minutes. We then used the data from these interviews to provide a sociological context for the observed land use and vegetation cover change analysis for 1989-2015.

***Assessment of species at risk from land-use changes***

We conducted a literature survey and data were collected during the spring and autumn to cover the whole aspect of the flora and fauna for determine the region's biodiversity values and compile a list of plants (Supplementary Table No. 1) and vertebrate animals (Supplementary Table No. 2) occurring in the Kurram district. We classified plants and animals in the region into their IUCN conservation status of rare, vulnerable, endangered, and critically endangered.

## RESULTS AND DISCUSSION

Our results suggest that there are vital variations in land use and land cover in the District Kurram, with most of these changes occurring over the last three decades (1989-2015). The land use transformation that took place during the study period is shown in Figure No. 2. Our preliminary investigation showed that the research area had seen remarkable modifications in the significant land use and land cover categories. Two distinct trends were observed in the four mainland cover classes. The area under farmland and barren land recorded some increase while on the other side a noticeable declining trend was seen in both rangeland and forest cover (Hussain *et al*., 2018). The spatiotemporal map unveiled that most of the land once covered by rangeland and forest has by now been transformed into land

producing food or degraded to the barren land. Besides, some minor changes have also occurred in snow cover and water bodies over the research period.

**Table No. 2**
**Land-use change in the Kurram District, Pakistan between1989-2015**

| Land use | 1989 | | 2015 | | Change1989-2015 | |
|---|---|---|---|---|---|---|
| | Area (ha) | Percent Share | Area (ha) | Share (%) | Change in Area (ha) | Percent Change (%) |
| Agriculture | 51,700 | 15.2 | 60,880 | 18 | + 9,180 | +15 |
| Rangeland | 143,100 | 42.3 | 130.400 | 38.5 | -12,700 | -8.8 |
| Forest Land | 71,040 | 21 | 5,6390 | 16.6 | -14,650 | -20.6 |
| Barren Land | 63,110 | 18.6 | 7,6770 | 22.7 | +13,660 | +17.8 |
| Snow Cover | 2,940 | 0.8 | 7,510 | 2.2 | +4,570 | +60.9 |
| Water Bodies | 6,210 | 1.8 | 6.150 | 1.8 | -60 | - |
| Total | 338,100 | 100 | 338,100 | 100 | | |

***Status of the Land Use/ Land Cover***

The current study used a post-classification detection approach. The metric change technique used by Weng (2001) was employed to assess the amount of land under various classes, including water bodies, agricultural land, forest, snow cover, rangeland, and barren land during the period 1989 - 2015, and to determine both the positive and negative changes in each class. Since the Neolithic settlements about 7000-9000 years ago, land use has changed profoundly. The first land-use types were grazing forests and alternative feeding areas involving farmland and pasture. The variety of land-use categories resulted in a tremendous increase and a significant degree of biodiversity in habitats and species until the 19th century. These habitats were either transformed into a more intensive agricultural system or reforested or abandoned. The analysis showed that in 1989, about 42% of the area was under rangeland, followed by forest that accounted for about 21%, while over 18% were barren land, 15% land producing food, 1.8% and 0.8% water bodies and snow cover respectively. Nearly three decades later, in 2015, the percentage of rangeland had dwindled to 38%, land under forest cover had decreased to some 17%, barren land had jumped to over 22%, farmland to 18%, and snow cover reached 2.2% beside this. The changes recorded for water bodies were negligible (Table No. 2; Figure No. 2). Two main reasons, i.e., increasing food production and timber and fuelwood production, were the main culprits for land use and land cover changes in Kurram District. Most of the rangeland and forest area has been transformed into agricultural land to amplify food production (Hussain *et al.*, 2018). Supplying timber and fuelwood to the local market has led to deforestation on a massive scale.

***Spatiotemporal analysis of land use and land cover***

The land use and land cover data revealed that the study area had recorded both positive and negative alterations over the last three decades (Table No. 2; Figure No. 2).

***Agricultural land***

Agricultural land recorded an increase of 15%, from 51700 ha in 1989 to appropriately 61000 ha in 2015. This gradual increase in farmland occurred at the cost of the forest, rangeland, and barren land. As natural habitats are converted to agricultural land, native species sensitive to specific environmental conditions become reduced. The plant species indicating habitat degradation due to agriculture land expansion include *Pertya aitchisonii, Schinus molle, Dodonaea viscosa, Punica granatum, Sageretia thea* and *Solanum elaeagnifolium.*

***Forest land***

Due to rapid population growth, the demand for natural resources has increased dramatically, which leads to unsustainable use of forest and ultimately the reduction in the amount of area under forest cover. By comparing the land use and land cover data of the last three decades, an evident decline was seen in forest cover. The land under forest decreased to 56,000 ha in 2015 from over 71,000 ha in 1989. The recorded decrease in forest cover was around 21% in the study period. The plant species under stress for

the various socio-economic condition include *Quercus baloot, Quercus incana, Populus afghanica, Pinus gerardiana, Pinus wallichiana, Nannorrhops ritchieana, Olea europaea, Quercus semecarpifolia, Cedrus deodara, Abies pindrow.*

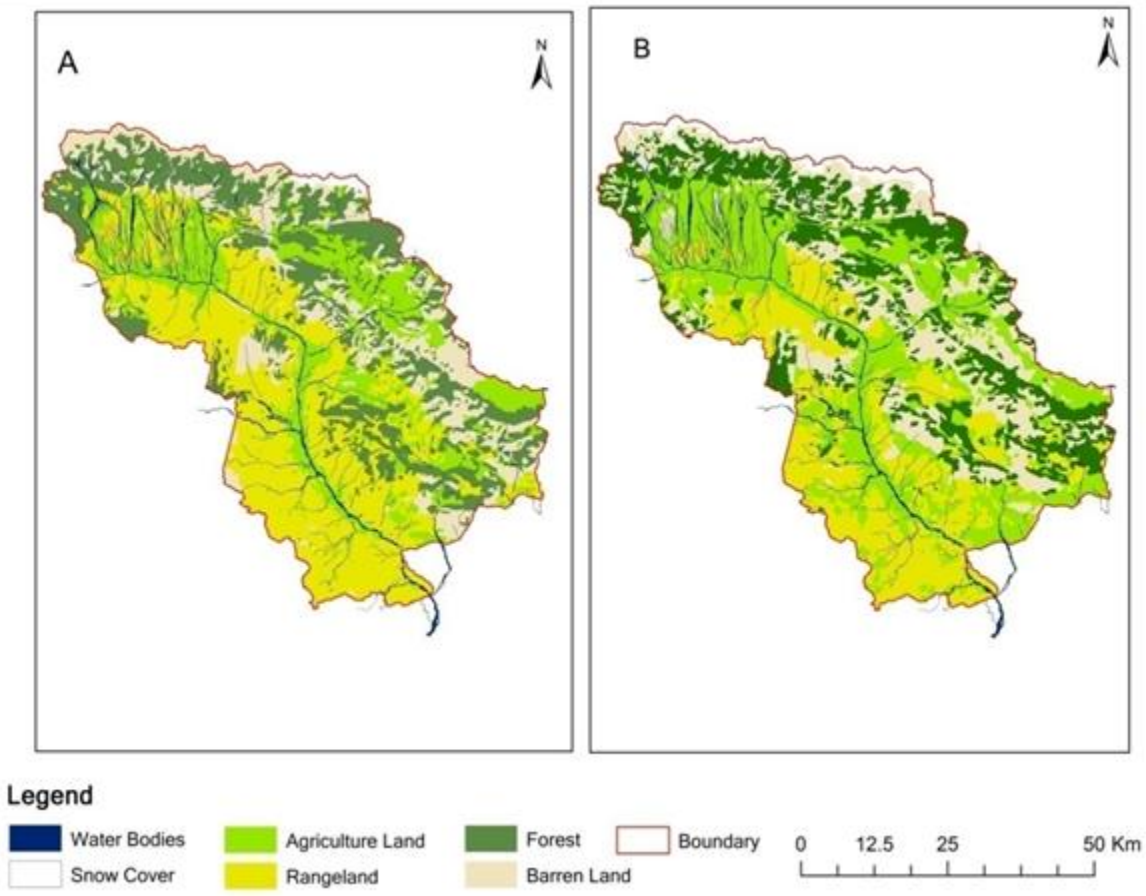


**Figure No. 2**
**Spatiotemporal Land Use and Land Cover Changes between 1989 and 2015 in the Kurram district, Pakistan, (a) Land use/ Land Cover 1989, (b) Land use/ Land Cover 2015.**

***Rangeland***

A century of biogeographic theory development has indorsed the tight linking between biodiversity and its surrounding habitat. During the study period, around 9% of decrease was also registered in rangeland, as it has lowered down to approximately 13,500 in 2015 from 143,100 in 1989. A growth of over 4,500 ha was seen in the snow cover area. The range of land use for grazing disturbs both animal habitat and valuable plant species. The rare plant species include *Arthraxon lancifolius, Puccinellia tenuiflora, Saccharum spontaneum, Poa aitchisonii* and *Podophyllum emodi.* Besides, over 20% of growth was also seen in the barren land as it had jumped from 63110 ha in 1989 to more than 76,000 ha in 2015. An increase of more than 4,500 ha also occurred in the area covered by snow

***Land use/ land cover change and its impact on biodiversity***

Boost in population, improved economic conditions and cultural values, government policies, and technology advancement can promote changes in the regional landscape change. The scale of these changes may be due to environmental constraints, but they are usually the main economic factor (Seabrook *et al*., 2006). Data on both flora and fauna data were recorded based on a field surveys and interviews and were grouped accordingly. In the current study, the conservation status of 148 wild plants species and 22 animal species was reportedly growing wild in the region. For each of the documented species, scientific name, gathering area, the reason for harvesting, conservation status and coordinates were noted. (Supplementary Table No. 1) and (Supplementary

Table No. 2). The information was collected and recorded for different conservation attributes by following the International Union for Conservation and Nature standard (2001). During the last few decades, human intervention has resulted in significant modification of land use and land cover, which led to the loss of biodiversity in the Kurram district. With the rapidly increasing population, the demand for natural resources is leading to unsustainable forest and rangeland use, and ultimately a decrease of forest and rangeland. In the past few decades, human activities have led to changes in land use and land cover, which led to the loss of biodiversity in Kurram. In the contemporary study, the conservation status of 148 wild medicinal species in the area was reported. Following the (IUCN) International Union for Conservation of Nature (2001) (Hussain *et al*., 2018) to collect and record information on different conservation attributes. According to reports, there were 22 critically endangered species (14.8%), 15 (10%) endangered species, 65 (43.9%) rare species, 29 species (19.5%) vulnerable, and 16 (10.8%) infrequent species. Unsustainable use and lack of suitable habitat have significantly impacted their regeneration of endangered species pushed them to the list of endangered species. The rare and endemic species included *Ephedra gerardiana, Lilium polyphyllum, Delphinium brunonianum, Vincetoxicum cardiostephanum, Pertya aitchisonii, Incarvillea emodi, Draba abajoensis, Dianthus afghanicus, Nepeta kurramensis, Berchemia pakistanica, Saxifraga afghanica, Rhododendron afghanicum, Rhododendron collettianum, Populus afghanica.*

The conservation status of the ecosystem services plants species was assessed with the facilitation of IUCN Red List Categories and Criteria (Hussain *et al*., 2019b) (Table No. 3). The classification of various conservation classes was used, including the availability, collection, growth, partly used and the total score. One hundred forty-eight plant species growing in the wild faced % anthropogenic and environmental stressed. Out of 148 species, 22 species (14.8%) were critical endangered, 15 (10%) species endangered, 65 (43.9%) species rare, 29 (19.5%) vulnerable, 16 (10.8%) species infrequent and one (0.6) species was dominant. Unsustainable use and lack of suitable habitat have affected their regeneration of endangered species pushed them to the endangered category. Climate change is the leading threatening process for species such as *Angelica ternata, Vincetoxicum cardiostephanum Betula utilis, Draba abajoensis, Kobresia scirpina, Gentiana kurroo, Nepeta kurramensis, Nepeta erecta, Podophyllum emodi, Primula macrophylla* and *Saxifraga afghanica.* Furthermore, *Vincetoxicum cardiostephanum, Draba abajoensis* and *Nepeta kurramensis* are narrow endemic plant species which are critically endangered.

Deforestation is the main threat faced by rare and endangered species. Species affected included *Abies pindrow, Cedrus deodara, Pinus gerardiana, Pinus wallichiana, Juniperus excelsa, Quercus baloot, Quercus incana,* and *Quercus semecarpifolia.*

Due to population growth, urbanization is another negative factor, and species facing habitat degradation due to urbanization included *Solanum elaeagnifolium, Populus afghanica, Celtis australis,* and *Opuntia monacantha.*

However, overall multiple anthropogenic and natural pressures are responsible for species decline in the region.

**Table No. 3**
**IUCN Red List Categories and Criteria (2001). Plants were classified into various conservation orders using the (IUCN, 2001).**

| **Availability and Collection** | |
|---|---|
| 0 = Uncommon or very rare | 0 = More than 1000 kg/year |
| 1 = Less common or rare | 1 = Consumed from 500-1000 kg/year |
| 2 = Occasional | 2 = Consumed from 300-500 kg/year |
| 3 = Abundant | 3 = Consumed from 100-200 kg/year |
| **Growth /Part used** | |
| 0 = Regrowth in more 3 years | 0 = Root/Whole plant |
| 1 = Regrowth within 3 years | 1 = Bark |
| 2 = Regrowth within 2 years | 2 = Seeds, Fruits |

| | |
|---|---|
| 3 = Regrowth within 1 year | 3 = Flowers |
| 4 = Regrowth in a season | 4 = Leaves/Gum/Latex |
| **Total Score:** | |
| **1** | 0 - 4 Endangered: |
| **2** | 5 - 8 Vulnerable: |
| **3** | 9 -12 Rare |
| **4** | 13 -14 Infrequent: |
| **5** | 15 -16 Dominant |

## CONCLUSIONS

The recent study was aimed to examine the biodiversity, land use, and land cover changes over the previous three decades in district Kurram, employing remote sensing data and GIS technologies. Our results indicated extensive alterations in land use and land cover in the research area, most of which occurred over the last three decades. Two distinct trends are observed in the four mainland cover classes. The area under farmland and barren land have recorded some positive changes while on the other side a noticeable declining trend was seen in both rangeland and forest cover. The spatiotemporal map unveiled that most of the land once covered by rangeland and forest has now been transformed into areas producing food and barren land. The analysis showed that in 1989, about 42% of the area was under rangeland, 21% was forest, 18% was under barren land, 15% was the land producing food, and 1.8% and 0.8% by water bodies and snow cover respectively.

In 2015, nearly three decades later, the percentage of rangeland has dwindled to 38%, land under forest cover has decreased to 17%, barren land has jumped to over 22%, farmland to 18%, and snow cover reached 2.2%, and the changes recorded for water bodies was negligible. Two main reasons for the land cover change were increasing food production and timber and fuelwood extraction. Agricultural land recorded a growth of about 15% as it has increased from 51,700 ha in 1989 to appropriately 61,000 ha by 2015. This gradual increase in farmland occurred at the expense of forest, rangeland, and barren land. As natural habitats are converted to agricultural land, native species that are sensitive to specific environmental conditions decline. The plant species facing habitat degradation due to agricultural land expansion included *Pertya aitchisonii Schinus molle, Dodonaea viscosa, Punica granatum, Sageretia thea,* and *Solanum elaeagnifolium.* Due to rapid population growth, the demand for natural resources has significantly increased, leading to unsustainable use of forests, ultimately decreasing the forest cover. By comparing the land use and land cover data of the last three decades, a noticeable decline was seen in forest cover. The land under forest decreased to 56,000 ha in 2015 from over 71,000 ha in 1989. The recorded decrease in forest cover was around 21% over the study period. The plant species under pressure due to various socio-economic reasons include *Quercus baloot, Quercus incana, Populus afghanica, Pinus gerardiana, Pinus wallichiana, Nannorrhops ritchieana, Olea europaea, Quercus semecarpifolia, Cedrus deodara, Abies pindrow.* During the study period, around 9% of decrease was also registered in rangeland, as it has lowered down to approximately 143,500 ja in 2015 from 143,100 ha in 1989.

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**Supplementary Table No. 1**
**Endangered plant species of Kurram under stress from facing multiple anthropogenic activities and climate change**

| Family | Scientific name | Location/Distribution | Coordinates | Reason | Conservation status |
|---|---|---|---|---|---|
| **Gymnosperms** | | | | | |
| Pinaceae | *Abies pindrow* (Royle ex D. Don) Royle | Koh-e-Safaid rage Temperate and sub-alpine regions | 34° 0'29.86"N 70° 4'34.62"E | Deforestation | Vulnerable |
| | *Cedrus deodara* (Roxb. ex Lamb.) G. Don | Terimangal Pak-Afghan border. (Transition zone of sub-tropical and Temperate zones) | 33° 58'13.03"N 69° 52'37.51"E | Deforestation | Critical<br>Endangered |
| | *Pinus gerardiana* Wall ex. D. Don | Pak-Afghan border | 33°57'57.51"N 69°52'14.94"E | Deforestation | Critical<br>Endangered |
| | *Pinus wallichiana* A.B. Jacks | Koh-e-Safaid range | 33°59'30.07"N 70° 4'31.62"E | Deforestation | Rare |
| **Angiosperms** | | | | | |
| Acanthaceae | *Justicia adhatoda* L. | Balishkhail LK Sub-tropical | 33° 43'50N 70° 18'56E | Used as fuel wood | Rare |
| Amaryllidaceae | *Allium jacquemontii* Kunth | Khushangool Sadda LK | 33° 42'29N 70° 19'06E | Extensively collected as a medicinal plant (used for stomach ache) | Endang |
| | *Allium griffithianum* Boiss. | Hilly and plain of Kurram Subtropical zone | 33° 54'56.53"N 70° 3'54.51"E | Extensively collected as a medicinal plant (used as a spice) | Rare |
| Anacardiaceae | *Cotinus americana* Nutt. | Tarali CK | 33° 44'13N 70° 24'18E | Extensively collected as a medicinal plant (used in urinary, gastrointestinal disorders) | Rare |
| | *Pistacia atlantica* Desf. | Sarkhawi Dara CK | 33° 37'54N 70° 40'58E | Used as fuelwood | Endang |
| | *Schinus molle* L. | Gogani CK Temprate zone | 33° 51'30N 70° 19'18E | Road construction. | Rare |
| Apiaceae | *Angelica ternata* Regel & Schmalh | Alpine region of Koh-e-Safaid range Alpine zone | 34° 2'10.11"N 69° 54'31.41"E | Extensively collected as a medicinal plant Climate change | Endang |
| | *Chaerophyllum reflexum* Aitch. | Koh-e-Safaid range | 33° 59'9.05"N 69° 58'54.00"E | Extensively collected as a medicinal plant (used as food) | Vulner |
| Apocynaceae | *Caralluma tuberculata* N.E. Br | Ahmadi Shama LK Subtropical | 33° 24'04N 70° 23'01E | Extensively collected as a medicinal plant | Critical<br>Endang |
| | *Calotropis procera* (Aiton) Dryand. | Alizai LK | 33° 30'42N 70° 19'43E | Extensively collected as a medicinal plant (used as anthelmintic) | Rare |
| | *Periploca aphylla* Dcene. in Jacquem. | Tablighi Markaz LK | 33° 42'15N 70° 20'05E | Overgrazing | Rare |
| | *Caralluma tuberculata* N.E. Br. | Pak Afghan border Malikhail The subtropical and tropical zone | 33° 44'11N 70° 83'37E | Extensively collected as a medicinal plant (used as food and herb) | Critical<br>Endang |

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|---|---|---|---|---|---|
| | *Vincetoxicum cardiostephanum* (Rech.f ) Rech. f. | Khaiwas Temperate zone | 33° 57'47N 69° 59'50E | Habitat degradation, Climate change | Critical<br><br>Endang |
| Araceae | *Arisaema jacquemontii* Blume | Manato CK | 33° 34'02N 70° 39'14E | Extensively collected as a medicinal plant (used for stomach ache) | Endang |
| Areceaea | *Nannorrhops ritchieana* (Griff.) Aitch. | plain of areas Subtropical zone | 33° 44'50.13"N 70° 8'1.81"E | Extensively collected as a medicinal plant | Rare |
| Asparagaceae | *Asparagus adscendens* Roxb. | Mountain and plains Subtropical zone | 33° 46'34.23"N 70° 12'6.54"E | Extensively collected as a medicinal plant (used as food) | Rare |
| | *Polygonatum verticillatum* (L.) All. | Hilly area of Koh-e-Safaid ranges Temperate zone | 33° 58'42.98"N 69° 59'8.45"E | Extensively collected as a medicinal plant | Critical<br><br>Endang ered |
| Asteraceae | *Carthamus oxyacantha* M. Bieb. | Shasho LK | 33° 33'44N 70° 19'29E | Extensively collected as a medicinal plant (used for infertility and also used to treat jaundice) | Infrequ |
| | *Centaurea iberica* Trevir. ex Spreng. | Murghan CK | 33° 39'15N 70° 32'48E | Extensively collected as a medicinal plant (used for burns, skin rashes, defective lactation) | Rare |
| | *Cichorium intybus* L. | Sadda LK | 33° 41'21N 70° 19'27E | Extensively collected as a medicinal plant (used as a diuretic, expectorant) | Infrequ |
| | *Launaea procumbens* (Roxburgh) Ramayya & Rajagopal | Khwar kali LK | 33° 42'19N 70° 18'60E | Extensively collected as a medicinal plant (used as tonic) | Vulner |
| | *Onopordum acanthium* L. | Ghulyango CK | 33° 40'55N 70° 28'54E | Extensively collected as a medicinal plant (used as expectorant, anti-asthmatic, anti-carcinomas) | Vulner |
| | *Sonchus asper* (L.) Hill | Sangeena LK | 33° 43'04N 70° 18'56E | Extensively collected as a medicinal plant (used for wound healing) | Domin |
| | *Pertya aitchisonii* C.B. Clarke | Makhrani CK | 33° 57'13N 70° 14'35E | Road construction for mining.<br>Habitat degradation | Vulner |
| | *Artemisia absinthium* L. | Plains of Upper Kurram Subtropical zone | 33°58'22.46"N 69°59'11.46"E | Extensively collected as a medicinal plant | Vulner |
| | *Scorzonera raddeana* C. Winkl. | Malikhail Subtropical zone | 33°47'48.12"N 70° 6'48.76"E | Grazing. | Vulner |
| | *Tanacetum artemisioides* Sch.Bip. ex Hook.f . | Plains of Upper Kurram Subtropical zone | 33°57'5.48"N 69°55'16.37"E | Extensively collected as a medicinal plant | Rare |
| | *Carthamus oxyacantha* M. Bieb. | Shasho LK | 33° 33'44N 70° 19'29E | Extensively collected as a medicinal plant (used for infertility and jaundice) | Infrequ |
| Berberidaceae | *Berberis lyceum* Royle | Sursurang UK | 33° 56'21N | Extensively collected as a | Endang |

| | | | | | |
|---|---|---|---|---|---|
| | | | 70° 53'27E | medicinal plant | |
| Betulaceae | *Betula utlis* D. Don | Alpine region of Koh-e -Safaid range Timber line zone | 34° 0'26.60"N 70° 3'51.00"E | Climate change | Critical Endang |
| Bignoniaceae | *Incarvillea emodi* (Royle ex Lindl.) Chatterjee | Manato CK grow on the rock cleft | 33° 35'05N 70° 32'12E | Extensively collected as a medicinal plant | Critical ly Endang ered |
| Boraginaceae | *Onosma hispida* Wall. ex G. Don | Guwaki CK | 33° 38'45N 70° 26'01E | Extensively collected as a medicinal plant (used as a tonic and against cardiac diseases) | Rare |
| | *Trichodesma indicum* (L.) Lehm. | Marokhail LK | 33° 27'59N 70° 24'41E | Extensively collected as a medicinal plant (used for removal of kidney stones) | Infrequ |
| Brassicaceae | *Draba abajoensis Windham & Al-Shehbaz* | Khawri CK Alpine | 33° 57'20N 70° 15'52E | Climate change/ Sensitive to temperature | Critical Endang |
| Buxaceae | *Buxus wallichiana* Baill. | Sharki Boundary LK | 33° 39'41N 70° 13'31E | Extensively collected as a medicinal plant (used as a bitter tonic, diaphoretic, diuretic) | Rare |
| Cactaceae | *Opuntia monacantha* Haw. | Plains of Upper Kurram Subtropical zone | 33°47'46.76"N 70° 6'30.03"E | Urbanization | Critical Endang |
| Cannabaceae | *Celtis australis* L. | Plains of Upper Kurram Subtropical zone | 70° 1'47.84"E 70° 1'47.84"E | Urbanization/ Land expansion for construction | Vulnerable |
| Capparaceae | *Capparis cartilaginea* Decne. | KhushangoolSadda LK Subtropical | 33° 42'32N 70° 19'09E | Extensively collected as a medicinal plant | Endang |
| Caryophyllacea e | *Silene conoidea* L. | Pirqayum LK | 33° 41'32N 70° 19'25E | Extensively collected as a medicinal plant (used in respiratory infections) | Infrequ |
| | *Silene vulgaris* (Moench) Garcke | Badama CK | 33° 41'30N 70° 19'28E | Extensively collected as a medicinal plant (used for stomach disorders) | Infrequ |
| | *Dianthus afghanicus* Rech. f. | Kochi Laka LK subtropical | 33° 42'55N 70° 16'20E | Forest fire exploitation | Rare |
| Celastraceae | *Maytenus abbottii* A.E. van Wyk | Kochi laka LK | 33° 42'06N 70° 16'57E | Used as fuelwood | Rare |
| Colchicaceae | *Colchicum robustus* (Bunge) Stef. | Sakhi Ahmad Shah LK | 33° 40'57N 70° 19'27E | Extensively collected as a medicinal plant (used as a pain reliever) | Endang |
| | *Colchicum luteum* Baker | Khaiwas Temperate zone | 33° 58'48.28"N 69° 59'59.41"E | Grazing and destruction of habitat (Mining) | Vulner |
| Convolvulaceae | *Convolvulus arvensis* L. | Sakhi Ahmad Shah LK | 33° 40'57N 70° 19'27E | Extensively collected as a medicinal plant (used as a laxative) | Vulner |
| | *Cuscuta reflexa* Roxb. | SaddaChawni LK | 33° 42'19N 70° 20'10E | Extensively collected as a medicinal plant (used as astringent) | Infrequ |

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| Cupressaceae | *Juniperus excelsa* M. Bieb. | Terimangal Pak-Afghtan border Temperate and sub-alpine regions | 33° 58'27.48"N 69° 52'40.47"E | Deforestation /used as fuel | Critical Endang ered |
| | *Juniperus excels* M. Bieb. | Terimangal Pak-Afghtan border Temperate and sub-alpine regions | 33° 58'27.48"N 69° 52'40.47"E | Overexploitation for fuelwood | Vulner |
| Cyperaceae | *Cyperus difformis* L. | Sangeena LK | 33° 42'58N 70° 19'01E | Extensively collected as a medicinal plant (used as bio-herbicides) | Vulner |
| | *Cyperus rotundus* L. | Sangeena LK | 33° 42'51N 70° 19'05E | Extensively collected as a medicinal plant (used in respiratory infection) | Infrequ |
| | *Kobresia scirpina* Willd. | Alpine and sub-alpine regions of Koh-e-Safaid range Alpine zone | 34° 0'15.28"N 70° 5'7.25"E | Climate change | Vulner |
| Dipsacaceae | *Scabiosa olivieri* Coult. | Saddalaka LK | 33° 42'25N 70° 18'05E | Extensively collected as a medicinal plant | Rare |
| Ebenaceae | *Diospyros lotus* L. | Karman UK | 33° 55'01N 70° 08'12E | Extensively collected as a medicinal plant (used as purgative and laxative agent) | Vulner |
| Elaeagnaceae | *Elaeagnus angustifolia* L. | Kochi LK | 33° 41'38N 70° 18'56E | Extensively collected as a medicinal plant (Oil used in the treatment of bronchial affections) | Endang |
| Ephedraceae | *Ephedra gerardiana* Wall. ex. Stapf | Koh-e-Safaid rage Subtropical zone | 33° 58'27.50"N 69° 52'34.26"E | Extensively collected as a medicinal plant | Endang ered |
| Ericaceae | *Rhododendron afghanicum* Aitch. & Hemsl. | Awidara CK | 33° 53'38N 70° 29'44E | Mining and road construction | Endang |
| | *Rhododendron collettianum* Aitch. and Hemsl | Awidara CK Sub-alpine | 33° 54'20N 70° 25'26E | Extensively collected as a medicinal plant. | Endang |
| Euphorbiaceae | *Euphorbia helioscopia* L. | Arawali LK | 33° 35'32N 70° 19'37E | Extensively collected as a medicinal plant | Infrequ |
| | *Euphorbia wallichii* Hook. f. | Gandaw E. hills CK | 33°56'42N 70°13'41E | Extensively collected as a medicinal plant | Rare |
| Fabaceae | *Indigofera heterantha* Brandis | Jawdara CK | 33°39'24N 70°38'37E | Used as fuelwood | Rare |
| | *Sophora mollis* (Royle) Baker | Dogar CK | 33° 49'40N 70° 24'42E | Extensively collected as a medicinal plant (used in skin allergies and as antiseptic material) | Rare |
| | *Astragalus amherstianus* Royle ex Benth. | Mulayano Kali LK | 33° 42'55N 70° 20'27E | Fodder | Domin |
| | *Astragalus psilocentros* Fisch. | Khar Kali LK | 33° 43'34N 70° 20'06E | Extensively collected as a medicinal plant (used in flue and toothache) | Infrequ |
| | *Dalbergia sissoo* DC. | Balish Khel LK | 33° 43'30N 70° 19'40E | Extensively collected as a medicinal plant (used as an expectorant). Harvested as | Rare |

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| | | | | fuelwood/ furniture wood | |
| | *Ebenus stellate* Boiss. | Muhammad Khuwaja LK | 33° 42'06N 70° 18'54E | Forage value | Infrequ |
| | *Vicia saiva* L. | Sangeena LK | 33° 43'04N 70° 18'56E | Extensively collected as a medicinal plant (Powder of the plant dissolve in water used for bathing) | Rare |
| Fagaceae | *Quercus baloot* Griff. | Mountainous region of Koh-e-Safaid range Subtropical zone and temperate zone | 33°59'3.43"N 70° 5'11.00"E | Deforestation For fuelwood | Vulner |
| | *Quercus incana* Bartram. | Mountainous region of Koh-e-Safaid range Subtropical zone and temperate zone | 70° 1'56.57"E 70° 1'56.57"E | Deforestation Cutting for fuelwood and urbanization | Vulner |
| | *Quercus baloot* Griff. | Tarali CK | 33° 48'05N 70° 36'48E | Used as fuel wood | Rare |
| | *Quercus semecarpifolia* Sm. | Naka zayarat CK | 33° 45'56N 70° 02'55E | Used as fuelwood. Extensively collected as a medicinal plant (used against scabies). | Vulner |
| | *Quercus incana* Bartram. | Mountainous region of Koh-e-Safaid range Subtropical zone and temperate zone | 70° 1'56.57"E 70° 1'56.57"E | Deforestation Cutting for fuelwood and urbanization | Vulner |
| Gentianaceae | *Gentiana Kurroo* Royle | Sub-alpine region of Koh-e-Safaid range Temperate zone | 34° 0'7.96"N 69°55'37.76"E | Climate change | Endang |
| Ixioliriaceae | *Ixiolirion tataricum* (Pall.) Schult. & Schult.f. | Sadda Tablighi Markaz LK Subtropical | 33° 42'10N 70° 20'15E | Over collection for grace color Urbanization | Rare |
| Juglandaceae | *Juglans regia* L. | Tari Mangal UK | 33° 57'20N 70° 53'23E | Extensively collected as a medicinal plant (Edible nut is used as brain and heart tonic; root feeling for colors) | Rare |
| Juncaceae | *Juncus inflexus* L. | Sangeena LK | 33° 43'05N 70° 18'55E | Thatching | Rare |
| Lamiaceae | *Rydingia limbata* (Benth.) Scheen & V.A. Albert | Guwaki CK | 33° 38'48N 70° 26'05E | Extensively collected as a medicinal plant. | Rare |
| | *Nepeta erecta* (Royle ex Benth.) Benth. | Sarkhawi Dara CK | 33° 37'51N 70° 24'18E | Climate change | Critical Endang |
| | *Nepeta kurramensis* Rech. f. | Gharibi CK Temprate | 33° 52'04N 70° 30'43E | Climate change | Critical Endang |
| | *Perovskia atriplicifolia* Benth. | Awidara CK Temperate | 33° 51'27N 70° 24'16E | Used for honey bees attraction | Rare |
| | *Mentha longifolia* (L.) L. | Kurram river LK | 33° 43'39N 70° 19'00E | Extensively collected as a medicinal plant (Stomachic, anti-diarrheal, | Comm |

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| | | | | stops vomiting and nausea). | |
| | *Thymus linearis* Benth. | Dogar CK | 33° 49'39N 70° 24'41E | Extensively collected as a medicinal plant (used in toothache, digestive disorder) | Rare |
| | *Ziziphora tenuior* L. | Plains of Upper Kurram Subtropical zone | 33°54'29.48"N 70° 3'45.97"E | Extensively collected as a medicinal plant | Rare |
| Liliaceae | *Tulipa clusiana* DC. | Dogar CK | 33° 47'41N 70° 27'53E | Extensively collected as a medicinal plant (used in skin disease/ over-collection for graceful color) | Rare |
| | *Gageapakistanica* Levichev and Ali | Shakardara | 33° 47'12N 70° 18'25E | Grazing | Rare |
| | *Lilium polyphyllum* D. Don | Hilly area of Upper Kurram Temperate zone | 33° 59'56.87"N 70° 4'51.17"E | Extensively collected as a medicinal plant | Critical<br>Endang |
| | *Linum corymbulosum* Reichenb. | Khawar Kali LK | 33° 43'20N 70° 19'40E | Extensively collected as a medicinal plant (used in therapies of cancer and diabetes) | Rare |
| Lythraceae | *Punica granatum* L. | Kotki CK | 33° 38'34N 70° 31'33E | Extensively collected as a medicinal plant (affect the blood pressure) | Rare |
| Meliaceae | *Melia azedarach* L. | Khawar kali LK | 33° 43'14N 70° 19'45E | Extensively collected as a medicinal plant (blood purifier)<br>Fuelwood | |
| Moraceae | *Ficus carica* L. | Kochi LK | 33° 41'40N 70° 18'52E | Extensively collected as a medicinal plant (used in the treatment of foot ache) | Rare |
| | *Ficus religiosa* L. | Kochi LK | 33° 41'45N 70° 18'51E | Extensively collected as a medicinal plant (used in the treatment of diarrhea, dysentery; as an anti-inflammatory, antibacterial agent) | Rare |
| | *Morus alba* L. | Pir Qayum LK | 33° 41'29N 70° 19'26E | Extensively collected as a medicinal plant (used as a laxative, expectorant) | Rare |
| | *Morus nigra* L. | Pir Qayum LK | 33° 41'29N 70° 19'27E | Extensively collected as a medicinal plant (used as food). | Infrequ |
| Myrtaceae | *Eucalyptus globulus* Labill. | Arawali LK | 33° 35'32N 70° 19'37E | Extensively collected as a medicinal plant (used to kill germs in wounds) | Rare |
| Nitrariaceae | *Fagonia cretica* L. | Chapari LK | 33° 25'44N 70° 29'07E | Extensively collected as a medicinal plant | Rare |
| | *Peganum harmala* L. | Sadda Colony LK | 33° 42'04N 70° 20'12E | Extensively collected as a medicinal plant (used in the treatment of measles and as anti-lice shampoo) | Rare |
| Oleaceae | *Olea europaea* L. | Murghan CK | 33° 38'27N | Extensively collected as a | Rare |

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| | | | 70° 31'51E | medicinal plant<br><br>(used as anthelmintic, anti-diabetic agent). | |
| | *Syringa emodi* Wall. ex Royle. | Khawri Kali CK | 33° 56'33N<br>70° 13'37E | Extensively collected as an essential oil medicinal plant (commercially used for perfume extraction). | Rare |
| | *Jasminum humile* L. | Gandaw CK | 33° 56'45N<br>70° 16'17E | Agriculture expansion. | Endang |
| Oxalidaceae | *Oxalis corniculata* L. | Guwaki lower mt CK | 33° 38'52N<br>70° 26'10E | Extensively collected as a medicinal plant (Young shoots used as salad acting as an appetizer, prevent teeth sensitivity; indigestion) | Infrequ |
| Papaveraceae | *Papaver dubium* L. | Ghulyango CK | 33° 40'53N<br>70° 28'57E | Extensively collected as a medicinal plant (used in skin problems and memory enhancer) | Rare |
| | *Papaver somniferum* L. | Azam Abad kochi LK | 33° 41'41N<br>70° 18'54E | Extensively collected as a medicinal plant (used as a sedative, astringent, expectorant) | Rare |
| Plantaginaceae | *Plantago lanceolata* L. | Ghundi Kali LK | 33° 30'56N<br>70° 19'31E | Extensively collected as a medicinal plant (used in the treatment of diarrhea) | Rare |
| | *Plantago major* L. | Murukhail LK | 33° 30'53N<br>70° 19'34E | Extensively collected as a medicinal plant (used against dysentery, leaves used for born crick) | Rare |
| Platanaceae | *Platanus orientalis* L. | Makhizai LK | 33° 34'33N<br>70° 18'32E | Extensively collected as a medicinal plant (Soothing inflamed eye and sour throat) | Infrequ |
| Poaceae | *Arthraxon lancifolius* (Trin.) Hochst. | Makhizai LK | 33° 37'56N<br>70° 17'26E | Fodder | Rare |
| | *Melica persica* Kunth | Kurram river LK | 33° 42'22N<br>70° 19'22E | Extensively collected as a medicinal plant (used in the treatment of dysentery and as a wound healings) | Rare |
| | *Imperata cylindrical* (L.) Raeusch | Ahmadi Shama LK | 33° 26'50N<br>70° 26'32E | Extensively collected as a medicinal plant (used in urinary calculi, retention) | Rare |
| | *Puccinellia tenuiflora* (Griseb.) Scribn. & Merr. | Tarali CK | 33° 48'10N<br>70° 36'38E | Extensively collected as a medicinal plant | Vulner |
| | *Cenchrus ciliaris* L. | Ibrahimzai LK | 33° 44'29N<br>70° 17'38E | Overgrazing | Vulner |
| | *Poa aitchisonii* Boiss. | Awidara CK | 33° 52'39N<br>70° 25'28E | Overgrazing | Critical<br><br>Endang |
| Podophyllaceae | *Podophyllum emodi* Wall. ex Hook.f. & Thomson | Koh-e-Safaid range Temperate zone | 33°59'47.01"N<br>70° 4'10.37"E | Climate change | Critical<br><br>Endang |

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| Polygalaceae | *Polygala abyssinica* R. Br. ex Fresen. | Sharqi LK | 33° 35'31N 70° 19'30E | Extensively collected as a medicinal plant (Treatment for snake bite) | Rare |
| Primulaceae | *Primula macrophylla* D. Don | Koh e Safed CK Alpine | 33° 55'44N 70° 29'29E | Extensively collected as a medicinal plant. Climate change | Critical<br>Endang |
| | *Myrsine Africana* L. | Kochi Mountains LK | 33° 40'26N 70° 15'55E | Extensively collected as a medicinal plant (used in the treatment of asthma and colic) | Rare |
| Ranunculaceae | *Delphnium brunonianum* Royle | Koh-e-Safaid range Sub-alpine region | 34° 2'2.25"N 69°59'29E | Snow avalanches and erosion. | Critical<br>Endang |
| Rhamnaceae | *Berchemia pakistanica* Browicz | Speenashaga UK Sub-alpine | 33° 59'66N 69° 55'38E | Fencing for the field. | Rare |
| | *Sageretia thea* (Osbeck) M.C. Johnst. | Manato CK Sub-tropical | 33° 44'06N 70° 30'47E | Agriculture land expansion. | Rare |
| | *Ziziphus vulgaris* Lamk. | Plains of Upper Kurram Subtropical zone | 33°56'22N 70° 1'53E | Over cutting for fencing around cultivated fields/gardens | Vulner |
| Rosaceae | *Spiraea pilosa* French. | Badama CK | 33° 41'32N 70° 19'19E | Veterinary uses | Vulner |
| | *Prunus dulcis* (Mill.) D. A. Webb | SaddaLaka mt LK | 33° 42'23N 70° 18'03E | Extensively collected as a medicinal plant (Treatment of many disorders, including skin conditions like eczema and pimples) | Critical<br>Endang |
| | *Potentilla gerardiana* Lindl. ex Lehm. | Koh-Sufaid CK Temperate | 33° 54'42N 70° 29'58E | Climate change | Rare |
| | *Rosa ecae* Aitch. | Tari Mangal UK Dry temperate | 33° 57'40N 70° 53'03E | Urbanization. | Endang |
| Salicaceae | *Populus alba* L. | Ali zai LK | 33° 30'48N 70° 19'38E | Extensively collected as a medicinal plant | Infrequ |
| | *Salix excelsa* S. G. Gmel | Ibrahim zai LK | 33° 44'25N 70° 17'42E | Extensively collected as a medicinal plant (used as pain-relieving, fever-reducing, and anti-inflammatory drug, aspirin) | Rare |
| | *Populus afghanica* (Aitch. & Hemsl.) C.K. Schneid | Plains of Upper Kurram Subtropical zone | 33°56'22.48"N 70° 5'7.51"E | Urbanization/Cutting for timber | Vulner |
| | *Populus nigra* L. | Plains of Upper Kurram Subtropical zone | 33°54'53.90"N 70° 2'15.54"E | Urbanization/Cutting for timber | Vulner |
| Sapindaceae | *Dodonaea viscosa* L. Jacq. | Muhammad Khuwaja LK | 33° 42'05N 70° 18'55E | Extensively collected as a medicinal plant (used as sex tonic).<br>Used as fuelwood | Rare |
| Sapotaceae | *Sideroxylon mascatense* | Muhammad khuwaja | 33° 42'22N | Extensively collected as a | Rare |

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| | (A.D.C) T.D.Penn | LK | 70° 18'57E | medicinal plant (anthelmintic, gum of the tree is used as antimony). | |
| Saxifragaceae | *Bergenia ciliate* (Haw.) Sternb. | Mir Janam Kali CK | 33° 56'50N 70° 13'45E | Extensively collected as a medicinal plant | Rare |
| | *Saxifraga afghanica* Aitch & Hemsl. | Chapar CK Sub Alpine | 33° 56'38N 70° 14'13E | Climate change | Critical Endang |
| Scrophulariaceae | *Verbascum thapsus* L. | Ali zai LK | 33° 31'38N 70° 21'46E | Extensively collected as a medicinal plant (used in the treatment of diarrhea) | Rare |
| Solanaceae | *Atropa acuminata* Royle ex Lindl. | Balish Khel LK | 33° 43'42N 70° 19'19E | Extensively collected as a medicinal plant (used as an analgesic, narcotic, and sedative). | Rare |
| | *Datura stramonium* L. | Ibrahim zai LK | 33° 31'53N 70° 19'12E | Extensively collected as a medicinal plant | Infrequ |
| | *Solanum nigrum* var. *villosum* L. | Badama CK | 33° 41'29N 70° 19'27E | Extensively collected as a medicinal plant (skin diseases) | Vulner |
| | *Solanum surattense* Burm. f. | Sadda LK | 33° 41'30N 70° 19'28E | Extensively collected as a medicinal plant (used in the treatment of cough, asthma, and rheumatism). | Rare |
| | *Withania coagulans* (Stocks) Dunal | Tindo Central Kurram | 33° 41'52N 70° 23'49E | Extensively collected as a medicinal plant (used as carminative in the treatment of stomach pain) | Rare |
| | *Solanum elaeagnifolium* Cav | Tindu CK | 33° 46'53N 70° 22'54E | Urbanization. | Rare |
| Taxacacea | *Taxus fauana* Nan Li & R.R. Mill | Koh-e-Safaid rage Temperate zone | 33° 59'15.74"N 70° 4'40.20"E | Timber use | Vulner |
| Thymelaeaceae | *Daphne mucronata* Royle | Kotghundi LK | 33° 44'11N 70° 18'42E | Extensively collected as a medicinal plant (wound healing) | Vulner |
| Typhaceae | *Typha latifolia* L. | Kurram river LK | 33° 27'29N 70° 25'26E | Extensively collected as a medicinal plant (used to stop diarrhea) | Endang |
| | *Typha laxmannii* Lepech. | CharkhailKurram River LK | 33° 27'19N 70° 25'56E | The whole plant is used for roof shelter | Rare |
| | *Typha minima* Funck | Adjacent areas of river Kurram Subtropical zone | | Destruction of Habitat due to flooding | Critical Endang |
| Verbenaceae | *Lantana camara* L. | Manduri LK | 33° 30'39N 70° 26'25E | Extensively collected as a medicinal plant (carminative activity) | Vulner |
| | *Vitex negundo* L. | Balish Khel LK | 33° 43'31N 70° 19'33E | Extensively collected as a medicinal plant (used in the treatment of rheumatism) | Rare |
| Violaceae | *Viola biflora* L. | Dogar CK | 33° 46'39N 70° 31'00E | Overgrazing | Critical |

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| | | | | | Endang |
| Vitaceae | *Vitis vinifera* L. | Jalamai CK | 33° 37'33N 70° 20'50E | Extensively collected as a medicinal plant (used as food) | Vulner |

**Supplementary Table No. 2**
**List of the endangered animal species Tribal District Kurram Parachinar**

| Scientific Name | English Name | Family | Location | Coordinates | Conservation status | Reason |
|---|---|---|---|---|---|---|
| *Camelus dromedaries* (Linnaeus) | Camel | Camelidae | Found in the Koh-e-Safaid range | 33°57'58.23"N 70° 3'13.30"E | Endangered | Camel is used in wood carriages but nowadays deforestation occurs due to this camel uses decreases day by day, so their number also decreases. |
| *Equus asinus* × *Equus caballus* (Linnaeus) | Mule | Equidae | Found in Tari mengal, Shalozan, Mala Bagh, Para chamkani and Mali khail region | 33°58'3.17"N 70° 1'3.43"E | Threatened | Mule is mainly used in mountain regions but due to new technology today people used vehicles in place of mule, their number decreases day by day. |
| *Equus caballus* (Linnaeus) | Horse | Equidae | Found in Tari mengal, Shalozan, Mala Bagh, Para chamkani and Mali khail region | 33°56'33.83"N 70° 9'48.86"E | Vulnerable | Horses are mainly used in mountain regions but due to new technology today people used vehicles in place of mule, their number decreases day by day. |
| *Bubalus bubalis* (Linnaeus) | Buffalo | Bovidae | Found in Parachinar city, Zeran, Shalozanand Malana region | 33°54'4.78"N 70° 5'35.50"E | Threatened | People do not keep buffalo in houses so their number decreases. |
| *Capra falconeri* (Wagner) | Markhor | Bovidae | Found in Koh-e-Safaid range | 34° 2'42.75"N 69°59'43.32"E | Critically endangered | Markhor number is decreases due to illegal hunting\Defo-restation |
| *Panthera tigris* (Linnaeus) | Tiger | Felidae | Found in Koh-e-Safaid range and Mali khail Tor ghar region | 34° 1'24.23"N 70° 3'16.06"E | Critically endangered | There are no protection steps taken by Govt and illegal hunting so their number decreases\Deforesta-tion. |
| *Selenarctosthibet anus* (Wagner) | Bear | Ursidae | Found in Koh-e-Safaid range | 34° 2'16.69"N 70° 1'33.78"E | Critically endangered | There are no protection steps |

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| | | | and Mali khail Tor ghar region | | | taken by Govt and illegal hunting so their number decreases\Deforesta-tion |
| *Canis lupus* (Brown) | Wolf | Canidae | Found in Koh-e-Safaid range and Mali khail Tor ghar region | 34° 1'20.96"N 70° 3'29.61"E | Endangered | There are no protection steps taken by Govt and illegal hunting so their number decreases\Deforesta-tion |
| *Panthera pardus* (Linnaeus) | Leopard | Felidae. | Found in Koh-e-Safaid range and Mali khail Tor ghar region | 34° 2'11.71"N 70° 0'42.21"E | Critically endangered | There are no protection steps taken by Govt and illegal hunting so their number decreases\Deforestat ion |
| *Acinonyx jubatus* (Johann Christian) | Cheetah | Felidae | Found in Koh-e-Safaid range and Mali khail Tor ghar region | 34° 1'46.49"N 70° 2'56.76"E | Critically endangered | There are no protection steps taken by Govt and illegal hunting so their number decreases\Deforesta-tion |
| *Meleagris gallopavo* (Linnaeus) | Domestic turkey | Phasianidae | Found in Mali Khail and Kakhel region | 33°46'57.13"N 70° 8'40.36"E | Critically Endangered | Unsustainable environment |
| *Coturnix coturnix* (Linnaeus) | Quail | Phasianidae | Found in Dander sehra, MalihkailKotragha and Kakhel region | 33°45'34.40"N 70° 8'37.80"E | Vulnerable | There are no protection steps taken by Govt and illegal hunting so their number decreases\Habitat loss |
| *Alectoris chukar* (J. E. Gray) | Chukar partridge | Phasianidae | Found in Mali khail Shana derga, Sera milaShorky, Tor ger, Koh-e-Safaid range | 33°58'28.96"N 70° 3'7.23"E | Vulnerable | There are no protection steps taken by Govt and illegal hunting so their number decreases. \Habitat loss |
| *Anas platyrhynchos* (Linnaeus) | Duck | Anatidae | Found in River Kurram, Kotragha dem, Malanadem and Safaid range region | 33°49'8.13"N 70° 4'53.69"E | Vulnerable | There are no protection steps taken by Govt and illegal hunting so their number decreases |
| *Grus grus* (Linnaeus) | Crane | Gruidae | Found in Safaid range , Tor ghar and all mountain region | 34° 0'9.89"N 70° 6'8.86"E | Endangered | There are no protection steps taken by Govt and illegal hunting so their number decreases |
| *Francolinuspondiceri anus* (Gmelin) | Grey francolin | Phasianidae | Found in Shorky, Mali | 33°44'49.72"N 70° 2'48.64"E | Threatened | There are no protection steps |

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| | | | khail, Tor ghar and Koh-e-Safaid region | | | taken by Govt and illegal hunting so their number decreases. |
| *Sturnus vulgaris* (Linnaeus) | Starling | Sturnidae | Found in Dander sehra,Shalozan, pewar,zeran and Mali khail | 33°50'46.69"N 70° 6'1.64"E | Threatened | There are no protection steps taken by Govt and illegal hunting so their number decreases. |
| *Amandava amandava* (Linnaeus) | Red avadavat | Estrildidae | Found in Dander sehra,Shalozan, Kirman, Sara gala, Kharlachi, Pewar, Zeran and Mali khail region | 33°51'38.48"N 70° 1'30.34"E | Threatened | There are no protection steps taken by Govt and illegal hunting so their number decreases. |
| *Tragopan melanocephalus* (Linnaeus) | Western tragopan | Phasianidae | Found in Shorky, Mali khail Tor ghar and Koh-e-Safaid range | 33°46'6.64"N 70° 9'56.45"E | Threatened | There are no protection steps taken by Govt and illegal hunting so their number decreases. |
| *Columba eversmanni* (Bonaparte) | Yellow-eyed pigeon | Columbidae | Found in Mali khail, Tor ghar, Tari Menga,lPewarS halozan and Koh-e- Safaid range | 33°49'30.26"N 70°15'22.81"E | Vulnerable | There are no protection steps taken by Govt and illegal hunting so their number decreases. |
| *Gyps bengalensis* (Linnaeus) | Vulture | Accipitridae | Found in Koh-e-Safaid and Dander sehra | 33°54'41.68"N 70°14'20.25"E | Critically Endangered | Unsustainable environment |
| *Aquila chrysaetos* (Linnaeus) | Eagle | Accipitridae | Found in Mali khail, Tor ghar and Koh-e-Safaid range | 33°55'30.92"N 70°12'4.77"E | Critically Endangered | Unsustainable environment |