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Assessment of land degradation changes in mountain areas in Tashkent province

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Abstract. Analyzing the trend of land degradation changes and its cause and consequence in the mountain ecosystem is a matter of concern for sustainable development. It's important to know that only 10% of the world's population in rural areas depends directly on natural resources for their livelihood and 40% depends indirectly, i.e. water, biodiversity, and ecosystem. This study focuses on the assessment of land degradation changes in mountain areas of Tashkent province using GIS techniques. The study area is located lowland in the western part of the Tian Shan mountains. The results show that overgrazing significantly affects the mountain ecosystem, which decreased up to 29 thousand ha of pasture land over ten years between 1989-1998. However, changes during 2008-2018 show a significant rise in the pasture area, ending with 45 thousand ha of land. In conclusion, during last decades in Uzbekistan rehabilitation achievements be due to (i) complex measures taken by government and ecologists, who clearly recognized that if the previous scenario will continue, the ecosystem of high altitude areas could be irreversibly damaged; (ii) cutting trees from a forest which leads to decrease forest area and increase pasture area.

1. Introduction

Climate change is a global problem that is stroking every country of the world, including Uzbekistan. According to the Intergovernmental Panel on Climate Change (IPCC) calculations, the temperature of Central Asia may increase by 3.7 C by the end of the century [10, 17]. The increase of the temperature to 0.29 °C in a decade in all parts of the country since 1950 and diminishing glacial areas to 0.2%-1% in a year were detected. Global warming will not be uniform, but will vary considerably among different regions; in particular, climate change will be greater over land and at high latitudes and elevations [15, 16]. However, studies focused on vegetation found that changes in seasonal climate patterns can have either positive or negative impacts on above-ground biomass quality depending on the agro-ecological zone [3, 8, 13, 14, 20].

Mountain ecosystems are indeed increasingly threatened by global warming as well as human impact is affecting mountain landscape dynamics and the ecosystem services that mountains provide. Except for these, there is evidence that numbers of days with high air temperature are increased [1, 11, 12, 19].

In general, 10% of the world's population in rural areas depends directly on mountain resources for their livelihood and 40% depends indirectly, i.e. water, timber, biodiversity, and ecosystem services [2, 18]. The western part of the Tian Shan mountains UCNNP was established to conserve and manage the sustainable use of components of nature and natural capital that embraced ecologic, economic, and cultural values in Uzbekistan. Ecosystem degradation becomes gradually visible in the territory of Ugam Chatkal National Nature park (UCNNP). The park is the largest natural protected area in the



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Tian Shan mountains and it has a variety of flora and fauna [5]. There have been recorded around 1800 vegetation and 74 of them are included in the Red Book of Uzbekistan. Wild relatives of nut and fruit species such as Pistachio, IUCN-listed Persian Walnut, and Sievers Apples are examples of protected vegetation types. Regarding with flora, there has been documented nearly 230 animal species. 38 out of 230 species are reckoned in Red Book of Uzbekistan as well as in the world. Endangered species such as IUCN-VU marmot species *Marmota menzbieri*, Snow Leopard, IUCN-listed *Vormela peregusna* and *Vipera renardi tienshanica* and 15 kind nesting predatory birds are evidence of having impressive species diversity in UCNNP included in Red Book [5, 19]. Environmental problems such as overgrazing and deforestation may threaten local people's livelihoods. Critically evaluating the driving force for land cover change dynamics of the past trend is important to understand the recent changes and predict future alteration. Therefore, the research goal is to study a specific area of UCNNP that has been severely degraded over decades using GIS tools. Therefore, following research objectives are determined: i) to determine being degraded areas where vegetation exist in lower part of the UCNNP using GIS tools; ii) to analyse stakeholders of the UCNNP.

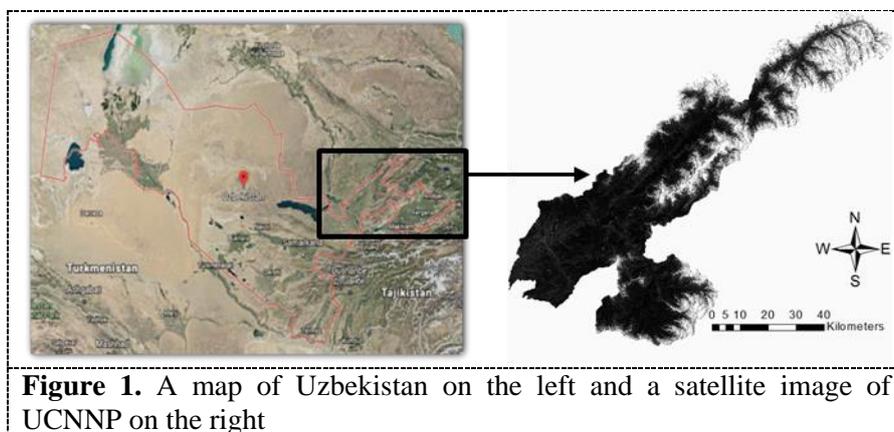
2. Materials and methods

2.1. Study area

The study area shows the territory of the UCNNP and its land use and land cover (see Figure 1). In this map, landscapes including water and glaciers, bare soil and rocks, pastures, and forests. The total area of the UCNNP is 574600 ha, including 110187.3 is used as a recreational zone, 428688.7 ha is used as different landscapes and 35 724 ha is a protected area. As determined by the decree on October 2, 2000, by the Cabinet of the Republic of Uzbekistan, the area of UCNNP is founded by Chatkal State Biosphere Reserve (CSBR), Burchimullo and Ohongaron Forest Committee.

As stated in the main book belong to Department of UCNNP, the land users of UCNNP and their proportion in the total territory are as followings:

- a) agricultural lands owned by farmers, dekhkans and state reserve lands (91577ha)
- b) forest lands:
 - i. CSBR (35 724 ha)
 - ii. Oxongaron forestry (76 600 ha)
 - iii. Burchimullo forestry (354 634 ha)
- c) Other lands allocated for recreational places, different organizations and residential areas (14 437 ha)



The focus of the study is located lowland bench range of UCNNP, the elevation between 800 and 1500 above the sea level. In history, these lands are being supposed to be used as habitat for wild shrubs and

trees such as pistachio, almond, and hawthorn. Current land use and a land cover map show that those area is being used as pasture and irrigated agricultural lands (see Figure 1).

2.2. Data collection

Satellite images were obtained from the usgs.com website of the United States Geological Department using Glovis online application. The image quadrat was downloaded for a specific area of Ugam Chatkal National Park (153/31 polygon) for the temporal period starting 1989 and ending 2018 (in Geo TIFF format) with time gap 10 years to analyze the general trend of land cover and pasture conditions respectively [9]. For acquisition month May was chosen due to two factors: 1) mature period of vegetation, when pastures rich almost peak of their biomass, and 2) during May period skies are often clear from clouds and it's easy to analyze land cover change (see Tab.1).

Table 1. DOYs analyzed satellite images

Year	Day of the year	Sensor
1989	148	Landsat 5 TM
1998	141	Landsat5 TM
2008	155	Landsat 5 TM
2018	148	Landsat 8 OLI

The conditions of live vegetation properties in the ecosystem can be measured with biophysical parameters analyzing satellite images [6]. One of the simple numerical indicators to analyze remote sensing measurements is the Normalized Difference Vegetation Index (NDVI, see equation 1) [7]. NDVI was applied to study land cover surface, and vegetation conditions particularly using the following formula [9]

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

where NIR is near-infrared reflectance, and RED is visible red reflectance. It takes the (NIR - red) difference and normalizes it to balance out the effects of uneven illumination such as shadows of clouds or hills.

The wavelength range of NIR band and RED band is 750-1300 nm and 600-700 nm respectively. The NDVI is motivated by the observation vegetation, which is the difference between the NIR and the red band. On a pixel by pixel basis subtracts the value of the red band from the value of NIR band and divides by their sum. A very low value of NDVI (≥ 0.1) corresponds to barren areas of rock, sand, and snow. Moderate values starting from 0.2 until 0.3; indicate shrub and grassland, where high values represent temperate and tropical rainforests (0.6 to 0.8). NDVI values that the closest to zero is usually true for bare soil, while negative values are shown water bodies [7]. In this research land use and land cover of the study area were classified using NDVI values as represented in Table 2.

Table 2. Land use classification with NDVI

Values	Land cover classification
0 and bellow 0	Water and glaciers
0 and 0.2	Bare soil and rocks
0.2 and 0.45	Pastures
0.45 and above	Forests

The changes in vegetation cover on pasture areas, moderate values of NDVI (0.2 to 0.45) were identified from the classified land cover image. Having identified pasture areas helped us (i) to quantify the change in hectares of pasture area over years, (ii) to observe a trend of NDVI where an ongoing increase or decrease within vegetation cover and (iii) to determine degraded pasture area.

2.3. Stakeholder analysis

To include the perceptions of farmers and residents on the evaluation of ecosystem services, farmers and residents were randomly selected in Khumson village at UCN NP. To obtain data from residents, several field trips were conducted during September 2018, and there, numerous households were visited. A survey with farmers was accomplished when available farmers were gathered in Mahalla1.

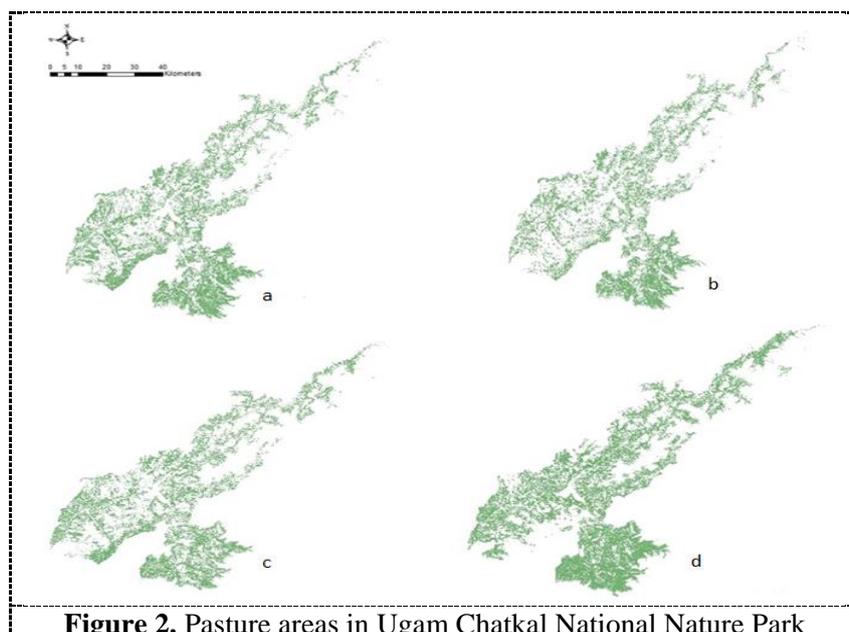
3. Results and discussions

The results show that in Table 3, there were an estimated 126.036 ha areas of pasture in 1989. The analysis shows that there was a noticeable decrease of 20.185 ha in 1998. After 10 years in 2008 pasture lands were recovered which was in 1989, however the grassland area has slightly decreased reaching at 177.780 ha. The changes of vegetation on land use land cover over 30 years can be seen via Figure 2 (a, b, c, d).

Table 3. Trend of changes in pasture areas of Ugam Chatkal National Nature Park over 30 years

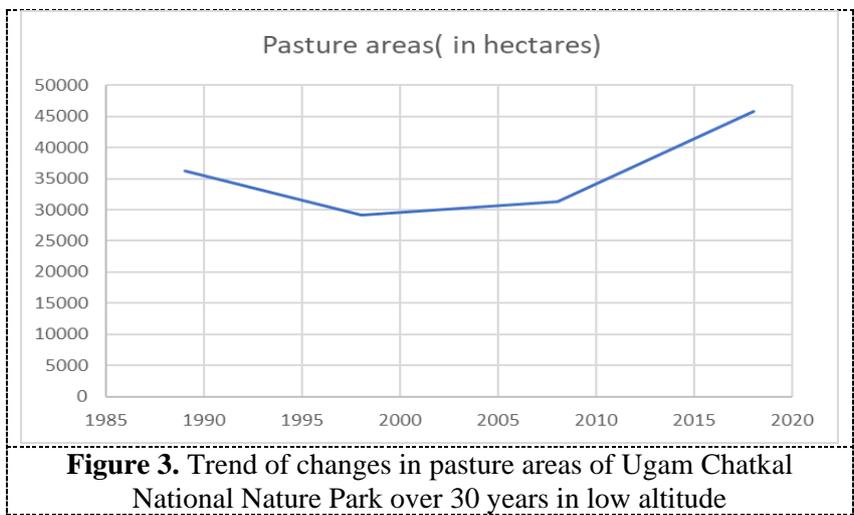
Observation year	Amount of areas (ha)
1989	126.036
1998	105.851
2008	122.293
2018	177.780

The results show the trend of changes in pasture areas of Ugam Chatkal National Nature Park (UCNNP) over 30 years in low altitude between 800-1500 m (see Fig. 3). Above there is a fluctuation trend of total land cover classified as pastures with remote sensing analysis. At the end of the post-soviet era total areas of high altitude, pastures in Tashkent province constituted approximately 36 thousand ha. Nevertheless, after the Soviet Union, there was a huge economic, political and demographical changes in Uzbekistan, that also resulted in land laws, intensive and unsustainable grazing practiced by local herders that lead to pasture degradation in country and this study area particularly. This lead to significant pasture area decline in UCN NP grazing areas. FAO [4] claims that forest degradation is a serious problem in mountain and valley areas of Uzbekistan. Expansion of agricultural land and increase of livestock populations are represented as drivers of the forest degradation issue.

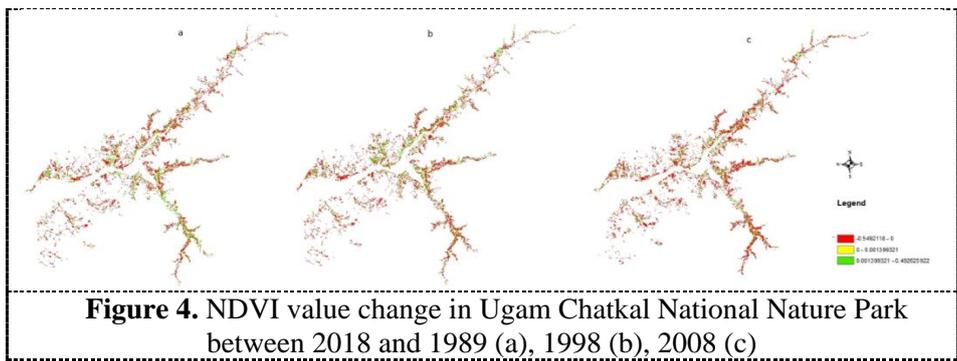


(Uzbekistan) during 1989 (a) 1998 (b), 2008 (c) and 2018 (d)

Later in nine years, the total pasture areas decreased up to 29 thousand ha of land, which is for 7 thousand ha less than in 1989. The next decade does not show a significant difference comparing to 1998. However, changes during 2008 and 2018 show a significant rise in the pasture area, ending with 45 thousand ha of land (+14 thousand ha comparing to 2008). Such rehabilitation achievement might be due to (i) complex measures taken by government and ecologists, who recognized that if the previous scenario will continue, the ecosystem of high-altitude areas of UCNNP could be irreversibly damaged and (ii) cutting trees from the forest which leads to decrease forest area and simultaneously increase pasture area.



The difference of NDVI values which was derived by subtraction of 2018 from 2008, 1998 and 1989 images. Pixels identifies that there were three types of changes in vegetation cover over the considered decade (see Fig. 4).



To recapitulate, general vegetation conditions and biomass of pasture pixels represent big degraded lands, comparing to previous decades. This picture can be seen from all three figures represented above. Especially, the significance in vegetation conditions can be seen in Figure 4, which identifies the degraded plots from 2008 to 2018. At first sight, it can look paradoxical, because during this period there is a clear rehabilitation trend and rise of total pasture areas, as was mentioned in previous remote sensing and GIS analysis. However, one should not confuse the total pasture area and vegetation condition, which is foremost, depends on aboveground biomass and plant health. Moreover,

mention that pasture areas could increase not only due to sustainable practices but also due to substituting other land cover classes, like cut forests, melted mountain glaciers, and greening of bare soil surfaces.

Finally, farmers and dekhkan farms (medium influence, high-medium interest) As stated in determining the territory of UCNNP, the main book of the Department, farmers and dekhkan farms are the part of land owners. Farmers and dekhkan farms have a medium effect to conserve ecosystems and ecosystem services. This is because farmers lease their land for max 49 years and year plan for plantation is approved by a local municipality. However, farmers and dekhkans have a high-medium interest to conserve their ecosystems. Having experiences on agriculture, farmers know well that if farming land is rich with nutrients and fertilizers, it yields productively. Farmers also recognize that yields on agricultural lands are not only affected by soil content, but climate change and availability of water resources impact noticeably.

4. Conclusion

In the last 30 years, land use and land cover dynamics have undergone considerable change in the UCNNP. Overgrazing significantly affects the pasture lands and decreased 29 thousand ha over ten years between 1989 and 1998. However, changes during 2008 and 2018 show a significant rise in the pasture area, ending with 45 thousand ha of land. The results of the stakeholder analysis stated that the farmers and dekhkans have the interest to conserve their ecosystem. In conclusion, according to the results Uzbekistan rehabilitation achievements was due to (i) complex measures taken by government and ecologists, who clearly recognized that if the previous scenario will continue, the ecosystem of high altitude areas of UCNNP could be irreversibly damaged and (ii) cutting trees from the forest which leads to decrease forest area and increase pasture area.

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