Analyses of Land Use Land Cover Change Detection of the Ugam Chatkal National Park, Uzbekistan

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Abstract: The Ugam-Chatkal National Park was established in 1992 as a result of reorganization of Chatkol Biosphere Reserve. Located in the southern Tien Shan Mountain range, in the Chatkal mountain system, it is the largest natural reserve in Uzbekistan. The national park was created to protect unique ecosystems and endangered animals. In this study, the national park land cover change during the years 2000-2020 and the change map of precipitation in the corresponding years were created based on the satellite images. Land cover change was calculated using the Maximum likelihood classification (MLC) supervised classification method. From the change of the land cover, it can be determined that the amount of vegetation has increased in the last two decades, and the snow cover has decreased on the contrary. It was also found that open land cover increased in the south.

1 INTRODUCTION

According to (Costanza et al., 2014), natural ecosystems offer a range of goods and services that are necessary for human survival. Human activity, particularly industry and urbanisation, has an impact on natural ecosystems. As such, there is risk to ecosystem services, which are benefits that humans derive from ecosystems (Kremen, 2005). The history of scientific study on ecosystem services dates back to the late 1970s, but the first systematic assessment of the world's ecosystem services was carried out in 1997 (Gomes et al., 2021). Many scientists are working to build and promote a set of ecosystem service categories gradually (Czúcz et al., 2018; Gafurova et al., 2021).

The increase and decrease in the area of a particular land use or land cover is called Land use land cover changes (Tian et al., 2014). The term "land-use" was used by people for the proper use of land covers for self-sufficiency. LULC makes a significant contribution to the study of the process of urbanization, to the monitoring and understanding of changes in the urban area, its intensity, direction and impact. It provides valuable information for land use management and sustainable urban planning (Kontgis et al., 2014). GIS and Remote Sensing technologies are widely used to assess the dynamics of spatial and

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temporal changes of global LULC on a global scale (Lambin & Geist, 2008).

Using Landsat and MODIS satellite imagery, Yin et al. mapped forest land cover changes in Central Asia for 2009–2011 (Didan, 2015). The dynamics of expansion of irrigated cropland in the Kashkadarya region of the Republic of Uzbekistan in 1972-2000 was calculated by Edlinger et al. Tashkent region has very rich natural resources, in particular, the Ugam-Chatkal National Park is the largest natural protection area in Uzbekistan (Yin et al., 2017). The presence of more than 2,200 plant species in the park and the presence of large forest areas made the national park a UNESCO World Heritage Site in 2016 (Oymatov et al., 2023). Chukwudi et al. (Kumar et al., 2022; MohanRajan et al., 2020; Harris et al., 2020) studied the degree of variability and trends in annual rainfall in southwest Nigeria, taking into account the specific nature of rainfall and these data have implications for predictive modeling and long-term climate change/variability adaptation programs in the basin.
In this research, we mapped the National Park's land use change dynamics, vegetation cover change dynamics, and decadal precipitation change maps using spatial data analysis. The objective of the article is to study the impact of global climate change on the ecological condition of the national park.

2 MATERIALS AND METHODS

2.1 Study Area

Tashkent region borders the Republic of Kazakhstan to the north and northwest, the Kyrgyz Republic to the northeast, Namangan Region to the east, the Republic of Tajikistan to the south, and Syrdarya Region to the southwest. The area (without the area of Tashkent city) is 15.3 thousand km². The population (without the population of Tashkent city) is more than 2.931 million people (2022) (Oymatov et al., 2023). The climate is a typically continental climate with mild wet winters and hot dry summers. Chatkal National Park, with mountains and forests, is located within Tashkent Region.

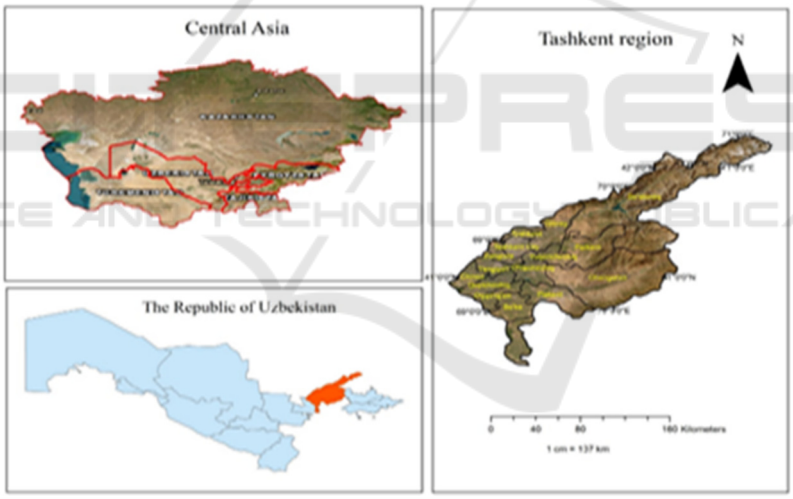

Figure 1: Location of Tashkent region.

2.2 Data Processing

Landsat-5 TM and Landsat 8 (OLI & TIRS) satellites were selected using the Earth explorer platform to download satellite images. Satellite images for the time period 2000–2020 were selected in June, allowing for up to 10 percent cloud cover (path 142, row 41;). Landsat satellite imagery has a resolution of 30x30 m with eight reflectance bands of 30 m, one panchromatic band of 15 m, and two thermal bands of 100 m. The downloaded raw data were processed in ArcGIS 10.7.1 without atmospheric correction. The remaining technical parameters of the satellite can be seen in the table below.

2.3 Method

There are various geospatial software tools used by us researchers at different stages in the precise study of remote sensing. An example is the pre-processing, classification, analysis, and prediction of LU/LC changes using multispectral satellite imagery. Some of them are: ENVI, ArcGIS, IDRISI, ERDAS Imagine, Quantum GIS and Google Earth. Land cover

change classification and understanding can also be assessed using various remote sensing indices: NDVI, NDWI, NDBI, SAVI etc. Indices calculated using satellite images have demonstrated the ability of GIS to systematically, reliably and spatially comprehensively monitor greenness and accumulation indices. Methodological workflow and data analysis of scientific research in the figure below (Fig. 2).

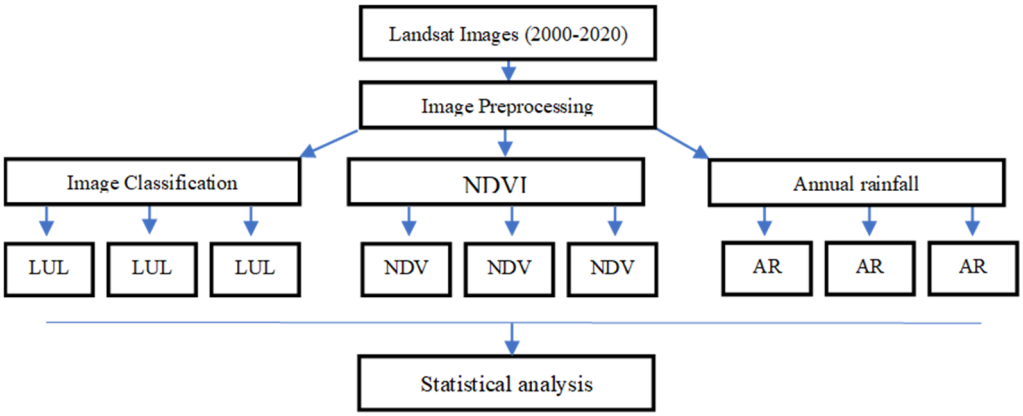

Figure 2: Methodological workflow and data analysis.

Several types of land cover were distinguished based on the study area in ArcGIS 10.7 using satellite images as a source of information. Image classification was performed using the MLC Supervised Classification method. The main reason that the downloaded spatial data was taken in June is that the vegetation index is close to the maximum point, as well as the selection of a cloudless image. As mentioned above, only four of the 8 bands - Red, NIR, SWIR, and TIRS1 bands- are required for LULC analysis (Fig. 5). Vegetation cover analysis is calculated by NDVI; the formula is given below. Index varies between -1 and 1. In this case, the larger the value, the healthier or dense plant cover is understood, and the negative value is not considered vegetation (Fig. 3).

NDVI = (NIR-RED)/(NIR+RED),

where: NIR is the Near Infrared band of Landsat sensor (band 4 for Landsat TM 5 and Landsat-5 TM; band 5 for Landsat 8 OLI); and RED is the red band of Landsat sensor (band 3 for Landsat TM 5 and Landsat ETM+ 7; band 4 for Landsat 8 OLI).

The CRU TS has provided a collection of high-resolution, monthly observations dating back to 1901 (Yin et al., 2017). This set consists of ten observed and derived variables. Rainfall data from this collection were analysed and mapped using software (Fig. 7).

3 RESULTS AND DISCUSSION

The achieved results show that within 20 years the LULC of the National Park changed significantly. The obtained results can be used for monitoring glaciers, determining the flood of glacial lakes, estimating forest biomass, and preserving biodiversity in the national park (Table 1).

Table 3: Results of LULC assessment in the National Park.

Classes	Area (km^2)		
	2000	2010	2020
Snow	3200.3	1513.96	587.019
Bare land	1686.68	2239.74	2273.74
Water	54.3852	73.8441	45.8622
Vegetation	1684.19	2798	3741.37

Significant changes in vegetation cover were observed due to the melting of glaciers and snow. Although there is an increase in NDVI, it can be seen that there is a regular decrease in the highest density of green vegetation (Fig. 4).

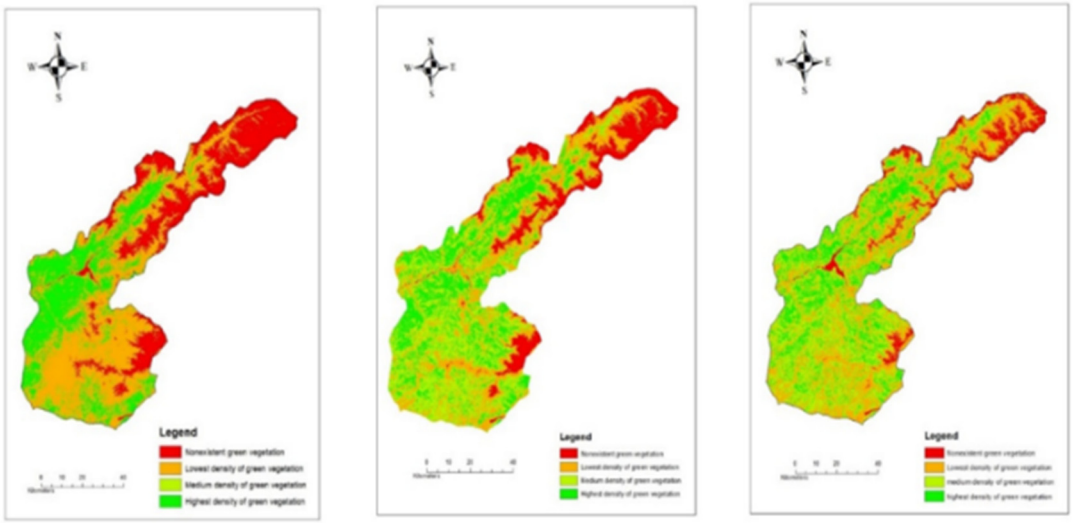

Figure 3: NDVI map of Tashkent region.

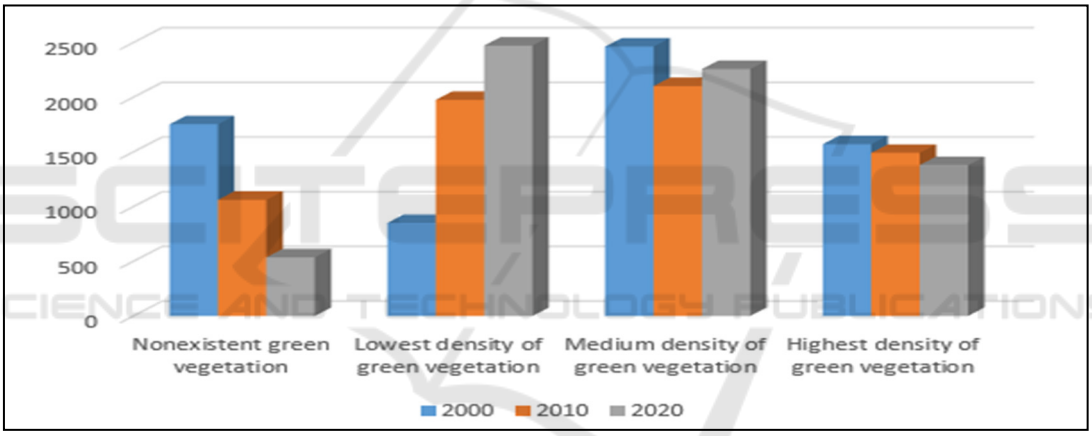

Figure 4: NDVI change dynamics of the study area.

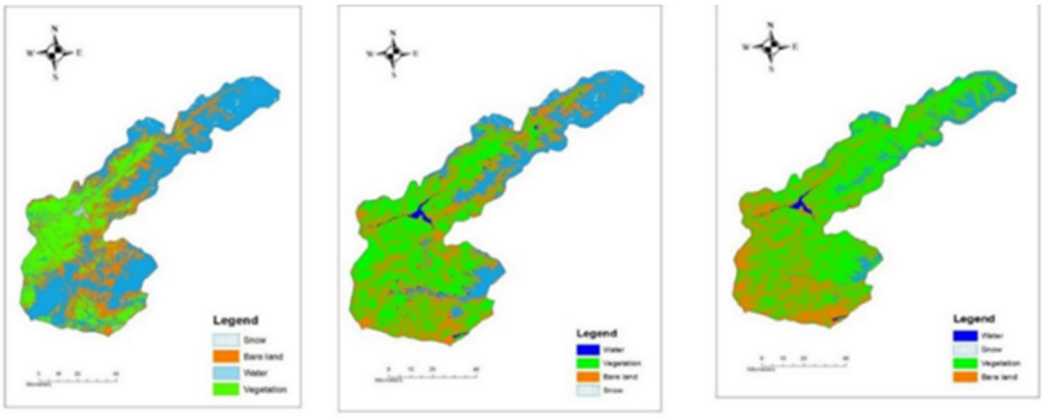

Figure 5: LULC in Tashkent region during 2000-2020.

The main reason for doing LULC is to evaluate the significant changes in the land surface over a long period of time due to natural causes. serious changes in the land cover caused a sharp change in the snow cover against the background of global climate change. as a result, it can be seen that the vegetation cover was formed on the lands formed by the melting of the snow cover, on the contrary, the amount of bare land in the residential areas and resort zones increased in the lands where there was a green cover (Fig. 6).

Annual precipitation data is derived from Version 4 of the CRU TS monthly high-resolution gridded multivariate climate dataset (Juliev et al., 2022; Teshaev et al., 2020; Aslanov et al., 2023; Musirmonov et al., 2023; Juliev et al., 2023). The downloaded data were analyzed in ArcGIS software to create rainfall maps for the respective years. The areas of the national park where bare land is growing, a decline can be seen the amount of annual precipitation while in the northern part the amount of precipitation has increased (Fig. 8).

It can be seen from these maps that the annual precipitation in the southwestern parts has decreased sharply in recent decades, while the amount of heavy precipitation has increased in the northeastern part of the division. This conclusion was also clearly shown by LULC maps (Fig. 5).

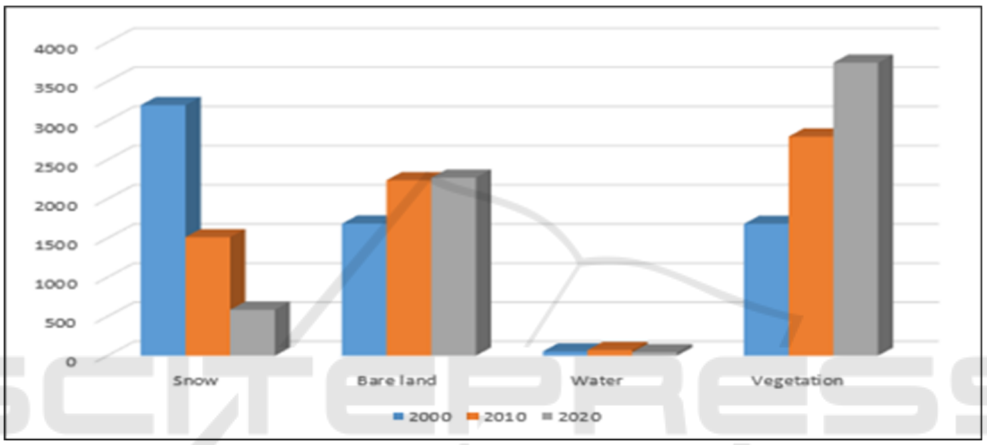

Figure 6: NDVI change dynamics of the study area.

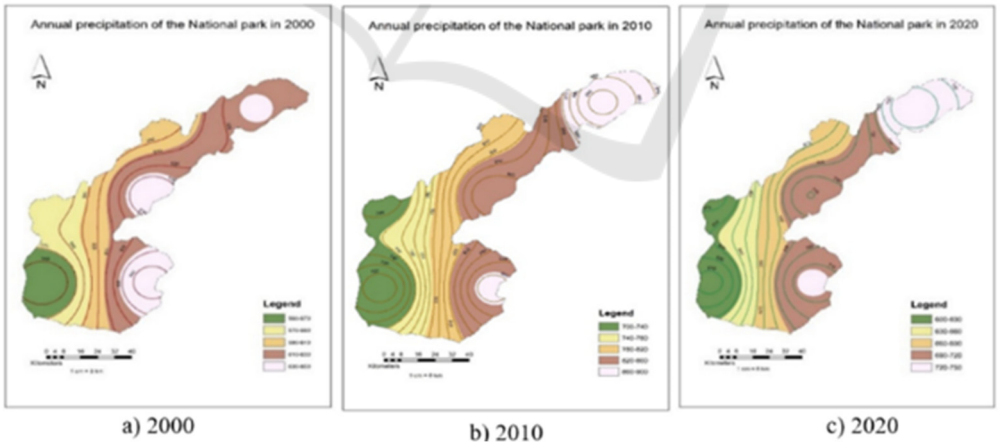

Figure 7: Annual precipitation maps of the study area.

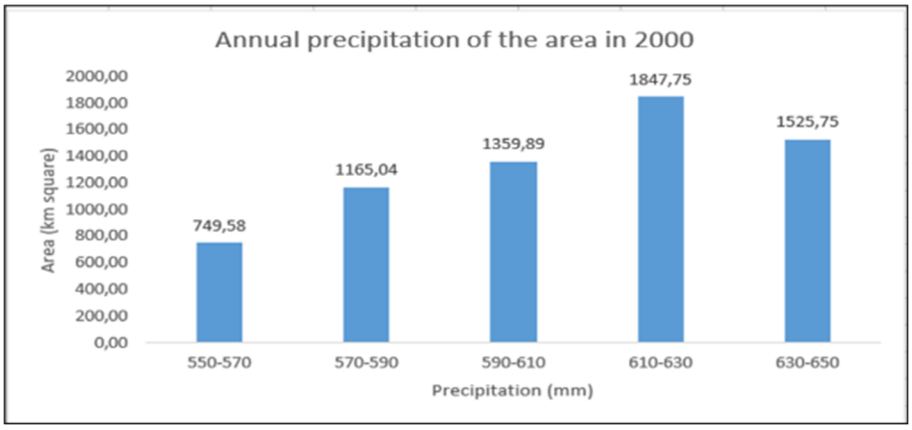

Figure 8: Yearly Precipitation Chart (in millimeters) for the study area in 2000.

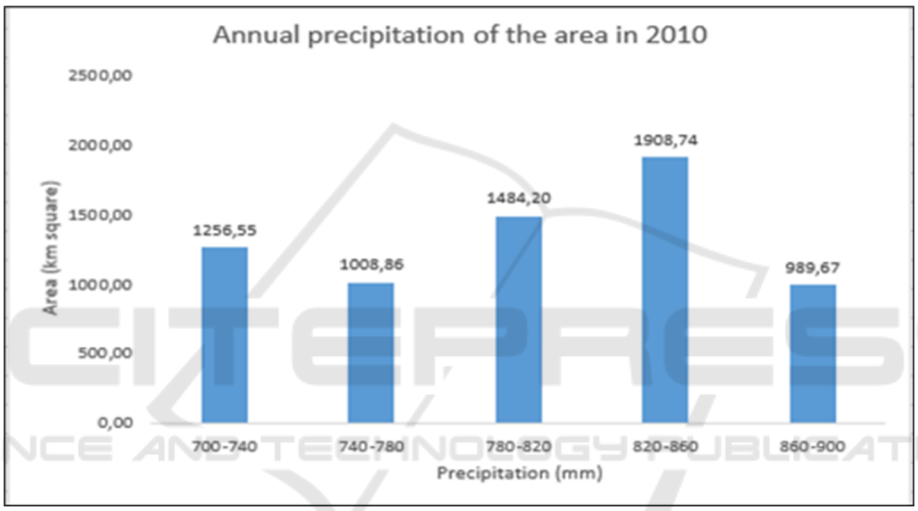

Figure 9: Yearly Precipitation Chart (in millimeters) for the study area in 2010.

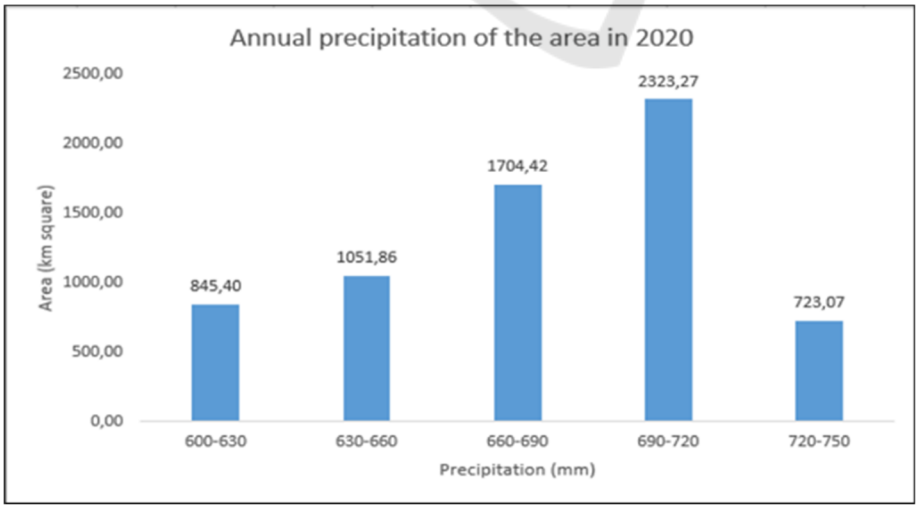

Figure 10: Yearly Precipitation Chart (in millimeters) for the study area in 2020.

4 CONCLUSIONS

The impact of global climate change in the Central Asian region is becoming more severe every year. In analyzing the dynamics of these changes, the importance of RS and GIS systems is getting stronger year by year.

- the greenness index has been increasing in the national park for the past 20 years. This is mainly observed in the northern and eastern parts of the region;

- in the territory of the national park, a decrease in snow cover was observed in the last 20 years, as a result of which the growth of vegetation accelerated;

- as a result of anthropogenic effects, an increase in bare lands was observed in the southwestern lands;

- the change in annual precipitation was observed to increase mainly in the northern region and decrease in the southern regions.

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