Land use remote sensing and monitoring using GIS technologies (in the example of the Republic of Karakalpakstan)

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Abstract: This article describes the application of remote sensing data to monitor and analyze land use and land cover changes, natural phenomena and human activities on the environment. In this case, the information on the maps helps to determine the categories of effective land use for sustainable development. Remote sensing and GIS help to organize and control the natural resources in any part of the world, analyze the effect of anthropogenic factors on the earth's surface and its use and change. In this article, the change of the land layer of the Republic of Karakalpakstan in the last 5 years and the identified changes were compared and analyzed with the help of geoinformation technologies in the analysis of space images using the Sentinel-2 global satellite data and data visualization [1,2].
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1. Introduction

Analysis of changes in the soil layer is very important for development planning and management, modeling of land use system. Examples include deforestation, dynamics of watershed lands, sedimentation phenomena, development of agricultural lands, etc. Land cover and land use are different. Considering that the earth layer is the biophysical surface of the earth (natural plants, water bodies, trees, soil and rocks), land use is formed as a result of human socio-economic and political visions. The change of the earth's layer is a natural phenomenon, but today we can see that it has changed rapidly under the influence of global and regional environmental changes and anthropogenic factors. Timely operational detection and analysis of such changes with the help of remote sensing and GIS is useful in land use management and land policy to prevent negative changes [2,7].

2. Materials and methods

Study Area. The land fund of the Republic of Karakalpakstan was taken as the object of this study. The Republic of Karakalpakstan is located in the southwestern part of Central Asia, the coordinates of its northern and southern parts are 40*55’ and 45*35’ north latitude, and the western and eastern extreme points are 56*02’ and 62*24’ east longitude.

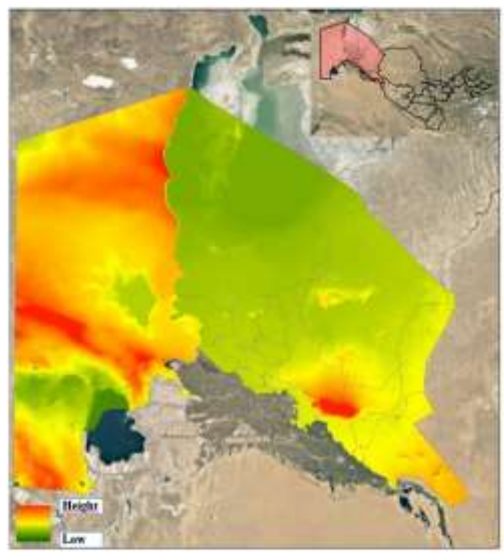


Figure 1. Study Area

The surface structure of Karakalpakstan is not complicated. The highest point is the Sultan Wais mountain range, which is 473 m above sea level. Sarikamish and Audan sediments are relatively low. The western part is the Ustyurt plateau, and the other part is the Turan lowland. The climate is sharply continental, the annual precipitation is around 90-100 mm. Of course, the drought is acutely felt in this part of the region. Evaporation is 9-10 times more than actual. Although the land area in the Republic of

Karakalpakstan is large (16,659.1 thousand hectares as of 01.01.2021), the possibilities of developing irrigation farming are limited.

Sources Data and Analysis Methods.

Downloaded Sentinel-2 datasets for land cover and land use dynamics(https://scihub.copernicus.eu/). Data were analyzed in ArcGIS 10.8. The Livingatlas.arcgis program was used to compare the results (https://livingatlas.arcgis.com/landcoverexplorer/).

Image pre-processing and classification.

One of the important tasks is to process the raster data before determining the changes in the ground layer. Sentinel-2 satellite images were mosaicked in ArcGIS software [4]. The ground layer classes data were inputted to obtain spectral wavelet thematic data at each pixel. There are many ways to select and define classes. But we can achieve high and accurate results if the classes of the earth's layer are selected based on the natural geographical conditions of the research area (figure 2) [6,7]. The study area was divided into seven main classes. These are water, trees, flooded vegetation, crops, built area, bare ground, rangeland. The complete information about the above ground layers is shown in Table 1.

Table 1. Details of land cover categories

Land cover types	Description
Water	Areas where water was predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built up features like docks; examples: rivers, ponds, lakes, oceans, flooded salt plains.
Trees	Any significant clustering of tall (~15 feet or higher) dense vegetation, typically with a closed or dense canopy; examples: wooded vegetation, clusters of dense tall vegetation within savannas, plantations, swamp or mangroves (dense/tall vegetation with ephemeral water or canopy too thick to detect water underneath).
Flooded vegetation	Areas of any type of vegetation with obvious intermixing of water throughout a majority of the year; seasonally flooded area that is a mix of grass/shrub/trees/bare ground; examples: flooded mangroves, emergent vegetation, rice paddies and other heavily irrigated and inundated agriculture.
Crops	Human planted/plotted cereals, grasses, and crops not at tree height; examples: corn, wheat, soy, fallow plots of structured land.
Built Area	Human made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings and residential housing; examples: houses, dense villages / towns / cities, paved roads, asphalt.
Bare ground	Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and sand dunes, dry salt flats/pans, dried lake beds, mines.
Rangeland	Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting (i.e., not a plotted field); examples: natural meadows and fields with sparse to no tree cover, open savanna with few to no trees, parks/golf courses/lawns, pastures. Mix of small clusters of plants or single plants dispersed on a landscape that shows exposed soil or rock; scrub-filled clearings within dense forests that are clearly not taller than trees; examples: moderate to sparse cover of bushes, shrubs and tufts of grass, savannas with very sparse grasses, trees or other plants.

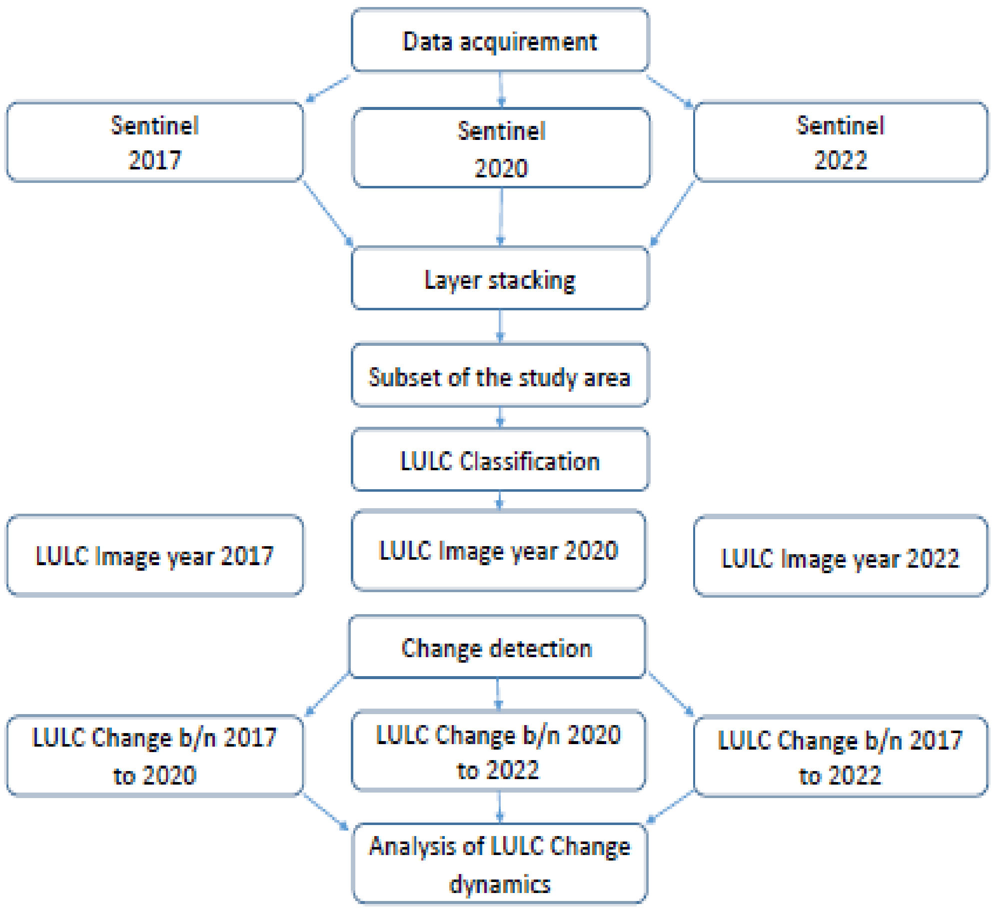
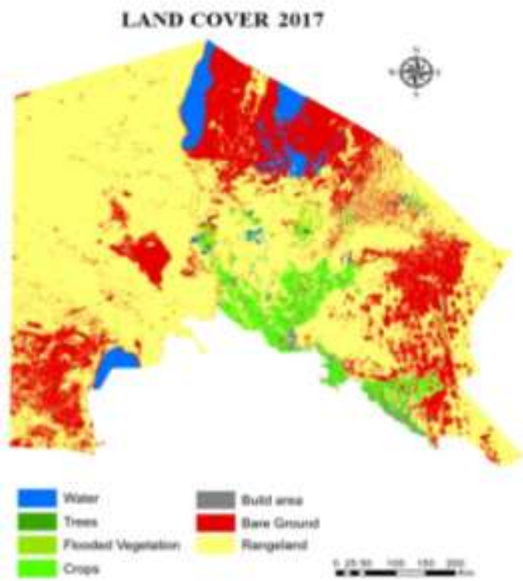
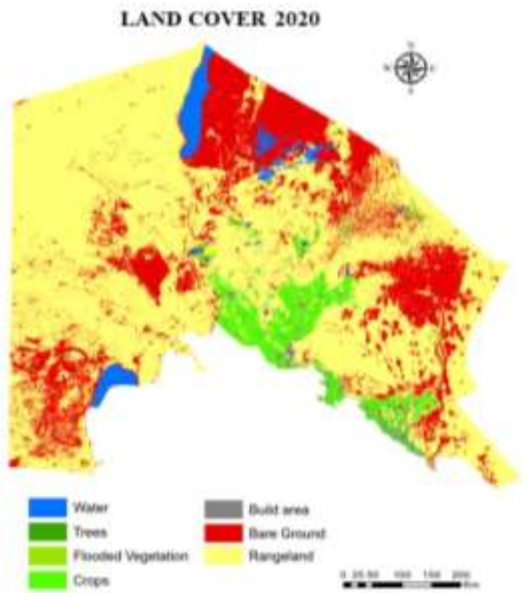


Figure 2. Structural analysis of image classification

3. Results and discussion

Variation detection analysis identifies and quantifies differences in the same fields at different times. This analysis can be done using three years of classified data to detect changes in land surface area and data. This is very useful for identifying changes that occur in different classes. For example, in land use, the increase of urban areas or the reduction of the vegetation layer, etc. Identified changes can convert a land layer into a land use or, conversely, a land use into a land layer. However, it is very difficult to generalize changes in land use. For example, land degradation.





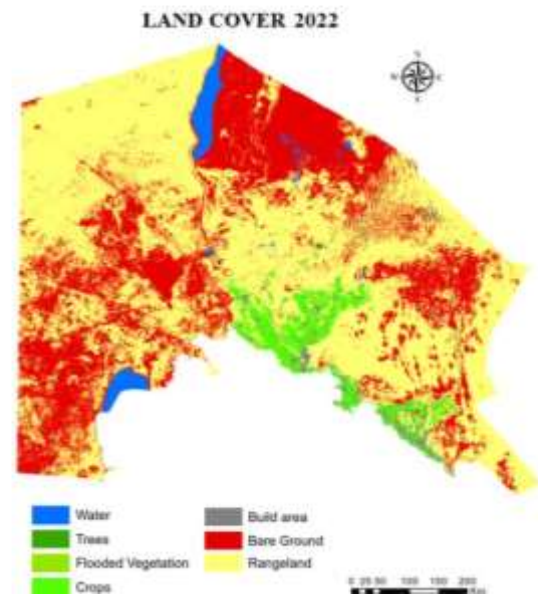


Figure 3. Land use land cover maps of study area

Changes in land use and surface area of the Republic of Karakalpakstan are shown in Table 2.

Table 2**:** Summary Statistics of land use / land cover from 2017 to 2022

Class	2017 Area (km.kv)	%	2020 Area (km.kv)	%	2022 Area (km.kv)	%	Rate of change		
							2017-2020	2020-2022	2017-2022
Water	6411	3,85	4744	2,85	3567	2,14	-1667	-1177	-2844
Trees	84	0,05	178	0,11	29	0,02	94	-149	-55
Flooded vegetation	1868	1,12	878	0,53	171	0,10	-990	-707	-1697
Crops	6818	4,09	7886	4,73	6685	4,01	1068	-1201	-133
Build Area	1500	0,90	1575	0,95	1727	1,04	75	152	227
Bare Ground	39758	23,86	39397	23,65	55068	33,05	-361	15671	15310
Rangeland	110161	66,12	111942	67,19	99353	59,64	1781	-12589	-10808

In 2017, we can see that Rangeland (66.12%) and Bare ground (23.86%) accounted for the most area of land use classes. This is due to the fact that the region is located in a desert zone. In 2020 and 2022, the changes in the land layer were also stronger in these classes. We can consider the drying of the Aral Sea, which is currently one of the global problems, to be one of the main reasons for these changes. The lack of water resources in the region and the increase in salinity have led to a sharp decrease in the vegetation layer (Figure 4).

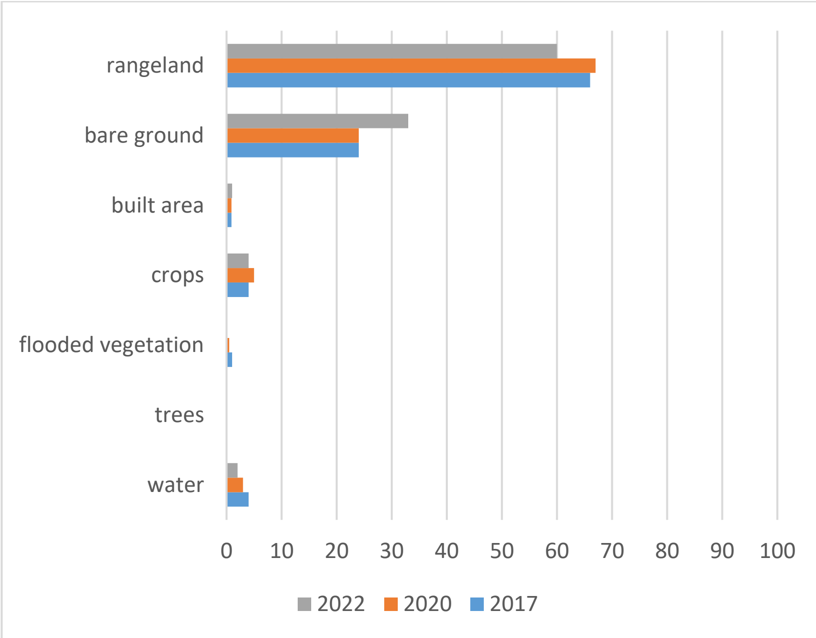


Figure 4. Pattern of Land Use/ Land Cover Change

We can see that the area of the tree layer in the study area is very small. This is due to the small and sparse area of forests in the region.

4. CONCLUSIONS

In the course of this study, data analysis and monitoring were carried out in the creation of geospatial data on land cover problems and soil salinity in the Republic of Karakalpakstan. In carrying out natural geographical research, observations were made using remote sensing data, effective solutions for obtaining cartographic and remote sensing data were used. The article also used land cover analysis sections, statistical and systematic approach methods.

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