Study of the dynamics of LULC change using remote sensing data and GIS technologies (case study of the Kashkadarya region)

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Abstract. In studies of global environmental change and heat balance, land surface temperature plays a crucial role in determining radiation budgets as a control for climate models. Particularly in quickly growing cities, the significance of precise and timely data characterizing the kind and amount of land resources and changes over time is growing. We used satellite imagery from 2000, 2007, 2015, and 2022 to create a system for identifying changes in land cover. The five categories in the study area were built-up area, plantation, watershed, agricultural land, and pasture. The maps showed that from 2000 to 2022, rural or developed land increased from 12.1% to 46.3% of the total area, while agricultural land, plantations, water bodies, and pastures covered the entire study area. It decreased from 91.88% to 47.6%. The results showed that the area of cities (many built up) has increased dramatically. In contrast, grasslands, agricultural land, water bodies, and plantations have clearly decreased from 2000 to 2022. The remote sensing and GIS techniques used in this study proved effective, reduced time to analyse city expansion, and have been found to be useful tools for assessing the effects of urbanization based on satellite imagery over the years. GIS technologies provide precise and affordable methods for tracking land cover change over time, which may be utilized as management choices and guidance. The results show patterns of land use and cover change in Kamashi district and highlight the potential of remote sensing.

1 Introduction

The Earth's surface has changed and evolved while its existence and history on a variety of spatial and temporal scales, some temporarily and others over many years; some of these changes are reversible, while others are irreversible [1]. The magnitude, velocity, and spatial scope of direct and indirect changes in the earth's surface in the last decade have been unprecedented [2]. Additionally, they contend that changes in land cover and land use are both causes and effects of human-induced surface alteration. Furthermore, both changes are

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so little when considered globally that they significantly affect the way the Earth system functions. Although land cover is a clear indicator of land use that encompasses both vegetative and non-vegetative properties, land use itself may be considered changeable. Arable land, grassland, pastures, and managed forests are examples of natural environments that are altered and managed in accordance with their functional roles in their respective catchment areas. In contrast, land cover refers to visible land use show that possesses both vegetative and non-vegetative characteristics [3]. Since Land use and land cover (LULC) are typically subtracted from one another in mapping, it is easy to identify land cover in the area. Furthermore, because they are employed in tandem to prevent ambiguity in the research area, the two concepts are closely related [4]. The flow of business and residential land to the countryside on the outskirts of large towns has long been regarded as a sign of a robust local economy. The term "urban expansion" describes this tendency. However, ecosystems' drawbacks are beginning to outweigh their benefits. Among these drawbacks include degradation of air and water quality, deforestation and loss of arable land, socioeconomic implications of economic inequality and social dispersion, infrastructure costs, and outflow of urban growth with SWAT models. The rapid emergence of sparsely populated suburbs in formerly rural areas, the formation of exurbs-urban or suburban areas bordering developing nations-and land modifications, sometimes referred to as urban expansion, all have an impact on the basic constituents of the Earth system.

Land cover is the term for observable evidence of land use that includes both vegetative and non-vegetative features, whereas land use can be defined as human land use, usually with an emphasis on land use [3]. It is widely accepted that natural and socioeconomic factors, together with human usage throughout time and space, influence the pattern of LULC in each area [8, 9]. A large amount of surface data is required to adequately monitor and analyze changes in LULC. Such data on land use and cover change was previously generated globally mostly by traditional land identification techniques, which were not only very time-consuming, expensive, and labor-intensive, but also impracticable for tracking dynamic changes over shorter timeframes. [10, 11]. Recent improvements in GIS and RS devices and methodologies have enabled academics to efficiently model urban growth. For example, as demonstrated in the works of [12, 13], and [14], satellite remote sensing has the potential to provide accurate and timely geodata describing changes in the LULC of agglomerations. Satellite remote sensing images provide excellent data sources from which efficient information about LULC can be extracted, analyzed, and simulated. The consumption of natural resources has grown due to urban expansion, which has also altered LULC patterns [15]. For instance, they have connected urban growth or expansion to regional economic viability, particularly when it comes to the transfer of land use from private to commercial usage in rural areas on the outskirts of large cities. To monitor and analyze changes in LULC effectively, a significant amount of surface data is needed.

Thus far, conventional methods of soil removal have generated most of the information on changes in land use and cover worldwide. These methods were labor-intensive, costly, time-consuming, and required a great deal of work. Moreover, they were not very practical for monitoring changes in land use over shorter time periods due to their slow pace [10]. Researchers can now efficiently estimate urban growth thanks to recent advancements in RS instruments and techniques as well as GIS. Excellent data sources for extracting, analyzing, and simulating LULC information are satellite photos obtained by remote sensing. As demonstrated by the studies of [12,13], and [14], satellite remote sensing, for instance, could deliver precise and fast geospatial information that characterizes changes in LULC in urban regions. To sustain or raise living standards and conditions, it is imperative to comprehend environmental processes and concerns, which can only be studied with the use of land use data. Changes in the categories of land use, land cover, and research area are described in this study. The current study set out to investigate how land and soil use in Kamashi district's

Kashkadarya region has changed over time. This area is well known for its rapid urbanization, which has led to uncontrolled growth of cities, substandard living conditions, and a declining environmental state-all of which have a negative impact on public health. Establish the rate and pattern of land use before creating a sensible land use policy. The aim of the study was a comparative analysis of the change in land use in the city of Kashkadarya region with RS and GIS tools.

2 Materials and methods

2.1. Study area

The Kashkadarya region is in the south of Uzbekistan. Kashkadarya region occupies an area of 28,400 km^2 and is in the south-eastern part of Uzbekistan on the western slopes of the Pamir-Aloy mountains. The Kashkadarya river enters the plain of the western part of this region, the Kamashi steppe. The climate of the region is continental, with hot and long summers, short winters, and little snow [19]. The long-term average annual temperature in the region is 13.5°C. Precipitation occurs mainly in the winter months, shows an increasing trend from the desert to the mountains, and averages 355 mm per year [20]. It borders Bukhara, Navoi, Samarkand, and Surkhandarya regions within the country. In addition, it has borders with Tajikistan in the northeast and Turkmenistan in the south. The Kashkadarya region is now divided into thirteen administrative districts. Kamashi serves as the region's center. The largest districts in terms of area are Dekhanbad, Chirakchi, Mubarak, and Mirshikor, while Kasbi and Kamashi are the smallest. Agriculture in the Kashkadarya region is based on increased irrigation, particularly during the summer, and considers rainfall and weather patterns. Since the mid-1960s and 1970s, this region has been heavily irrigated. The projected irrigation network was intended to provide water to over 550,000 hectares of irrigated land**.**

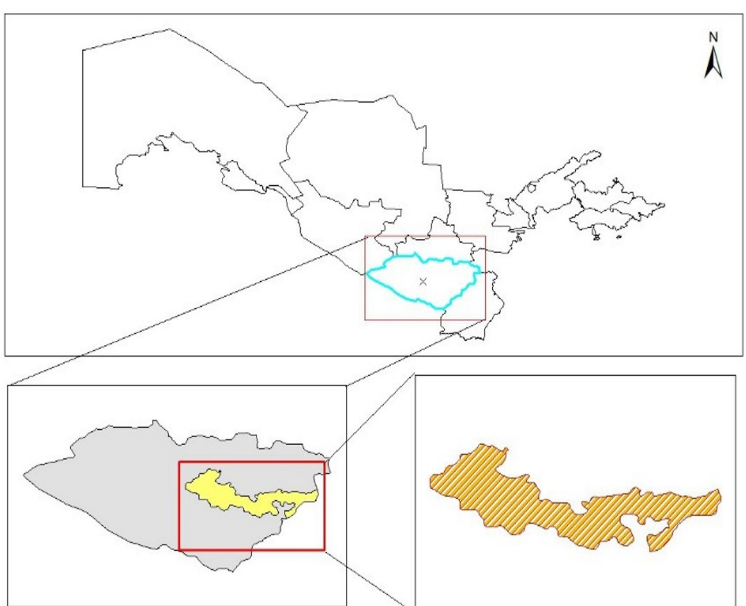

Fig. 1. Study area: Kashkadarya region (source: www.diva-gis.org/data adapted by ArcGIS).

The freely downloadable source for LULC dynamics was Landsat imagery from http://earthexplore.usgs.gov/ . The details of the satellite data are shown in Table 1. The imagery was processed using programs like ArcGIS 10.8 and ERDAS Image 14. The various procedures that were developed and applied to assess, measure, and analyze the map are shown in Figure 2. Areas of interest (AOIs) were selected and gathered to serve as training areas for the supervised classification of the pre-defined land cover types (LCTs). The clustering of pixels into built-up area, plantation, water body, agricultural land, and pasture land is shown in Table 2. Different numbers of AOIs were used to classify the images from the four dates (2000, 2007, 2015, and 2022) (Table 1).

Table 1. Satellite images were used.

s.no.	Image	Resolution(m)	Sensor	Road	Series	Source
1.	Landsat 8	30×30	OLI	1 36	42	http://earthexplore.usgs.gov/
2.	Landsat 7	30×30	ETM+	1 36	42	http://earthexplore.usgs.gov/
3.	Landsat 7	30×30	ETM+	1 36	42	http://earthexplore.usgs.gov/
4.	Landsat 7	30×30	ETM+	1 39	42	http://earthexplore.usgs.gov/

Table 2. Details of land cover categories.

Land cover types	Description
Built-up area	This category comprises all the manmade infrastructures like buildings, roads and concretized area
Plantation	This category is comprised of planted junipers, eucalyptus trees, Acacia and natural forest or areas covered by trees planted around homesteads and some public institution areas.
Water body	Manmade wells and ponds
Agricultural lands	Agricultural fields
Pastureland	Land under permanent pasture and grassland and it is owned either grazing areas or also those owned by various institutions. This includes grasslands, playground with grass covered, and garden

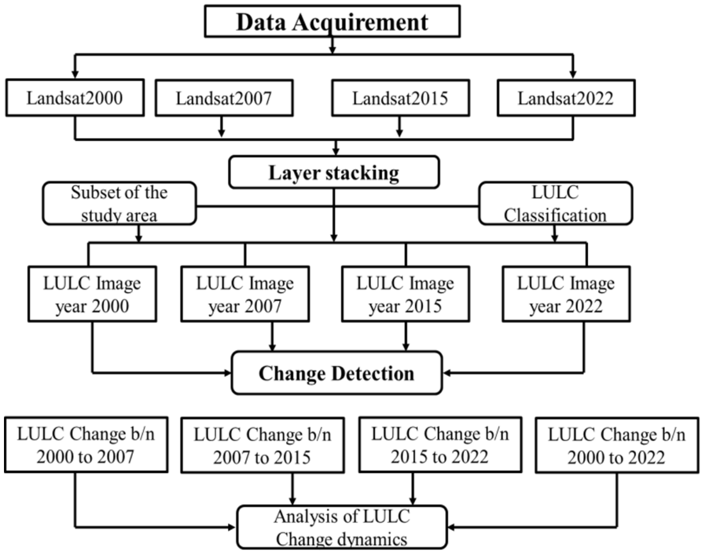

Fig. 2. Illustrate the methodology adopted for land use classification and land use change detection.

2.2. Change Detection Analysis

Change detection analyses determine and quantify the differences between images of the same scene taken at different times. Calculating the area covered by various land coverings and tracking changes over time may be done with the use of the classified photos from the four dates. This research is highly useful in identifying a variety of changes that are taking place in different land use classes, such as a rise in urban built-up area and a decrease in vegetation.

3 Results and discussion

3.1. Land Use Land Cover Changes Dynamics

The study's land use/land cover index findings were proposed and assessed for the purpose of mapping forested regions and bare land/open spaces using remote sensing data. The index allowed for the maximum likelihood classification of shifting forests and bare land/open regions. Changes in LULC would have an impact on the rate of urban growth, either directly or indirectly. The growth of the land use area and changes in land cover for the city of Kamashi districts between 2000 and 2022 are displayed in Table 3 and Figures 3(a), 3(b), and 4. The data on LULC were analyzed and collated, as shown in Table 4, to determine the main changes that occurred between 2000 and 2022. The outcome shows that between 2000 and 2022, the extension of covered area for agricultural land decreased.

Table 3. Territorial coverage of each LCT in 2000-2022.

LCT	2000 year		2007 year		2015 year		2022 year	
	A (km^2)	A (%)	A (km^2)	A (%)	A (km^2)	A (%)	A (km^2)	A (%)
Built up area	3,6	12,11	6,56	21,36	5,54	17,82	14,73	46,93
Plantation	7,4	24,90	1,16	3,78	5,18	16,66	3,9	12,42
Water body	0,26	0,87	0,68	2,21	1,04	3,35	0,56	1,78
Agricultural land	13,76	43,18	18,18	59,20	17,22	55,39	11,02	35,11
Pasture land	4,7	14,75	4,13	13,45	2,11	6,79	1,18	3,76
Total	29,72	100	30,71	100	31,09	100	31,39	100

As indicated in Table 4, the LULC information was computed and compiled to identify the primary shifts that took place between 2000 and 2022. The percentage of developed areas increased significantly between 2000 and 2022. The outcome shows that between 2000 and 2022, the agricultural land's covered area shrank. This displays agricultural land that can be used for homes. Over the course of 22 years, the urbanized area increased at an extremely rapid rate. The built-up area was roughly 14,7 km^2 in 2022. Of the entire research area, 46,9% is covered by the construction. Over the past 22 years, almost all aspects of land cover have changed, either by gains or losses.

All classifications of land cover have been explained in terms of gains and losses, as shown in Fig. 5. As shown in Figure 5 and Table 4, the trend to alter LULC between 2000 and 2022 was previously expressed in tabulations and charts. Over a 22-year period (2000–2022), the built area grew by 11,13 km2, whereas the amount of agricultural land fell by 9,19 km2. We utilized the results of the GIS map categorization from 2000 to 2022 to determine the increase and decrease of the LULC in the region.

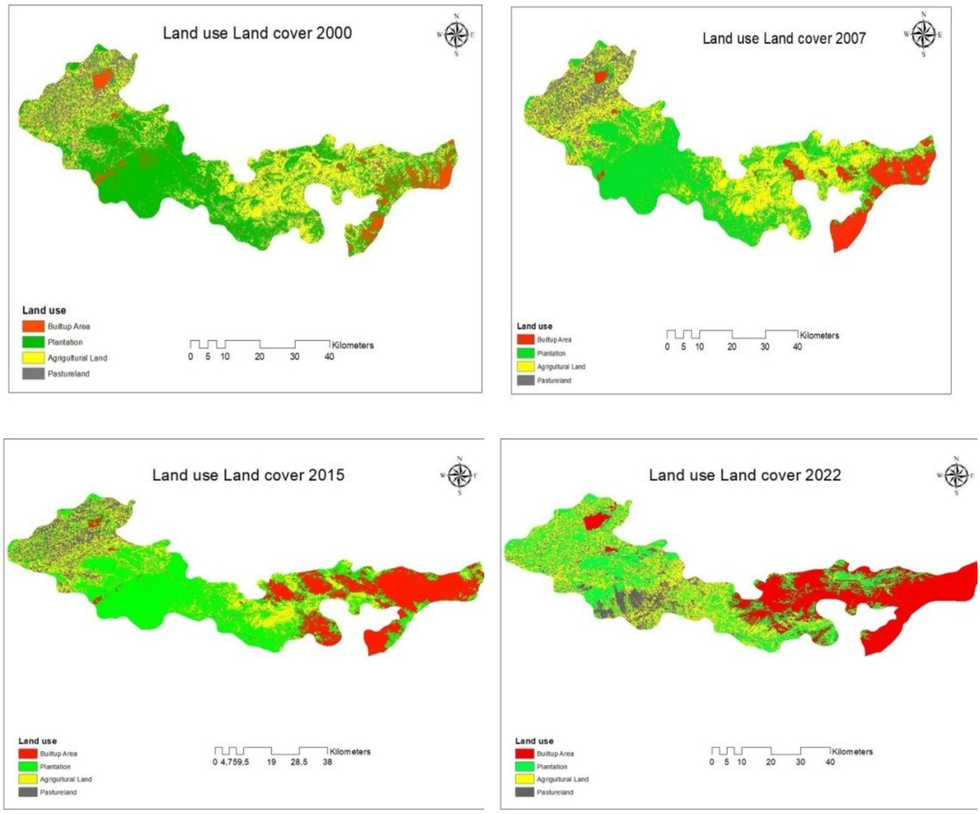

Fig. 3. ((a) Land cover maps of Kamashi district in 2000 and 2007; (b) Land cover maps of Kamashi district in 2015 and 2022.

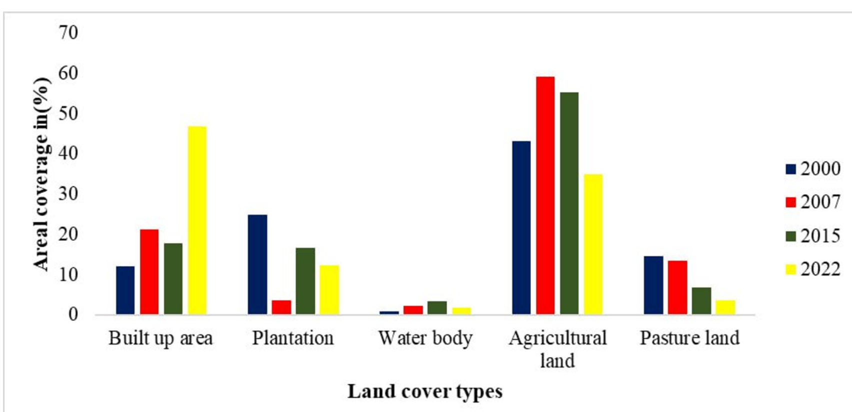

Fig. 4. Classification status of land covers in 2000, 2007, 2015, and 2022.

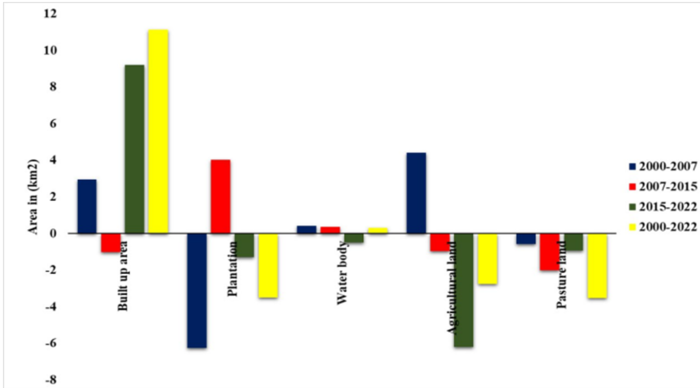

Fig. 5. Area increases and decreases in LULC between 2000 and 2022.

Table 4. Summary statistics of land use/land cover from 2000 to 2022.

LCT	2000 y	2007 y	2015 y	2022 y	2000-2007 years	2007-2015 years	2015-2022 years	2000-2022 years
	km square							
Built up area	3,6	6,56	5,54	14,73	2,96	-1,02	9,19	11,13
Plantation	7,4	1,16	5,18	3,9	-6,24	4,02	-1,28	-3,5
Water body	0,26	0,68	1,04	0,56	0,42	0,36	-0,48	0,3
Agricultural land	13,76	18,18	17,22	11,02	4,42	-0,96	-6,2	-2,74
Pastureland	4,7	4,13	2,11	1,18	-0,57	-2,02	-0,93	-3,52

3.2 Cause of LULC Change Dynamics

Land use change has consequences and effects that are outlined in Figure 4 and Table 4. The main causes of land cover-land-use dynamics are a variety of natural and human-induced processes, even though the exact timing of the occurrence varies. Some sections of the literature point to rapid population increase as one of the main reasons of population change, even if the impact of population growth on land cover dynamics is controversial. This also holds true for Kamashi district's, where the district's fast population increase has caused land scarcity, soil erosion, forest cover elimination, and land degradation. Nonetheless, the practice of afforestation encouraged the local population, which led to a gradual rise in the amount of forest covered in urban areas. Furthermore, they were compelled to expand pastures and agricultural areas due to a lack of available land. As a result, resources moved to different LULC groups and became increasingly susceptible to additional erosion and degradation. Soil erosion and degradation are not usually caused by changes in land cover and usage. However, productive soil is more susceptible to severe erosion and degradation as land-use change quickly spreads into grazing, dry, and agricultural regions, especially on terrain without thick forests [20] [21]. Agricultural land, pastures, water bodies, and land plantations were moved to urban areas between 2000 and 2022, according to the categorized picture of the shift in many land use classifications. This suggests that erosion and deterioration, along with its consequences, are made worse by the ways in which LULC categories change over time.

4 Conclusions

Due to population and economic growth, urban areas are rapidly growing, which changes land use, especially in cities, and increases demand for natural resources. In a rapidly expanding urban town, remote sensing and GIS technologies have been used to thoroughly examine the major issues brought on by rapid development, including the need for more infrastructure, informal settlements, pollution, ecological structure destruction, and a shortage of natural resources. The Kamashi district of the city's LULC changes (LULC) are assessed in this study. Rapid population increase and urbanization have the most substantial effects on land cover, necessitating immediate intervention.

In the city of Kamashi district, land use and changing land cover are classified as built areas, plantations, water bodies, agricultural land, and pastures. The results indicate that the city's growth is becoming more urbanized. Generally speaking, the Kamashi district's built area would grow to 14.1 km^2 between 2000 and 2022, including 3.6 km^2 of planting space, 0 km^2 of a body of water, and pasture and agricultural land. The overall area of bodies of water has dropped to 0.0% in the last 20 years. The study area's generated area would grow more and account for around 52.4% of the total area between 2000 and 2022 than the other city groupings.

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