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Urban land use/cover mapping and change detection analysis using time series satellite images

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Abstract

Land use and land cover change have been among the most important perceptible changes taking place around us. Although perceptible, the magnitude, variety and the spatial variability of the changes taking place has made the quantification and assessment of land use and land cover changes a challenge to scientists. Furthermore, since most of the land use and land cover changes are directly influenced by human activities, they rarely follow standard ecological theories. The Remote Sensing and Geographic Information System has proved to be very important in assessing and analyzing land use and land cover changes. Satellite-based Remote Sensing, by virtue of its ability to provide synoptic information of land use and land cover at a particular time and location, has revolutionized the study of land use and land cover change. The temporal information on land use and land cover helps identify the areas of change in a region. The use of Geoinformatics has enabled us to assign spatial connotations to land use land cover changes, namely, population pressure, climate, terrain, etc which drive these changes. This has helped scientists to quantify these tools and to predict various scenarios. The purpose of this paper is to detect and evaluate land use and land cover changes (LULCC) of Khanaqin urban area over 20 years using remote sensing techniques and Landsat dataset for years 2000, 2010, and 2020. For this purpose supervised classification algorithm and maximum likelihood method has been used. Results show that Water lands, Built-up area, and Vegetation areas increased from 2000 to 2020 in the last 20 years while Barren lands, and Agricultural mixed lands had decreased. According to the analysis and results obtained, this research can be useful in the field of regional and environmental management in the city of Khanaqin and in the field of urban planning and management and research decisions in this region can be used.

Keywords: Land use, Land cover, Change detection, Remote sensing, Khanaqin.

1. Introduction

Human beings have been altering the face of the earth for the last few centuries but with the introduction of machines, the land cover of the earth has changed drastically in the last three centuries. The debate about the relationship between human population dynamics and the availability of natural resources dates back to more than 200 years when Malthus (1798) put forward his argument that population growth would eventually outstrip the production capacity of the land. It was only in the second half of the 20th century when the probability of the Malthusian projection seemed to be a reality, that sincere efforts to study the human population–environment relation were undertaken. The Scientific study and analysis of land use and land cover change involves a quantitative estimation of land use and land cover at a particular location and time. In this regard, remote sensing plays a major role in giving a synoptic view of the spatial extent of land use and land cover at a particular point of time (Roy el al., 2010).

The Human use of land resources gives rise to “land use” which varies with the purpose it serves, whether it be food production, provision of shelter, recreation, extraction and processing of materials, and the biophysical characteristics of the land itself. Tropical ecosystems are under continuous threat by organic and chemical pollution from agriculture and industries and the resultant degradation of the natural resources has taken on an alarming aspect (Benidick, 1999). In the developing countries, due to population pressure and in a bid to extract the maximum output from the available sources, the impact of degradation can be worse than in other countries and adversely affect the land cover of the region (Roy el al., 2010).

Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil and/or artificial structures (Ellis, 2007). Land use, on the other hand, has a more complicated aspect as it involves social sciences and management principles and is defined as the social and economic purposes and contexts for and within which lands are managed. Although land use and land cover are frequently used together, there is a very clear difference between the two. While land cover signifies the spatial distribution of the different land cover classes on the earth’s surface, and can be directly estimated qualitatively as well as quantitatively by remote sensing, land use and its changes require the integration of natural and social scientific methods to determine which human activities are occurring in different parts of the landscape, even when the land cover appears to be same (Lambin et al., 2001).

Land use and land cover change are perhaps the most prominent form of global environmental change since they occur at spatial and temporal scales immediately relevant to our daily existence (CCSP, 2003). Technically, land use and land cover change mean quantitative changes in areal extent (increase or decrease) of a given type of land use and land cover respectively. Land use and land cover change are a manifestation of forces both anthropogenic and environmental – climate driven factors (Liu et al, 2009). The changes in land use in various spatial and temporal domains are the material expressions, and also indicate environmental and human dynamics and their interactions mediated by land availability (Lambinet al., 2003).

Land use is a dynamic process that has a complex connection with time and place so that it is formed over time and due to the pressures and growth of human society in the environment (Al-dosky et al, 2013). Land use land cover (LULC) change underway in many parts of the world and its extent and intensity is far greater now than were in the past and so it is a key issue considering worldwide dynamics and their responses to environmental and socio-economic drivers (Hassan et al, 2016; Viana et al, 2019; Tewabe & Fentahun, 2020). Management of the earth's surface transformation due to LULC changes characterizes one of the pressing global environmental challenges to address in current century (Alawamy et al., 2020).

Land use assessment and its changes detection are very important for many activities related to the development, planning, and management of urban land use and projects and for this purpose, most countries try to adjust the use of environmental resources through many unique plans that are related to the analysis of the urban LULC patterns. In order to understand the role of cities as engines of regional development it is important to recognize and asses the changes related to urban development (Grigorescu et al, 2019).

Assessing current land uses and their temporal changes is an easy yet strategic approach for urban planners, politicians, and natural resource managers and remote sensing technologies provide an important capability for the detection and analysis of temporal variations, taking into account the dynamic properties and there is a great need for these technologies to successfully plan urban sustainable development (Erasu, 2017). Remote sensing-based Timely and accurate change information can be very useful in the urban environment for successful planning and management and is a powerful tool for studying urban land use patterns and changes. Recent advances in remote sensing tools and techniques provide increasingly better opportunities to detect and monitor such changes (Hemati et al, 2021; Pickering et al, 2021). Accurate information on land use can help regional development officials make improved use of available resources. Improved use of resources is actually exploiting the potential of the land, so this process will not have adverse environmental effects and will also ensure social and economic sustainability (Tesfaw et al, 2018; Näschen et al, 2019).

Urban LULCC have been discussed in many studies around the world. Mustafa et al. (2012) used Landsat satellite data and two change detection techniques to detect areas of change in The Duhok City, Kurdistan Region-Iraq. Othman et al. (2013) employed Landsat MSS, TM, and ETM data acquired in 1976, 1990 and 2002 and using different indicators showed that desertification has increased in the central part of Iraq since 1990.

Alqurashi et al. (2016) used Landsat dataset for years 1985, 1990, 2007 and 2014 to evaluate land cover changes in order to study of urban growth in five cities of Saudi Arabia. Hashim et al. (2019) extracted the values of the normalized difference vegetation index (NDVI) for the period 1977–2017 from Landsat and Sentinel satellite images and used supervised classification to quantify land and water cover change in Iraqi southern marshes. Nistor et al (2021) developed a case study focused on LULCC in Bucharest, Romania based on a diachronic set of high-resolution satellite imagery.

The urban communities of Iraq, especially the remote and less developed cities in this country, have suffered many problems in various economic, social, and environmental aspects of the spatial pattern of urban facilities and land uses. Khanaqin city is one of the marginal urban regions and relatively populated in this country. The rapid growth of Khanaqin city in recent decades, which has been mainly due to political factors, has led to changes in the settlement patterns of the population in this area and considering these factors, it is expected that the land use pattern in this city is in a disorganized situation and has not followed the stable distribution pattern. The aim of this study is to detect and evaluate land use and land cover changes (LULCC) of Khanaqin city over 20 years from 2000 to 2020 using remote sensing and GIS techniques.

2. Study area

The study area is located in the Diyala governorate in eastern Iraq and includes the center of Khanaqin city and its two subordinate town Jalawla and Sadiyah. It occupies 3062.7 km2 and situated at 61-255 meters above sea level. This area is bordered to the north by the Kalar district, to the west by the Kifri district, to the south by the Baladrooz district and to the east by Iran. The spatial extension of the study area is present between 33°56′45″ N to 34°36′28″ N and 44°50′22″ E to 45°34′34″ E (Fig. 1). This region of Iraq has experienced many demographic changes in recent decades due to various political and social events such as war, terrorism, and bordering position and it seems that land use has been overshadowed by these events in the long run.

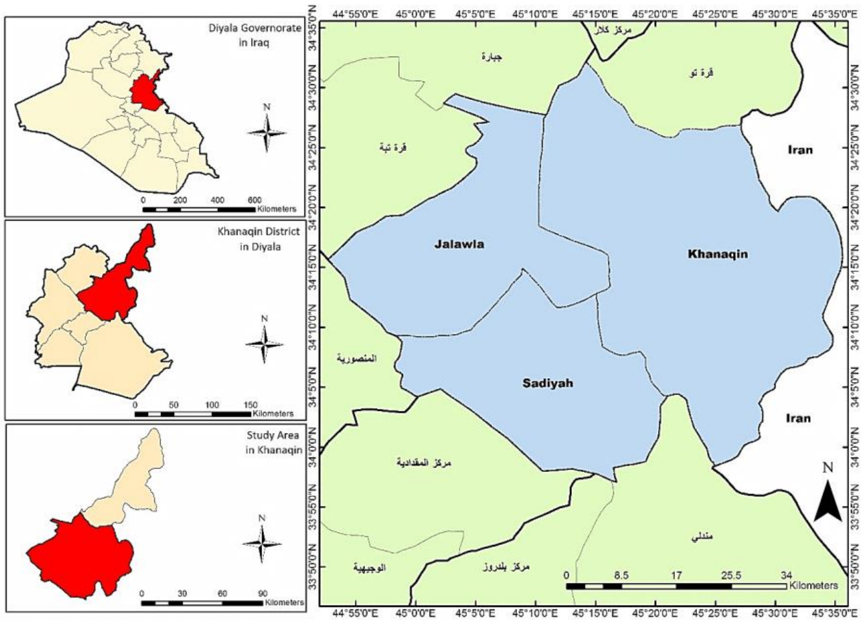


Fig. 1. Study area

3. Materials and Methods

3.1. Data acquisition

In order to detect and assessing LULCC in the study area, three multispectral satellite images of the area for the years 2000, 2010, and 2020 were used and Landsat 7 ETM[1] data of 2000, Landsat 5 TM data of 2010, and Landsat 8 OLI[2]data of year 2020 have been acquired from USGS earth explorer, given its substantial historical record.. Specifications of the satellite data acquired for LULCC analysis are given in Table 1.

Table 1

Specifications of the satellite data acquired (* used bands)

Satellite	Sensor	Path/Row	Date	Band	Resolution (m)	Wavelength (μm)	Cloud

Enhanced Thematic Mapper[1]
Operational Land Imager[2]

							cover (%)
Landsat 7	ETM	168/36	2000.06.28	1 *	30	0.45-0.515	0
				2 *	30	0.515-0.605	
				3 *	30	0.63-0.69	
				4 *	30	0.75-0.90	
				5 *	30	1.55-1.75	
				6	60	10.4-12.50	
				7 *	30	2.09-2.35	
				Pan	15	0.52-0.90	
Landsat 5	TM	168/36	2010.06.31	1 *	30	0.45-0.52	0
				2 *	30	0.52-0.60	
				3 *	30	0.63-0.69	
				4 *	30	0.76-0.90	
				5 *	30	1.55-1.75	
				6	120	10.4-12.50	
				7 *	30	2.08-2.35	
Landsat 8	OLI	168/38	2020.06.27	1 *	30	0.45-0.52	0
				2 *	30	0.52-0.60	
				3 *	30	0.63-0.69	
				4 *	30	0.76-0.90	
				5 *	30	1.55-1.75	
				6 *	30	10.4-12.50	
				7 *	30	2.08-2.35	
				8	15	0.50-0.68	
				9 *	30	1.36-1.38	
				10	100	10.60-11.19	
				11	100	11.50-12.51	

3.2. Image pre-processing

Satellite images pre-processing before performing classification is very important in order to establish a more direct association between the acquired data and biophysical phenomena (El-Kawya et al, 2011). Satellite images were projected at first, and geographic coordinate system has been defined for them and then georeferenced and subset on the basis of region of Interest (ROI) for extracting study area boundary (Fig. 2).

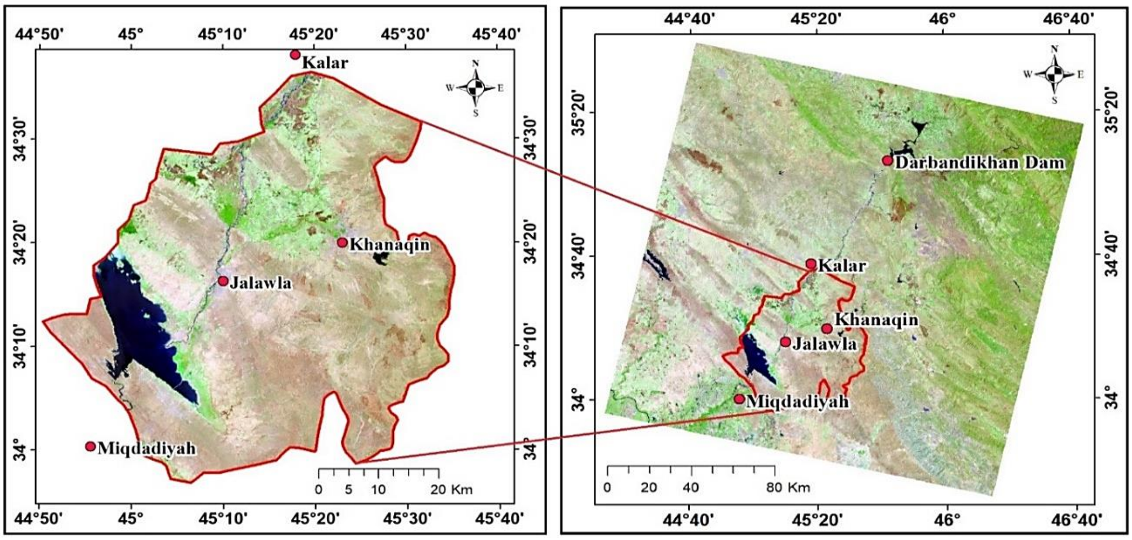


Fig. 2. study area extracted from Landsat 8 image

3.3. Supervised classification

Image classification using remote sensing techniques has attracted the attention of research community as the results of classification are the backbone of environmental, social and economic applications (Lu and Weng, 2007). Because image classification is generated using a remotely sensed data, there are many factors that cause difficulty to achieve a more accurate result. Some of the factors are:

The characteristics of a study area,

Availability of high resolution remotely sensed data,

Ancillary and ground reference data,

Suitable classification algorithms and the analyst's experience, and

Time constraint.

These factors highly determine the type of classification algorithm to be used for image classification.There are various image classification methods that can be applied to extract land cover information from remotely sensed images (Lu and Weng, 2007). However, their application depends on the methodology and type of data to be used. Some of these methods are: artificial neural networks, fuzzy-sets and expert systems. In a more specified way, image classification approaches can be categorized as supervised and unsupervised, or parametric and nonparametric, or hard and soft (fuzzy) classification, or per-pixel, sub-pixel and per-field. In this study, supervised classification is used. In supervised algorithms, a labelled training dataset is used first to train the underlying algorithm. This trained algorithm is then fed on the unlabeled test dataset to classify them into similar groups (Uddinn et al, 2019). They are flexible statistical prediction techniques collectively referred to as machine learning techniques (Stephens & Diesing, 2014). There is a large number of supervised classification methods are available and the maximum-likelihood method has been run in this study. Maximum-likelihood classifier is based on probability theory and assumes that each class in each band can be described by a normal distribution (Shivakumar & Rajashekararadhya,2018; Norovsuren et al, 2019). In order to classification of land types in study area, and based on the United States geological survey (USGS) classification system, five classes were assigned to it. Assigned classes were Water, Barren lands, Mixed lands, Built-up, and Vegetation (Table 2). Satellite images has been classified according to delineated classes and for this purpose 350 training samples have been collected from the entire in two ways: 1) 50 samples from field observation,2) 300 samples randomly (Fig.3).

Table 2

Classes assigned to supervised classification

No	Classes	Description
1	Water	Lakes, Rivers, Dams, Estuary, Crop ponds
2	Barren lands	Saline field, Sand, Rocks

3	Agricultural mixed lands	Rainfed fields, Gardens and nurseries, Greenhouses
4	Built-up area	Urban lands, Residential area, Industrial zones, Roads
5	Vegetation	Forests, Rangelands, Shrubs, Meadow

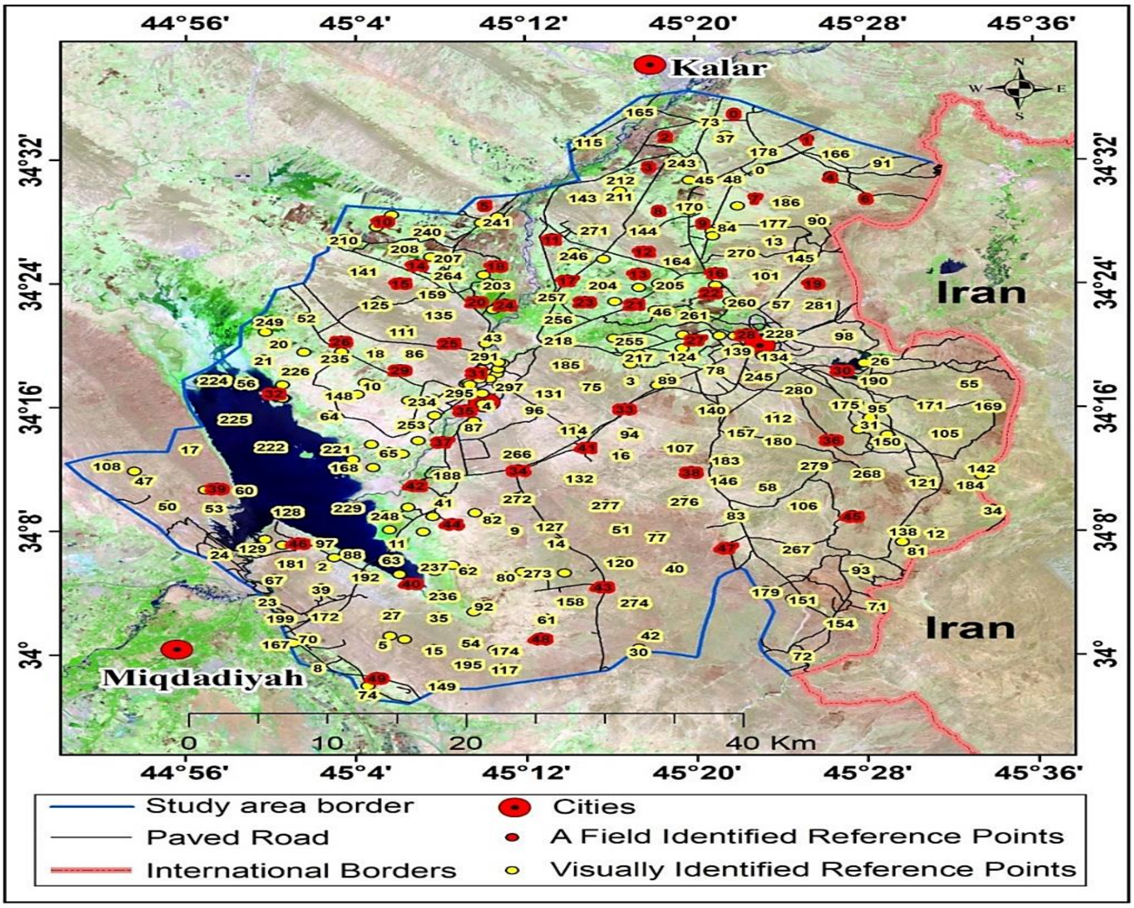


Fig 3. Training samples

3.4. Accuracy assessment

The accuracy assessment is a comparison of a classification with ROI or ground-truth data to evaluate how well the classification represents the real world. This is produced in the traditional error matrix and kappa coefficient method (Li & Zhou, 2009; Kafi *et al* 2014). However, change detection accuracy assessment requires that a sufficient number of samples per map class be assembled when the classified results are compared with actual ground conditions. For this purpose, and in order to improve the accuracy and comprehensiveness of the process, we have used four sources (Fig. 4): 1) The Google Earth image has been used to capture a number of samples for year 2000 (Fig. 4a); 2) A high resolution QuickBird satellite image is

used for capturing some of samples for year 2010 (Fig. 4b); 3) ArcGIS Server high resolution images has been used for recording some of samples for year 2020 (Fig. 4c); 4) Finally, field observations have been used to complete the classification samples and 300 samples were collected (Fig. 4d). Furthermore, error matrix and kappa

coefficient method applied to show the final accuracy of the performed assessment. The workflow of the entire procedure for LULC assessment has been shown in the Figure 5.

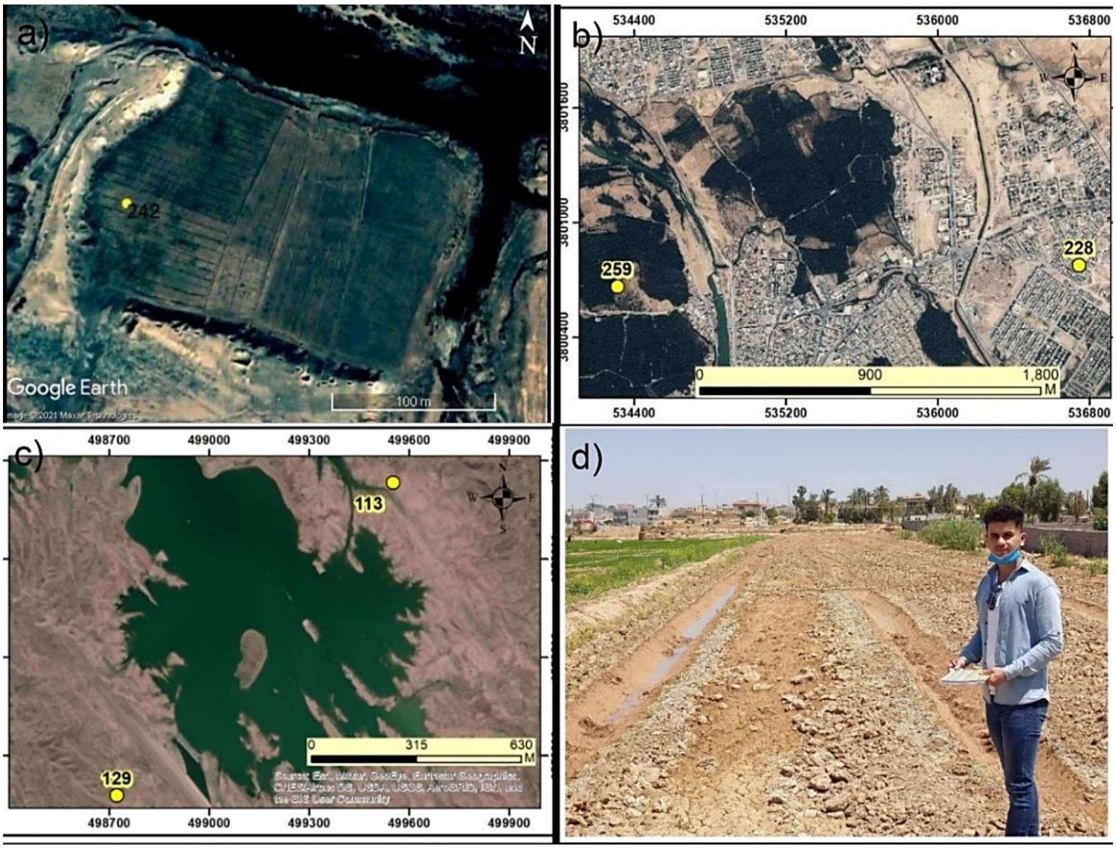


Fig. 4. Accuracy assessment sampling

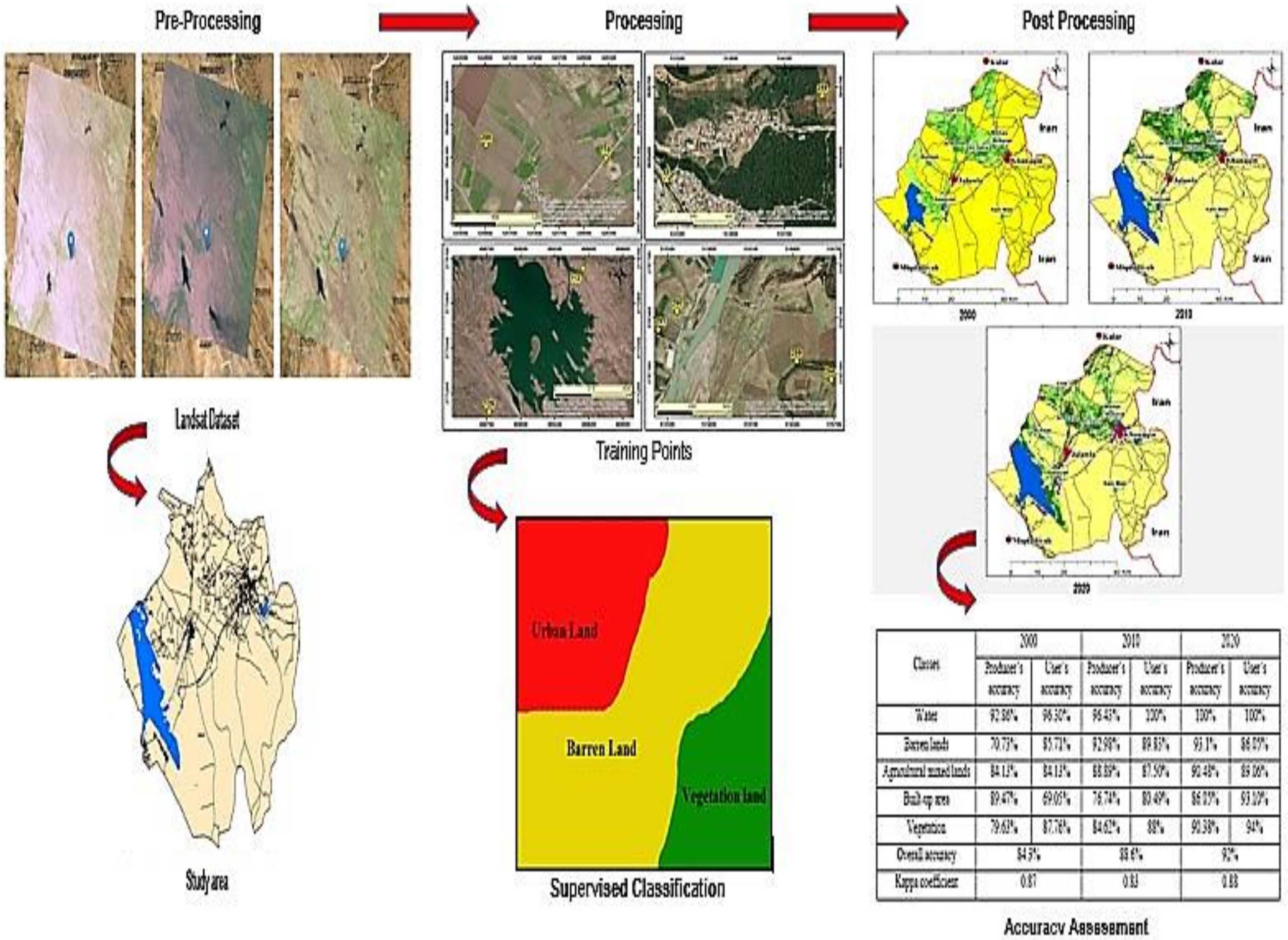


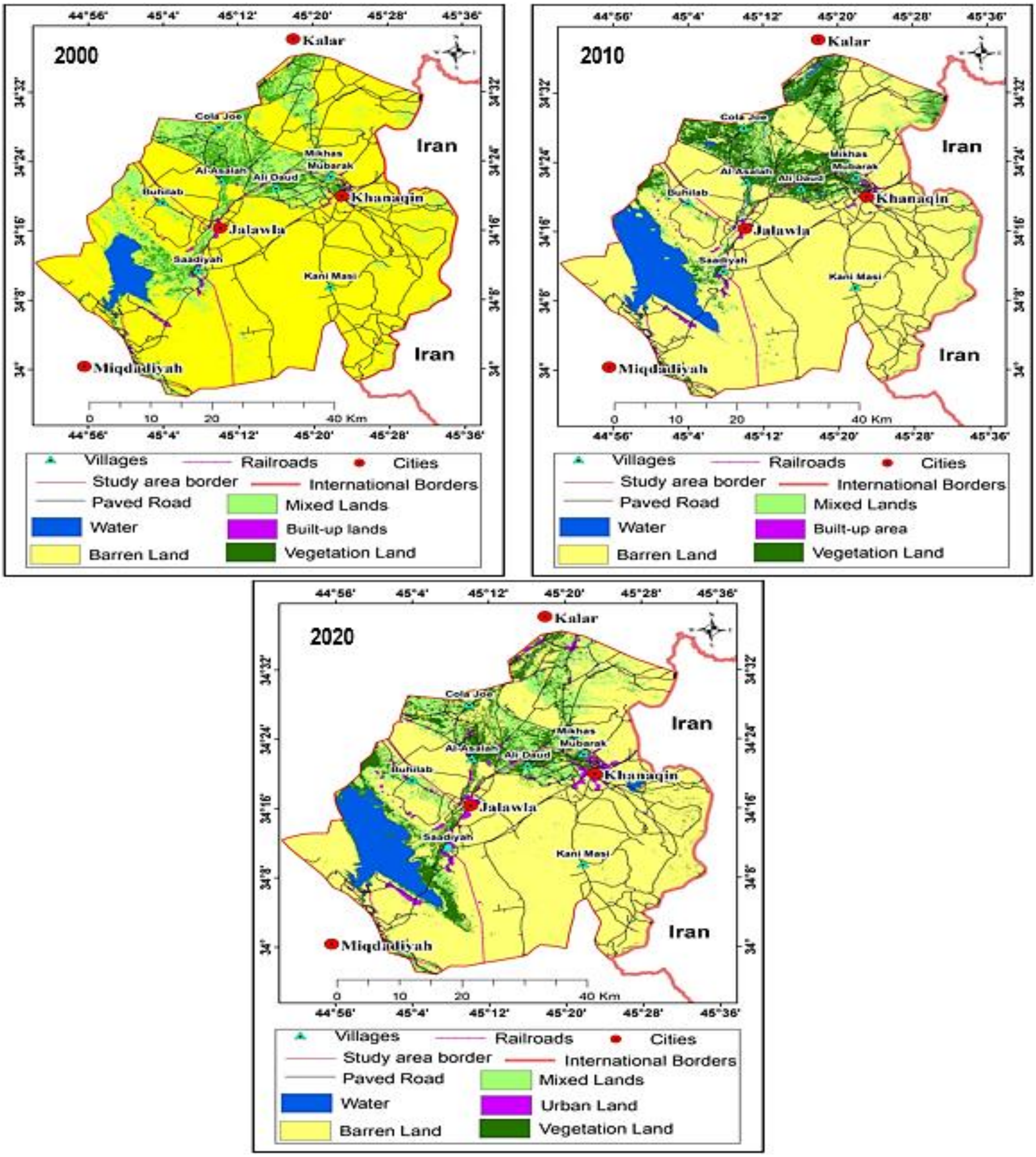
Fig. 5. Methodology workflow

4. Results and discussion

The land use and land cover changes detection process performed for study area based on Landsat satellite images and the resulting LULCC maps for years 2000, 2010, and 2020 shown in Fig. 6. The results of the analysis showed that various changes have taken place during these 20 years of study. Analysis of the results for year 2000 indicated that Barren lands had the largest share in area and representing 75% (3062 km^2) of the total LULC classification. This class faced few changes and it was reduced to 74% (2284 km^2) in 2010. Finally, this class with a 3% decreasing has shrunk to 71% (2206 km^2) in 2020. The other land types which faced some decline during the study period was Agricultural mixed lands. The area of this class in 2000 was 15% (456 km^2) which in 2010 it was reduced to 8% (231 km^2) while again it has gradually increased and reached 10% (300 km^2) in 2020. The other class with changes during 20 years is Water lands. This type of land faced a relatively remarkable increase in 2010 but again faced a few decreasing and so that its area from 2% (71 km^2) reached 7% (202 km^2) in 2010 and 6% (177 km^2) in 2020. The other two classes have always been faced with a gradual increase and Vegetation land reached from 6% to 10% in 2010 and 11% in year 2020. And finally Built-up area has a slight growth in the first period and was faced with a slight increase in area and reached to 2% (76 km^2) in 2020 (Fig 7).

In order to detect types and locations of land-use changes, a crosstab matrix was performed. The crosstab matrix reflects dynamic information about the interactive LULCC of a particular region at the beginning and end of a given period. The results of the matrix show various changes and transitions over a period of 20 years. Fig. 8 show the spatial LULCC in the study area. Based on Fig. 8, changes can be examined in the short term and long-term. In the short term, the most changes were in the northern and western parts (around Lake Hamrin), and the southern parts witnessed the least changes between 2000 and 2010. Furthermore, most changes between 2010 and 2020 in the central, southwestern, and northern parts of the area have occurred. In years 2000 to 2020, most changes in the western parts, eastern parts (around Khanaqin city), northeastern and northern parts of the region have occurred due to urban and rural population growth and development of constructions.

Table 4 show types and amount of changed lands. The table indicate that the major changes observed were from mixed agriculture to vegetation (168.7 km^2), mixed agriculture to barren (110.9 km^2), and barren land to agriculture (77.7 km^2) in 2000-2010, vegetation to Built-up (145.9 km^2), barren to agriculture (144.78 km^2), and agriculture to barren (100.58 km^2), in 2010 -2020. Finally, major LULCC in 2000-2020 were from agriculture to barren land (144.31 km^2), barren land to agriculture (139.06 km^2), and agriculture to vegetation (132.44 km^2), relatively.


2000
2010
2020
Kalar
Cola Joe
Mikhas
Mubarak
Al-Asalah
Ali Daud
Buhilab
Khanaqin
Jalawla
Saadiyah
Kani Masi
Miqdadiyah
Iran
44°56'
45°4'
45°12'
45°20'
45°28'
45°36'
34°32'
34°24'
34°16'
34°8'
34°
0
10
20
40 Km
Villages
Railroads
Cities
Study area border
International Borders
Paved Road
Mixed Lands
Water
Built-up lands
Built-up area
Urban Land
Barren Land
Vegetation Land

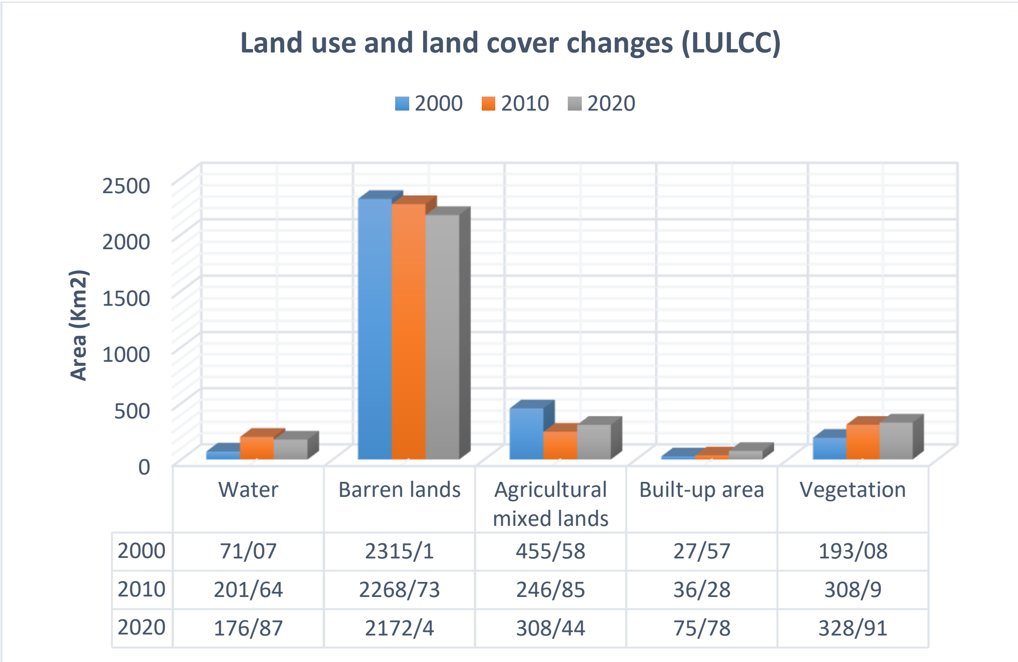
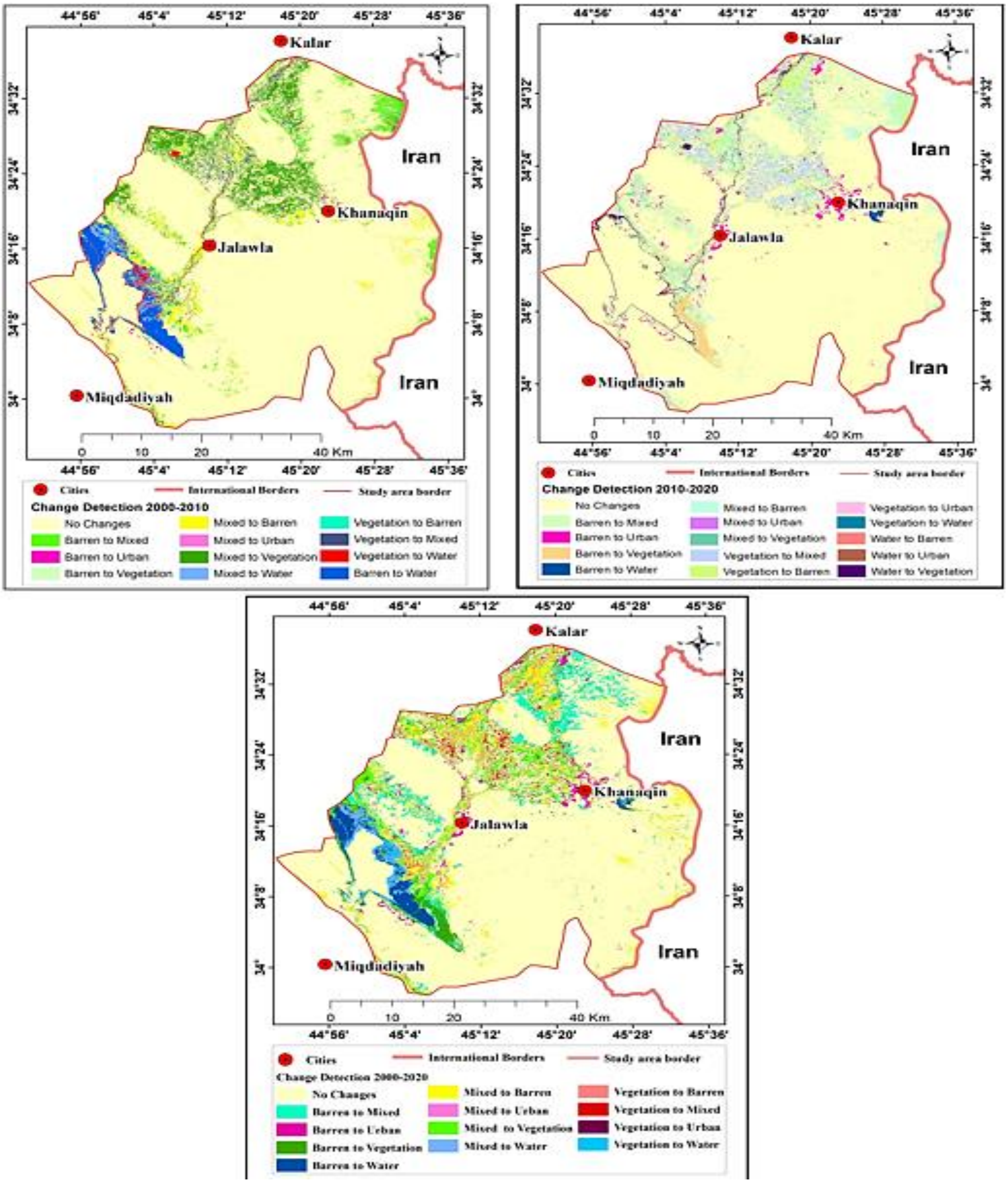


Fig. 7. Change in land use and land cover

Table 3
Classes' statistics and the trend of changes over 20 years

Classes	2000		2010		2020		2000-2010	2000-2020
	Km ^{2}	%	Km ^{2}	%	Km ^{2}	%	Change rate	Change rate
Water	71.07	2	201.64	7	176.87	6	+ 184%	+ 148%
Barren lands	2315.1	75	2268.73	74	2172.4	71	- 2%	- 6%
Agricultural mixed lands	455.58	15	246.85	8	308.44	10	- 46%	- 32%
Built-up area	27.57	1	36.28	1	75.78	2	+ 32%	+ 175%
Vegetation	193.08	6	308.90	10	328.91	11	+ 60%	+ 70%

LULCC assessment in the Khanaqin urban area revealed that Water lands, Built-up area, and Vegetation areas increased from 2000 to 2020, while Barren lands, and Agricultural mixed lands had decreased in the last 20 years (Table 3). These changes are largely related to climatic, political, and social factors as well as urban and rural population dynamics.



Kalar
Khanaqin
Jalawla
Miqdadiyah
Iran
Iran
44°56'
45°4'
45°12'
45°20'
45°28'
45°36'
34°32'
34°24'
34°16'
34°8'
34°
0
10
20
40 Km
Cities
International Borders
Study area border
Change Detection 2000-2010
No Changes
Barren to Mixed
Barren to Urban
Barren to Vegetation
Mixed to Barren
Mixed to Urban
Mixed to Vegetation
Mixed to Water
Vegetation to Barren
Vegetation to Mixed
Vegetation to Water
Barren to Water
Change Detection 2010-2020
No Changes
Barren to Mixed
Barren to Urban
Barren to Vegetation
Barren to Water
Mixed to Barren
Mixed to Urban
Mixed to Vegetation
Vegetation to Mixed
Vegetation to Barren
Vegetation to Urban
Vegetation to Water
Water to Barren
Water to Urban
Water to Vegetation
Change Detection 2000-2020
No Changes
Barren to Mixed
Barren to Urban
Barren to Vegetation
Barren to Water
Mixed to Barren
Mixed to Urban
Mixed to Vegetation
Mixed to Water
Vegetation to Barren
Vegetation to Mixed
Vegetation to Urban
Vegetation to Water

Table 4
Cross-tab matrix for LULCC maps (changes per km^2)

years				**2000**		
2010	LULC	Water	Barren lands	Agricultural mixed lands	Built-up area	Vegetation
	Water	70.93	64.6	40.9	0	25.2
	Barren lands	0	2159	110.9	0.4	14.5
	Agricultural mixed lands	0	77.7	121	0.1	32.4
	Built-up area	0.1	3.8	2.3	29.6	0.5
	Vegetation	0.03	24.6	168.7	0.1	115.4
				2010		
2020	LULC	Water	Barren lands	Agricultural mixed lands	Built-up area	Vegetation
	Water	171.9	3.8	0.4	71.1	5.3
	Barren lands	1.8	2028.1	100.6	1.2	86.4
	Agricultural mixed lands	0.1	144.8	67	0.1	4.6
	Built-up area	0.07	31.1	5.3	34.6	145.9
	Vegetation	22.5	77	58	0.3	0.8
				2000		
2020	LULC	Water	Barren lands	Agricultural mixed lands	Built-up area	Vegetation
	Water	202	58.6	31.5	37.1	0
	Barren lands	0	2023.9	144.3	0.9	36.1
	Agricultural mixed lands	0.2	139.1	124.9	0	3.8

Built-up area	0	32.3	10.6	29	95
Vegetation	70.7	75.8	132.4	0.2	16.2

For the accuracy assessment of land cover maps obtained from satellite images, confusion matrix method was used including overall accuracy, user's accuracy, producer's accuracy, and Kappa coefficient to represent different land cover classes of the area. The accuracy was assessed by using 300 reference points, based on ground truth data and visual interpretation (Table 5). This accuracy gives the overall results of the confusion matrix. The results of the accuracy assessment obtained for classification, indicating a remarkable spatial accuracy. Results show that the overall accuracy of 2000 was 84.3% while the producer's and user's accuracy range from 70.73% to 92.86% and 69.05 to 96.30% respectively .The overall accuracy for 2010 and 2020 was 88.6% and 92%, respectively. Kappa statistics had calculated from the error matrix, and the coefficient of the classification for 2000 was 0.87, for 2010 was 0.83, and for 2020 was 0.88 Thus, the classification lies in a very suitable range.

Table 5

Accuracy assessment results

Classes	**2000**		**2010**		**2020**	
	Producer's accuracy	User's accuracy	Producer's accuracy	User's accuracy	Producer's accuracy	User's accuracy
Water	92.86%	96.30%	96.43%	100%	100%	100%
Barren lands	70.73%	85.71%	92.98%	89.83%	93.1%	86.05%
Agricultural mixed lands	84.13%	84.13%	88.89%	87.50%	90.48%	89.06%
Built-up area	89.47%	69.05%	76.74%	80.49%	86.05%	93.10%
Vegetation	79.63%	87.76%	84.62%	88%	90.38%	94%
Overall accuracy	84.3%		88.6%		92%	
Kappa coefficient	0.87		0.83		0.88	

5. Conclusions

The study and evaluation of changes that have occurred on a complication or phenomenon over time has been the goal of many studies. Changes in the political and social situation of a particular region, changes in the development or decline of cities, changes in the bed of a river, expansion of deserts, decrease in forest or vegetation levels, decrease or increase in coastline are examples of changes in different features by different researchers. Is evaluated and the purpose of many future research studies is to predict the course of change that has taken place. At present, satellite imagery is one of the most powerful tools for researchers to detect and detect changes due to its unique capabilities, which is used in many environmental sciences. Examining changes is one of the most important parts of analyzing satellite images, which today are used in a variety of ways to study changes before and after a particular time.

Land use maps are one of the requirements of any national and regional development planning that enables managers and planners to design and implement the necessary measures by identifying the current situation and comparing capabilities and potentials to meet current and future needs. In fact, the results of such studies indicate the type of management applied in the region and also indicate its strengths and weaknesses during the study period, which can be a powerful management tool for optimal land management to achieve sustainable development and appropriate for managers and local officials. To take. Irregular land use changes in the future, regardless of the environmental situation, can also lead to environmental hazards. Therefore, the mentioned changes, especially the changes in residential areas, should be done in accordance with the conditions governing the environment and in compliance with the relevant principles.

The urban communities of Iraq, and especially the remote and less developed cities of the country, have suffered great losses in economic, social, environmental, and managerial aspects of the spatial distribution of urban land uses. The rapid growth of Khanaqin city in recent decades along with the current growth pattern has led to economic, demographic, and urban development and so on. This issue is due to the significant growth of residential, industrial, and commercial construction in recent years, which has led to changes in land-use patterns in this city.

In this study, urban land-use changes in the city of Khanaqin in Iraq have studied over a period of 20 years from 2000 to 2020 using remote sensing techniques and GIS. To classification of satellite images of the study area, 5 land use classes including barren lands, agricultural lands, built-up lands, mixed vegetation, and water lands have been considered for analysis. And using 350 training samples, the supervised classification algorithm of the maximum likelihood type has been implemented for this purpose. Results show that all classes except barren lands have been growing from 2000 to 2020, and therefore only barren lands have lost in total 6% of their area during this due to the growth of other lands, especially urban and agricultural lands. Also, during this period, the amount of residential and commercial constructions has been growing and in total, over a period of 20 years, about 141% of the urban land area has been added to them. Vegetation lands of the study area are also faced growth in these 20 years and the rate in the first period with 61%, compared to the second period with 6% was much higher. But the water lands had Growth in 20 years, in the first period increased by 148 percent and in the second period compared to the first period decreased by 12 percent. Agricultural lands also had a 25% growth in the second period, with a 46% decrease in area in the first period.

According to the analysis and results obtained, this research can be useful in the field of regional and environmental management in the city of Khanaqin and in the field of urban planning and management and research decisions in this region can be used. Also, due to the lack of relevant research in this area, the results of this study can be useful and effective in future studies for analyzing interactive between land-use types and land-use trends, and land cover in this area.

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