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RESEARCH PAPER

Spatio-Temporal Variation in Land Use and Land Cover from 1988 to 2018: A Study of District Khairpur Mir's, Pakistan

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ABSTRACT

One of the major drivers of environmental change at the global and regional levels is defined as land use and land cover (LULC). The process of LULC modification is a result of the complex interactions between people and their surroundings In order to effectively use and manage natural resources, Detecting the changes of land use and land cover of the earth's surface is extremely important to achieve continual and precise information about study area for planning and development. The aim of this study is to map the land use and land cover of District Khairpur on year 1988, 1998, 2008 and 2018 respectively to monitor the possible changes that may occur particularly in agricultural land and urban or built-up land, and detect the process of urbanization in this city. Maximum likelihood supervised classification were used in all four imageries and five classes were made namely Vegetation, Water Body, Sand, Barren land, and Built-up Area.

KEYWORDS: Agriculture, Development, Infrastructure, Land Cover Changes, Land Use

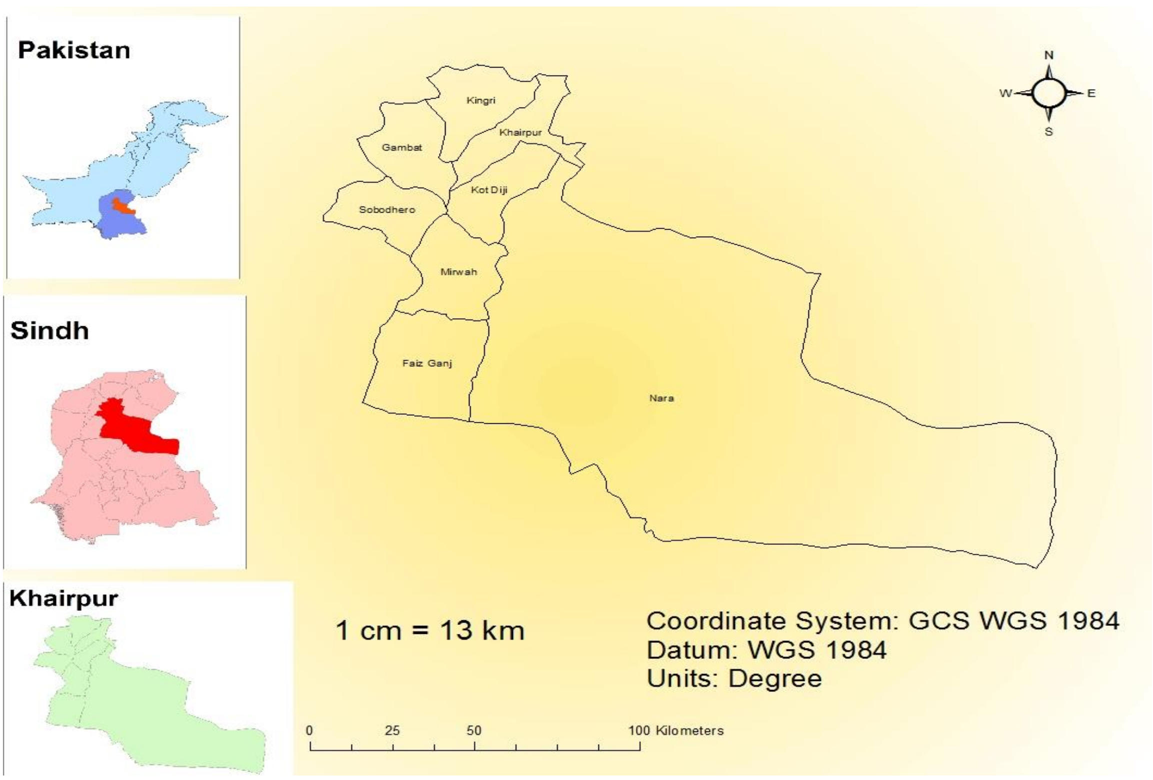
Introduction

One of the major drivers of environmental change at the global and regional levels is defined as land use and land cover (LULC). The process of LULC modification is a result of the complex interactions between people and their surroundings (Teixeira et al. 2014) In order to effectively use and manage natural resources, it is imperative to quantify the causes and effects of LULC change. In the planning of a region's land use and environmental management, understanding the trends of LULC change would be highly beneficial (Twisa et al. 2019) . Researchers can now effectively characterize and evaluate the dynamic changes in LULC because of recent advancements in geographical information science (GIS) and remote sensing (Chaudhuri and Mishra 2016) The effectiveness of monitoring these LULC changes has increased because to the accessibility of spatiotemporal consistent satellite imagery and inventive image processing tools. According to estimates from the United Nations (2010), more than 50% of the world's population already resides in urban areas and that number will rise to 69.6% by 2050. Despite the fact that the entire urban area makes up a very tiny fraction of the planet's surface (Grimm et al., 2000; Grbler, 1994), urbanisation is thought to be the most significant driver of changes in land use and cover (McCarthy et al., 2010). Rapid and extensive urbanization is one instance of LULC change that is caused by humans, as discussed in earlier studies. According to Hassan et al. (2016) and Rahman et al (2012), a number of forces acting at the local, regional, and global levels are to blame for the dynamic changes in land use. The land use pattern has been continuously changing as a result of the population's rapid and unchecked increase, industrialization, and economic expansion (Dutta, et al., 2019). The growth of industry and urban agglomeration (Walker, 2001), population growth and climate change (Hassan et al., 2016), urban expansion (Dutta & Das, 2019), and policy provisions (zeng et al., 2007) are a few potential causes of LULC changes. A large portion of the labour force can now commute everyday thanks to the development of public transport (Kasraian, et al ., 2019) and the expansion of metropolitan regions brought on by urban sprawl (Bhat, et al., 2017). As a result of the conversion of agricultural and other natural land cover types into built-up space, urban areas are expanding outward (Dutta, et al., 2020). The conversion of natural land cover types into artificial land use types is thought to be the primary cause of the changes in the environment around the world. LULC changes have already been linked to negative effects on biodiversity (Kingsley et al., 2021), hydrological systems (Patra et al., 2018), urban thermal environment (Gogoi et al., 2019), urban landscape quality and (Shahfahad et al., 2021) focused over the air quality by urban sprawl. The main driving forces behind the LULC changes are population growth and urbanization (Msofe, Sheng, &Lyimo, 2020). Further, the conversion of forest into agricultural land to meet the demand for food grains is another major driver of LULC change (Nugroho,et al., 2018). Most of the LULC change occurs in the form of expansion of built-up area at the cost of agricultural land, vegetation cover and open spaces (Dutta et al., 2020).Thus the present study explored the changes occurred in land morphology of district Khairpur from the year of 1988, 1998, 2008 and 2018.

Study Area

The Khairpur district is situated in the northern Sindh, Latitude and longitude coordinates are 27°31' 47.8236'' N, and 68° 45' 29.3076'' E.Khairpur is a fast growing city of the Sindh province. The Geographical location of Khairpur is very exclusive. It is located on the east of the River Indus.The total area of Khairpur is about 15910 sq. kilometers. The district is surrounded within the North by Sukkur and Shikarpur districts, Sanghar is located in the south direction, and Larkana district conventional in west of the district Khairpur. Arore hill is on the east of the city, beyond the hill Nara Thar Desert is located The Khairpur is located on the agricultural belt of Indus Plain. Rohri canal and Mir Wah canal are crossing the cityGeographicallyKhairpur divided in to two types the Eastern Valley Section and the Desert Section, both be in the right place to the Province of the Lower Indus Basin.

Fig 1 Study Area



Material and Methods

Landsat Data

The data that has been used for spatiao-temporal land use and land cover change include four historical Landsat satellite images covering Khairpur Mir's for the past 30 years (1988-2018). The four obtained images have the same 30 meters resolution only difference is in capturing sensors. In first two images, the sensor used is Landsat TM, the third one is Landsat ETM, and in last one Landsat OLI and TIRS sensor used as shown is Table 3.2. These images were downloaded from the USGS.

Table 1
Acquired Satellite images Characteristics

Reference year	Sensor	Resolution	WRS:P/R	Date of Acquisition
1988	Landsat TM	30m	2:149/37	05-11-1988 22-11-1988
1998	Landsat TM	30m	2:149/37	10-10-1998 17-11-1998
2008	Landsat ETM	30m	2:149.37	14-10-2008 06-09-2008
2018	Landsat OLI_TIRS	30m	2:149/37	13-09-2018

Land Use Land Cover (LULC)

Eight spectral bands are seen in the Landsat 5 and 7 imagesimages. Bands one through five and seven were employed in this investigation to evaluate the LULC. Thermal band number six is employed in LST change analysis. For LULC and LST changes in Landsat 8, we used band two to band nine. ArcGIS software (version 10.8) was used to process and analyse satellite photos imported from various years. With the use of the ArcGIS envision software, an image was first analysed and processed, clipped, and corrected for atmospheric distortion.Second, Landsat images were preprocessed in ArcGIS 2015 for layer stacking, mosaicking, and subsetting of the image based on Area of Interest (AOI) (Worku et al., 2018). Layer stacking is a technique used to create a multiband image from discrete bands. According to Singh et al. (2011), per-pixel fingerprints were used to analyse all satellite data. The supervised classification method Maximum Likelihood Classification (MLC) and training site selections for the years 1988, 1998, 2008, and 2018 were used to create the LULC maps.

Validation of results through Accuracy assessment, Cohen's Kappa classification

Accuracy assessment technique applied on supervised classification. This accuracy technique compare manually classified image to that image which considered tobe correct. (Parece,Campbell, & McGee). To calculate overall accuracy and Cohen's Kappa error matrix table first compiled. For example, For Cohen's Kappa, the formula is given as follows.

$$K = Obersvedvalue - Expectedvalue$$

Observed value is the overall accuracy while Expected value is calculated from results. To calculateexpected value. By putting calculated values in above equation Cohen's Kappa is calculated. Cohen'sKappa in this case calculated in percentage but in actual it varies from -1 to +1, the more the computedvalue near to +1 the more its accuracy is. In this study total 150 random points were taken, remember thisis the sum of all five classes that classified namely vegetation, sand, barren land, water body and built uparea.

Results and Discussion

The overall results are being calculated and observed through the help of GIS. The research study, results interpretation carried out on the classified land cover maps of the satellite images. Assessment of created maps accuracy, analysis of their nature, extent, and their rate of land cover change and their statistics is mentioned below table and graph.The quantitative analysis of land cover maps can be done by using variousmethods but the most often used method is simply tabulation where calculated statistics summarized. Trends of each year examine between four years period. There were remarkable changes occur in selected years. In the first change detection period 1988 to 1998, the vegetation land cover type has shown a gradually decreased 6845.07ha (2.4%). Built-up Area increased 1913.02 ha (0.8%). An increase also occurs in case of Barren land that is 7990.65ha (25.8%), same case with Water Body that increased 1878.47ha (19%).Change detection between the period of 1998 to 2008, Vegetation continue to decrease by 80296.63ha (3.1%). Major downfall faced by Water

Table 2
Overall and Use Land Coverable
District Khairpur,Sindh (1988-2018)

1988			1998		
Land Cover types	**Area (Hectare)**	**%**	**Land Cover types**	**Area (Hectare)**	**%**
Vegetation	317568.17	78.4	**Vegetation**	274551.04	80.8
Water Body	7595.63	1.9	**Water Body**	11080.70	2.8
Barren land	29022.63	7.9	**Barren land**	29711.10	10.0
Sand	7248.09	3.2	**Sand**	4695.68	2.0
Built up Area	2486.71	0.9	**Built up Area**	5588.73	1.8
TotalArea	**325721**	**100**	**TotalArea**	**325721**	**100**
2008			**2018**		
Land Cover types	**Area (Hectare)**	**%**	**Land Cover types**	**Area (Hectare)**	**%**
Vegetation	261614.83	74.8	**Vegetation**	192078.04	76.7
Water Body	6369.17	2.0	**Water Body**	6354.62	1.5
Barren land	47436.80	17.3	**Barren land**	51274.28	11.9
Sand	2361.07	1.8	**Sand**	5281.11	1.2
Built up Area	7355.34	1.9	**Built up Area**	14767.27	5.13
TotalArea	**325721**	**100**	**TotalArea**	**325721**	**100**

AreaChangeDetection(1988-2018)		
Land Cover types	**Area (Hectare)**	**%**
Vegetation	**-125490.13**	**-60.48**
Water Body	**-1241.01**	**-16.33**
Barren land	**22251.65**	**76.66**
Sand	**-1966.98**	**-27.13**
Built up Area	**128 280.56**	**493.84**
TotalArea	**325721**	**100**

Body that increasesin the first phase but now in that period it decreased by 3609.08ha (41.1%).Barren land again increased by 17722.6ha (45%)Sand area reduces to 1457.83 (27.7%). Built-up Area again receives an increment of 2925.61ha (65.8%). In the next duration 2008 to 2018, Built-up Area continues conversion into other classes and increased to 3928ha (52%). While Vegetation remains unchanged and increased by 788.47ha (0.5%). Water Body also receive a small change of 2.78ha (0.06%). Sand area increased to 1490.38ha (39%). And the last one is Barren land that decreased to 3844.33ha (11%). Therefore in 30 years of a time period from 1988 to 2018 built up area receive a drastic increment, and increased up to 300 times then it was in 1988. Moreover, Vegetation, Water Body, and Sand areas decreased to 6.5%, 29.46%, and 36.8% respectively. While Barren land area varies in different years but on the whole context increased by 43%. On the basis of computed numerical data, a chart formed labeled with land cover types.The trend of change in land cover of Khairpur district depicted.

According to the figure 4.5 major decline faced by Vegetation from 1988 to 2018, while Built-up Area shows a dramatic increase. Water Body vary in different years but at the end decreased. Same with the case of Barren land but increased as compared to 1988. The sand area also follows a decreasing trend.During the period of 1988 to 2018, the annual change in hector for vegetation was -18385.3 and its extent change was -4.5% while its rate of change was -0.25%. The second category was of water body whose annual change in hector was -2988.8 and its extent and rate of change were -36.4% and -1.5% respectively. As for as barren land category concerns it changes in hectors was +17668.9 and its extent varies by +58% and rate of change vary by +1.8%. The last field was of the built-up area that was a field that changed remarkably and its annual change in hector was about +9489.7 and its variation in extent was +367% and its annual rate of change was +14.1%.

Temporal Patterns of Land Use and Land Cover Change

Temporal variation in LULC from 1988 to 2018 in District Khairpur can be visualized in FIG. Spatial trends in figs explain the development of built-up areas. Because of the connectivity of the district Khairpur with other districts through Highway road most of the built-up areas develop along that road. And major hubs of this district like Gambat, Kingri and Khairpur are on the bank of that Highway road. Built-up areas in the 30 years of time span show continuous expansion. Mainly agriculture land affected and converted into built-up features. Variation in land use and land cover in different time period indicate that major transformation of land occur in vegetation and built up area. Positive variations held in the built-up area while negative change present in vegetation. For instance, in 1988 land cover was dominated by vegetation and occupy an area of 30577 ha 88% of the total area. From 1988 to1998 and 2008 to 2018 the change was 2.4% to 4.6% respectively. As the following Figure 4.8 shows the temporal pattern of LULC.

Figure2: Temporal trend of Land Cover Change

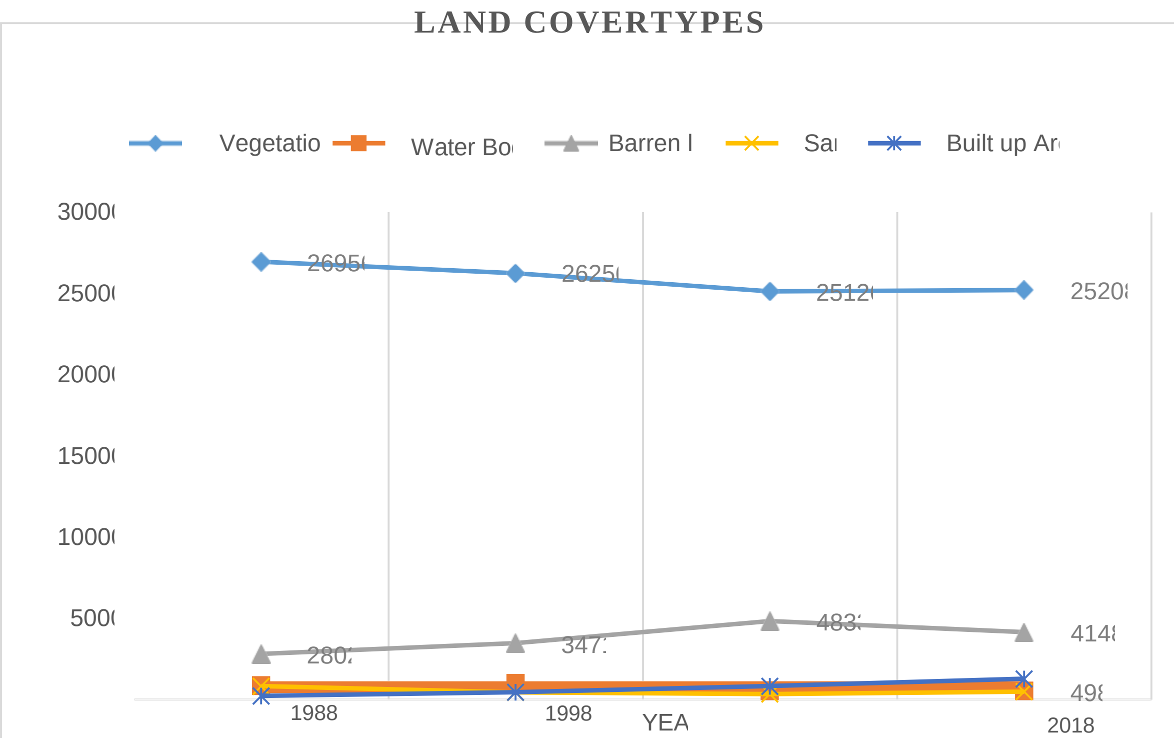


Figure 3:Overall change in land use and land cover

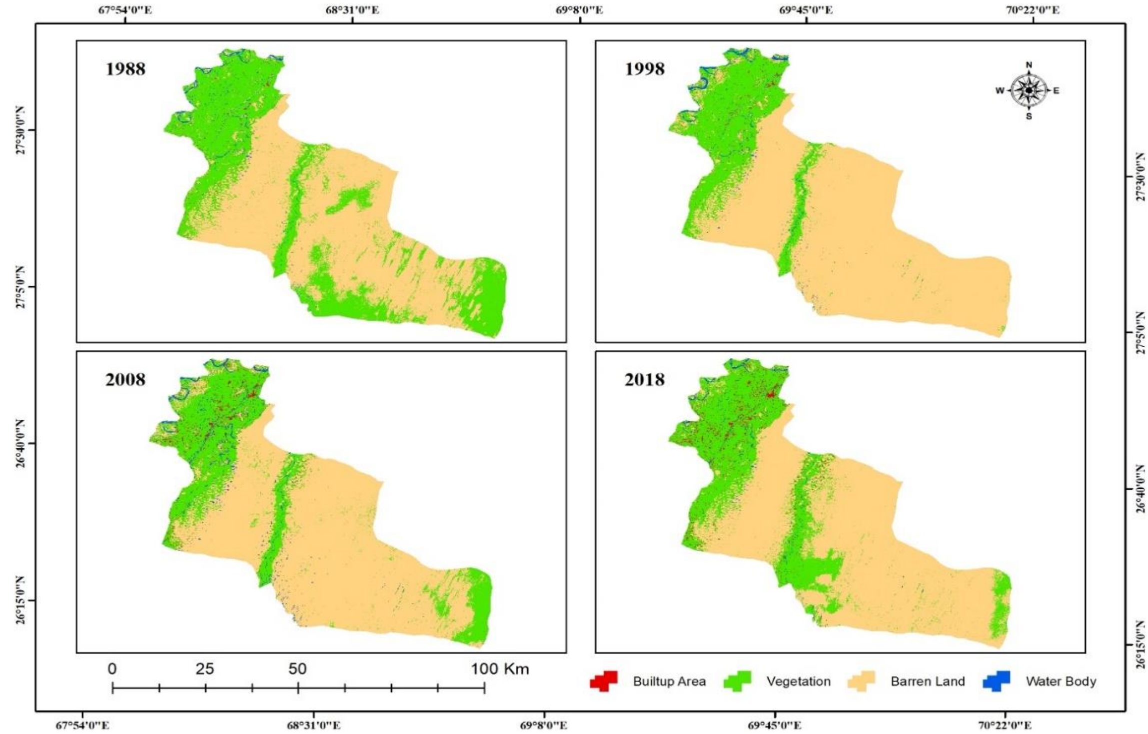


Table 3
Accuracy Assessment for the year of 1988-2018

Classes	Built-up Area	Vegetation	Barren Land	Water Body	Total	User Accuracy %	Over all map Accuracy	Cohen's Kappa Accuracy
Built-up Area	**42**	3	2	3	50	84		
Vegetation	2	**43**	4	1	50	86		
Barren land	1	0	**48**	3	50	96		
Water Body	0	1	4	**46**	50	92	89.5%	84.0%
Total	45	47	56	52	200			
Producer's Accuracy %	93	91	86	88				
				1998				
Built-up Area	**46**	0	2	3	50	92		
Vegetation	0	**47**	2	1	50	94		
Barren land	2	2	**43**	3	50	86		
Water Body	3	2	5	**40**	50	80	88%	83.0%
Total	50	51	52	47	200			
Producer's Accuracy %	92	92	83	85				
				2008				
Built-up Area	**42**	3	2	3	50	84		
Vegetation	2	**43**	4	1	50	86		
Barren land	1	0	**48**	3	50	96		
Water Body	0	1	4	**46**	50	92	89.5%	84.0%
Total	45	47	56	52	200			
Producer's Accuracy %	93	91	86	88				
				2018				
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Barren land	1	0	**48**	3	50	96		
Water Body	0	1	4	**46**	50	92	89.5%	84.0%
Total	45	47	56	52	200			
Producer's Accuracy %	93	91	86	88				

The 48% sample points were used to verify the outcomes of the LULC maps produced by the RF algorithm in GEE. The kappa coefficient method was applied in this study to achieve objective. The original land use type and the categorised image were compared using the points from the 48% validation dataset. The original image and Google Earth imagery were utilised as reference data after the value of the classified image assigned to each location was extracted using ArcGIS. The overall accuracy of the classified photos was calculated and represented in an error matrix table. The results indicated that the RF algorithm for LULC classification performed well. In 1988, the overall accuracy was 89.5%; it was 88% in 1998; 89.5% in 2008; and 89.5% in 1988 and 89.5% in 2018.

Table4
Conversion matrix of land use types in the Khairpur district during 1988–2018

LAND CLASS 1988	LAND CLASS 2018										
	Land Cover Types	**Vegetation**		**Water Body**		**Barrenland**		**Sand**		**Built upArea**	
	Vegetation	**21345**	**39%**	2132	35%	29156	74%	214	26%	10057	74%
	Water Body	4133	8%	**1413**	**29%**	453	2%	310	34%	221	2%
	Barren land	20013	33%	58	3%	**6988**	**21%**	96	20%	866	4%
	Sand	5134	18%	1704	33%	844	3%	**168**	**20**	234	2%
	Built up Area	401	3%	2	0%	78	0%	0	0%	**1898**	**18%**
	Total	33026	100%	5309	100%	37519	100%	788	100%	13276	100%

Change detection matrix also constructed for a whole time period that can be summarized as follows: 39%, 29%, 21%, 20%, 18% of land under vegetation, water body, barren land, sand and built up area respectively in 1988 remained under the same land use and land cover category in 2018. But conversion also seen in all define classes as shown in Table. While in 2008 to 2018 a little positive change recorded. Built up area continuously expand in all three periods. In the first phase (1988 to1998) built-up area increased by 98%, in the second phase (1998 to 2008) the net increase was 81%. And in the final phase (2008 to 2018) the net gain was 60% and still continue. From the figures it was cleared that major drastic impact exerted by built- up area was on fertile agricultural land and other non-built up surfaces.By knowing the facts of empirical results and by the analysis of maps it is cleared that district Khairpur is one the fastest growing district of Sindh province in the context of spatial and temporal sense. And the district needs the complete assessment of land use and land cover by incorporating temporal and spatial models and spatial metrics, remote sensing and socio-economic data as well. If the growth rate remain same in future district Khairpur will face problems of open spaces and resources shortage**.**

Conclusion

This research investigate the LULC Change occurrence and to monitor these changes at the local scale, by the integration of satellite remote sensing and GIS and as well to expose the nature and extent of these changes. Post classification techniques like change detection matrix and overlay analysis have become the important source in the land use and land cover change studies, therefore these techniques applied in the study of temporal variation in land use and land cover change in district Khairpur form 1988 to 2018 as well. This research work has proven that supervised classification for multi-temporal Landsat images is essential for the study of land use and land cover change. By analyzing the classified maps of satellite images of 1988, 1998, 2008 and 2018 the dynamics of change in land use identified. The rate of change varies for each LULCC category. The results of these images highlight the major classes that affected in 30 years of time span. Although all defined classes vary over the time period but the major variation is seen in two classes' vegetation and built up area. Vegetation reduces while the built-up area increases. The rate of change for both classes also vary for vegetation the annual change rate calculated was 5.21% and for the built-up area, it was 15.2%.

Therefore, the integration of this method is a necessity of this type of study. But the execution of this method requires great knowledge and expertise. The method applied by using ArcMap 10.1.3. Change detection matrix findings highlight the percentage of areas of the classes that remain the same in 30 years of the period. About 23%, 87%, 18%, 36%, and 41% of the land of a water body, vegetation, sand, barren land and built up area respectively remained under the same LULCC category. While other remaining areas of the classes vary to which are already described in above fields. To visualize the change in different categories overlay analysis also executed and their results confirm the conversion of categories into one another. The negative impacts of land use and Land cover changes on the environment caused by the urbanizations and growth in built-up areas need to be managed. This can only be managed through effective planning not only effective planning but also the execution of planning is important. The observing adverse effect in the study areas nowadays was only due to the lack of execution of the planning formed in the 1975s and 1993s. The effective planning not only becomes the remedy for the already existed adverse environmental impacts but would be useful for the protection of the vegetative land and another arable land. And also reduces environmental degradation, soil erosion, and pollution. Effective planning also helpful for the sustainability of the district.

Recommendations

This research investigate theLULCC occurrence and to monitor these changes at the local scale, by the integration of satellite remote sensing and GIS and as well to expose the nature and extent of these changes. Post classification techniques like change detection matrix and overlay analysis have become the important source in the land use and land cover change studies, therefore these techniques applied in the study of temporal variation in land use and land cover change in district Khairpur form 1988 to 2018 as well. The design objectives and lay the foundation for further study in that field. The effective planning not only becomes the remedy for the already existed adverse environmental impacts but would be useful for the protection of the vegetative land and another arable land. And also reduces environmental degradation, soil erosion, and pollution. Effective planning also helpful for the sustainability of the district.

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