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Spatial and Temporal Dynamics of Land Cover and Land Use in District Pishin through GIS

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Abstract: Anthropogenic activities have left only a few places on the surface of the earth in its natural state. So, observing the face of the earth from the space using satellites is of great importance for recording anthropogenic impact of man on natural environment. This study is an attempt to record and quantify spatial and temporal change in land use and land cover (LULC), using Remote Sensing (RS) and Geographic Information System (GIS). We used satellite imagery acquired from three LANDSAT satellites, and were processed in ArcMap10.1, and the supervised image classification script was applied for the detection of change in the study area. The analysed data revealed that built-up area, vegetation cover and the number of water bodies were increased by 5.842%, 3.891% and 0.051%, respectively, while 9.783% decrease was recorded in bare surfaces. The results of this study reveal that for keeping eyes on the land use and land cover of the Earth, the digital detection methods are not only significant but have great potential in pointing unused and potential pitches of land for utilization of different purposes.

Key words: Remote sensing, GIS, Land use, Change, Spatial.

INTRODUCTION

Various studies carried out on scientific lines revealed that human beings have left very few places on the Earth in untouched state. However, already occupied places by man along with natural process have greatly altered the natural state of the surficial earth. It has been found by many researchers that land use and land cover (LULC) pattern of an area is almost entirely defined by human and natural activities (Shoshany *et al.*, 1994). Therefore, monitoring and observing environment through satellite data and LULC change detection studies have become enormously significant for a judicious utilization of the resources of the Earth (Liu and Deng, 2010). Observation of the Earth for keeping an eye on the influence of human beings through satellite from the space using satellite imagery is very important for the judicious utilization of the Earth's resources (Rogan and Chen, 2004). The data acquired from various satellites can be used when it is geometrically and radiometry wise corrected for a particular application (Diallo *et al.*, 2014). The land use and land cover change detection study was carried out by using satellite images, having different temporal, radiometric and spatial resolution and characteristics. Such data, with fine temporal and spatial resolution, is available on the United States Geological Survey website and can be downloaded through a user interface designed for this purpose (Reis, 2008). Although, the data can be downloaded for free but one should have the technical knowledge that the data is comparatively of less resolution (Pijanowski *et al.*, 2002). Sometimes, it is necessary to rectify and enhance the data before it is used for a particular application (Gitas *et al.*, 2004). GIS experts can use different software to process and analyze the images for the detection of change once the images are enhanced and corrected. The maximum likelihood supervised classification is commonly preferred for such spatial extension (Macleod and Congalton, 1998). The common digital process carried out in this regard in known as maximum likelihood, which can be used both for low and high resolution images (Zhao, 2003). However, the supervised classification is mostly utilized and is, in fact, more accurate for getting the desired results (Mengistu and Salami, 2007). In order to reach the goal of detecting a change, a software, named as ArcMap, was used, which is one of the world's leading software used by GIS experts for various geographical operations. Topo-maps were also used during the process of detecting change through GIS and RS.

MATERIALS AND METHODS

1. Study area: Pishin is one of the fertile districts of the province of Balochistan, situated in the north-west part of Balochistan province of Pakistan (Fig. 1), and is covered by the rugged topography in the form of lofty mountains and intermountain valleys with scattered plains in the form of piedmont plains. The extent of district Pishin lies between 30°.33' N to 31°.20' N and 66°.79' E to 67°.85' E (IUCN, 2011). The administrative boundary of Pishin engulfs an area of about 5296 sq. km for the whole district. Pishin district has a climate with mild summers and very cold winters, with 280 mm rainfall annually with

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maxima in winters from western disturbances, which depicts the characteristics of the area of a dry and semiarid climate. Geographically, district Pishin is lying on the margin of the prominent weather systems of the subcontinent, i.e., the summer and winter Monsoon. Rainy season prevails from December to March with maxima in January. Sometimes, this rainy season extends upto the month of April (IUCN, 2010).

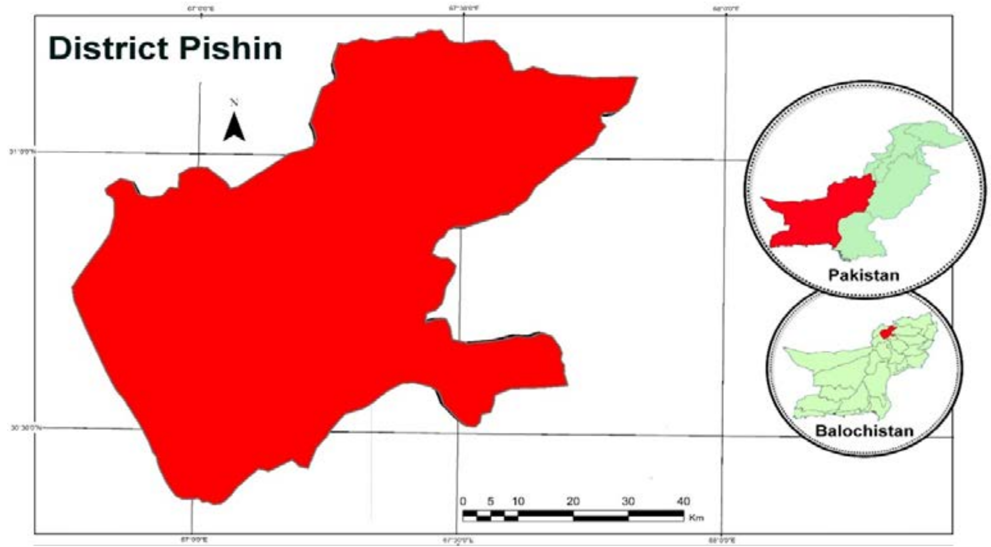

Fig. 1. Location map of district Pishin.

2. Data sources and acquisition: For the change detection in land use and land cover, satellite images were downloaded from LANDSAT 5, 7 and LANDSAT 8 satellites, which carry sensors that are known as Thematic Mapper, Enhanced Thematic Mapper and Operational Land Imager, respectively. The satellite images that were acquired from the above mentioned satellites are of fair spectral and spatial resolution. The process of land use and land cover change detection was also aided by Topographic maps.

3. Data processing and analysis: ArcMap version 10.1 was used to find out the land use and land cover change, the satellite images were classified, using the supervised classification process. The process of image classification was done with extraordinary care and all the pixels with same spectral characteristics were selected, based on personal knowledge of the study area and visible characteristics in the images. The images were also enhanced through pan sharpening command for better and accurate class making. In order to know and check the accuracy of the classification, a commonly used process called Error Matrix was also performed. Post classification accuracy assessment was performed, using the Error Matrix Method. Table 1 shows four classes that were identified in the images.

Table 1. Land use land cover classes.

Class	Description
Bare surfaces	Areas with no vegetation cover, soil, stony areas, uncultivated agricultural lands.
Vegetation	All kinds of green plants, trees, grass.
Water bodies	Dam, river, lake.
Built-up area	Settlements, like Town, city and village, etc.

RESULTS AND DISCUSSION

The images, that were downloaded for the year 2013, 2003 and 1992, were classified in the ArcMap 10.1 for the detection of any change in land use and land cover. The process of supervised classification rendered the following results, which are presented in detail, text and graphics generated through spatial analysis:

1. Classification results for 1992: The results, rendered through supervised image classification, showed that the water bodies covered the least part of the area which is 0.13% (Fig. 2), followed by 5.28%, 6.65% and 88% by vegetation, built-up area and bare surfaces, respectively. The accuracy assessment indicated that all the classes except water were classified with great accuracy. This is probably due to the fact that, sometimes, the colour of the rocks and water is stored and recorded with the same spectral signatures. The reason behind less water bodies in the district is attributed to the arid to semi-arid climate and recurrent droughts and dry spells.

2. Classification results for 2003: The results of the analysis showed that bare surfaces cover the largest proportion of the area, which is around 81.62%, followed by built-up area, which covers around 10.53%. The vegetation in the form of trees, crops, and bushes, etc., covers around 7.69%. The most important result is a slight increase in the amount of water bodies, which were recorded as 0.13%, increased slightly to 0.14% of the total area (Fig. 3). The results of the accuracy assessment indicated that the most accurately classified class was Bare surfaces. This is due to the fact that the study area largely consists of this particular land cover class and has very distinctive spectral signature. Water bodies were the least accurately classified class here as well as in the case of classification carried out for the year 1992.

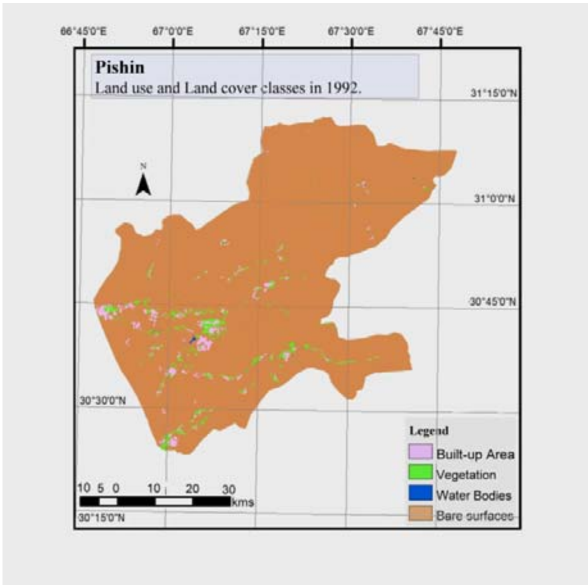

Fig. 2. Land use and land cover classification for the year 1992.

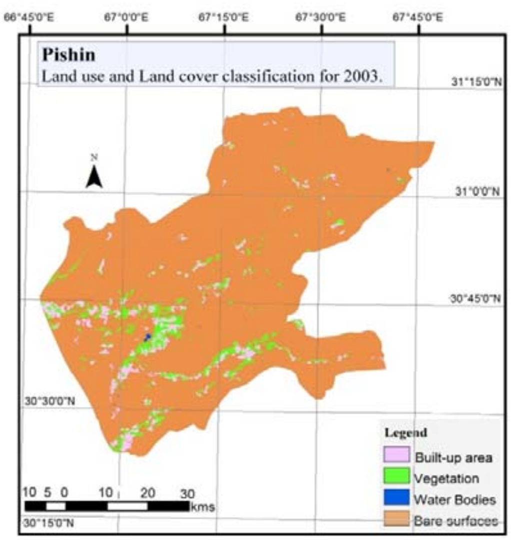

Fig. 3. Land use and land cover classification for the year 2003.

3. Classification results for 2013: The results of the classification rendered that water bodies still occupy the least part of the study area, which is 0.18% only. The built-up area covered around 12.40% of the total land area of the district Pishin. Vegetation covers around 9.17% of the total area. The barren land retained its top position in terms of area covered by it, which is 78.25% of the total area (Fig. 4). The adapted procedure of the accuracy assessment revealed that the least accurate class was water bodies and the most accurately classified class was again bare surfaces, which rendered around 93% accurately classified class.

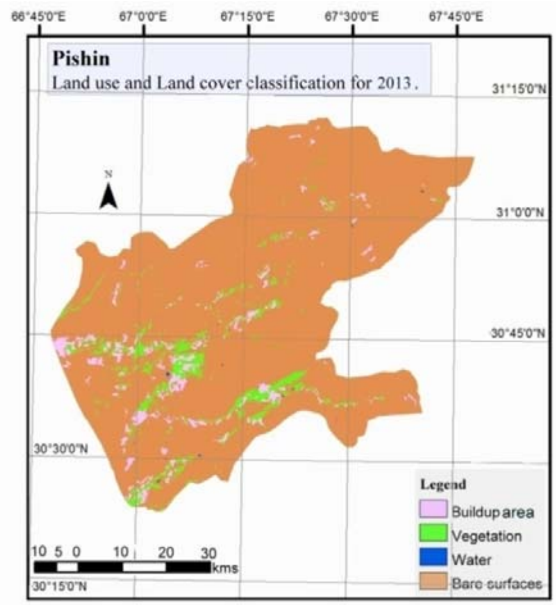

Fig. 4. Land use and land cover classification for the year 2013.

4. Change detection: The process of analysis with the help of ArcMap 10.1, carried out on satellite images acquired from LANDSAT, revealed that water bodies covered a very small proportion of total area in 1992, which was only 0.13%, which increased to 0.18 percent of the total area. Thus a total change of just 0.05% increase was recorded in it**.** The built-up area also witnessed a considerable increase in total area covered by it, during the study period. It increased to 12.40% in 2013 from 6.57% in 1992. Thus an overall increase of 5.84% was recorded. This increase in built-up area is attributed to the rapid increase in population in the study area. Green cover or vegetation in the form of trees, grasses, crops and bushes, etc., in the study area, covered 9.17% of total area in 2013, which was covering about 5.28% of the total area in the year 1992. This indicated a little increase of about 3.89% during the study period. The Bare surfaces became a dominant land cover class in the study area. It was the only class which witnessed a decrease during the study period. It was covering about 88.03% of the total area of the district Pishin, which decreased to 78.25% in the year 2013 (Table 2). An overall decrease of around 9% was recorded during the study period in this particular class (Fig. 5). The decrease in bare surfaces is attributed to the increase in human population which resulted in an increase in built-up area and an increase in vegetation as more population required more food as a result of crop cover and the orchards in the study area increased.

Table 2. Year-wise area covered by each class and percent of change.

Land use/land cover class	1992 (%)	2003 (%)	2013 (%)	Change (%)
Built-up area	6.57	10.53	12.40	5.84
Vegetation	5.28	7.69	9.17	3.89
Water bodies	0.13	0.14	0.18	0.05
Bare surfaces	88.03	81.63	78.25	-9.78

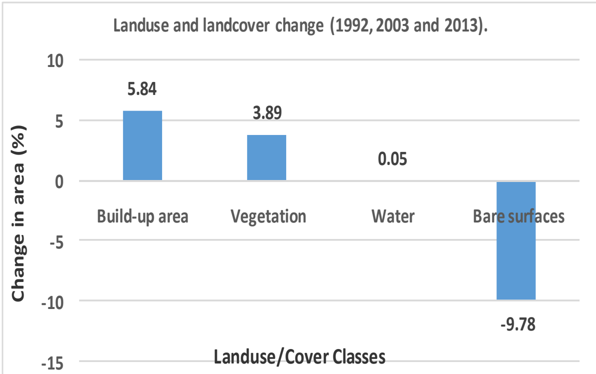

Fig. 5: Land use/land cover change during the study period.

Findings: The availability of the satellite images for the desired date and period of the year and the comparatively less resolution of satellite images were amongst some of the challenges that were faced during the course of this study. Despite these challenges, the resultant facts and figures proved that this kind of studies were not only effective but fruitful for keeping an eye on any change on earth surface related to land use and land cover. Below are some of the key findings of the study:

1. As we identified the change in the vegetation cover that resulted during the span of change fixed for the study is attributed to an increase in the number of tube-wells, as the electricity provision is on flat rates. So, the farmers try to bring more and more land under cultivation by irrigating their fields than the normal irrigation of their fields for normal crops growth and production.
2. The change in land-use of vegetation cover is mostly confined to the plain south eastern and southern parts of the study area. This is because the fertile lands are mostly situated in these parts of district Pishin.
3. It has also been noted from the data that there is a considerable increase in the built-up area. The analyzed data reflected that this increase is attributed to the natural increase in population of the area and now people prefer to have small families, resulting in new development in the built-up areas in district Pishin.
4. It has also been revealed from the analyzed data that there was a considerable change in the barren surfaces due to natural increase in population and an increase in vegetation cover has encroached the area by human settlements and vegetation cover as well.
5. The small increase of 0.05% in land covered by water bodies in a study period of 21 years clearly indicates that the area is hit by many dry spells in the recent times. This little increase is due to construction of many small dams on seasonal streams in the district.
6. The barren area mostly decreased in the plain and inhabitable parts of the district, which are mostly situated in southern parts of the study area.
7. **The build-up** areas mostly increased in southern parts of the district. This is attributed to the fact that most of the plain areas are situated in southern part of the district Pishin.
8. The Lake Kushdil Khan is able to retain its position of the largest water body of the district Pishin, built for the irrigation of the southern part of the district that has shrunken over the time.
9. The analyzed data revealed that the area with barren characteristics will shrink in future as well, as it would be utilized for other purposes.
10. As the water availability is very scarce in the area, so the available land must be utilized for cultivation with care and should be cultivated on scientific lines for optimum production and to prevent the land from degradation.

CONCLUSION

Land use and land cover change detection is now mostly done with the help of satellite imagery, in general, and most important for monitoring changes in the environment. This study was done with the aid of satellite images acquired from United States Geological Survey from LANDSAT satellite series with images, having multi-spectral and multi-temporal characteristics and strongly suggests that these images can be used for the detection of land use and land cover change in almost all geographical location of the earth. After the detail analysis of the results generated from this study, it is clear that a study of such spatial and temporal extent would have been impossible, if carried out with conventional methods of analysis and research. The results generated through the analysis of the data for the study revealed and confirmed the fact that both Remote Sensing and Geographic Information Systems can be used with great confidence and trust for the detection of change in land use and land cover in any geographical location of the earth.

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