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Environmental Assessment of Land Use Land Cover Using Remote Sensing and GIS: A Case Study of Khirthar National Park

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Abstract. National Park area is a natural reserve with an outstanding beauty having rich biodiversity, natural eco-system and sustainable environment is a gift from nature to conserve. It is extremely important to monitor the sustainability of National Park by extracting land use land cover change information over the period of time using satellite imagery which is the main application of change detection. The aim of this research study is to assess the land use land cover change at Khirthar National Park by acquiring multispectral Land sat satellite imagery to detect decadal information from 1992 to 2019 using supervised classification Maximum Likelihood classifier. The Land sat satellite data used in this research study was almost of the summer season to assess land use land cover change using supervised classification Maximum Likelihood Classifier and results showed increasing trend in agriculture while decreasing trend in natural vegetation at Khirthar National Park which is a clear indication of increasing anthropogenic activities. The supervised classification Maximum Likelihood Algorithm used to detect land use land cover change at Khirthar National Park results overall accuracy in the year 1992, 2000, 2010 and 2019 was 99.7446%, 99.4536%, 99.6495% and 96.7530% while the kappa statistics results achieved in the year 1992, 2000, 2010 and 2019 was 0.9951, 0.9879, 0.9648 and 0.9503. These increasing human activities will not only disturbs the ecology of National Park but also will impact on the local flora and fauna of the park, therefore it is highly recommended to prevent further loss of biodiversity, natural eco-system and the sustainable management for such natural heritage.

Keywords: Remote Sensing; NDVI; LST; National Park; Biodiversity.

1. INTRODUCTION

The assessment of land use land cover and monitoring its changes currently becomes preliminary issue because of growing human population which subsequently disturbs the natural environment and the land cover types (Qian, *et al.*, 2007) while these land cover changes are essential for development (Dhinwa, 1992) therefore planning of land use is necessary for the development of any region(Agenda, (1992). Understanding the change dynamics of land use land cover and its pattern is significantly essential due to increasing anthropogenic activities (Halimi, *et al.*,2017) (Pasha, 2016), which is at alarming stage and can have direct affect to the natural ecosystem, food availability (Minale,2013) and these increasing human activities are the main driving forces (Vitousek, 1994) which converts the land cover from one type to other and also threatened to the natural resources (Zewdie, and. Csaplovies, 2017). The conversion of these land cover types from one land form to other is a clear evidence of the interaction between nature and human(Fasona, and Omojola. 2005). And this interaction has not only disturbs the natural ecosystem but also destroyed the natural resources with the respect of time (Clevers, 2005) such as National Park and protected areas which are almost 7000 around the world (Mc Neely, 1992) and according to (Consortium, 2006) 13.4% of the Earth's surface is covered by protected areas and is considered to be much important for the conservation of natural environment, biodiversity and restrict the human interference in such protected areas which is the most challenging issue (Das, 1996).These long term land use land cover change impacts of anthropogenic activities has tainted the conservation processes (Wessels, 2004) (Soulé, 1991) (Sala 2000) (Araújo, 2004) and are important to monitor (Lambin, and Strahlers, 1994) (Lunetta, 2006) in such protected and National Park areas. These land use land cover changes were difficult to monitor larger areas in short time but remote sensing technology along with GIS tools made it easy not only to assess and monitor but also provide information of past scenarios and predicts the future losses. Land use land cover change is the main application of remote sensing for the assessment of long-term changes especially vegetation cover and its change dynamics at regional scale (Lunetta, 2006) (Reed, 2006) (Pettorelli, 2005) (John, and Nellis, 1991).

The aim and importance of this research paper is to detect and use land cover changes for sustainable monitoring and assessment of Khirthar National Park using supervised classification Maximum Likelihood Algorithm to be applied onmulti-spectral30 meter resolution Land sat TM and OLI & TIRS sensor data because of free available on https://earthexplorer.usgs.gov and inspire every

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individual researcher rather than acquiring costly high resolution satellite data. The present research would be ignition step towards conservation of Khirthar National Park and also supportive to decision makers (Abbasi, *et al.*, 2011).

Study Area

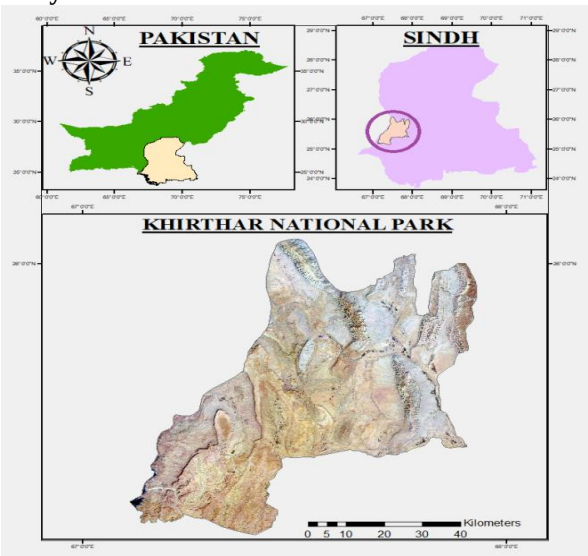


Fig. 1. Map of Khirthar National Park, Sindh, Pakistan.

Khirthar National Park is the second biggest National Park of Pakistan established in (1974) and the first National Park of Pakistan was enlisted in UN's list of National Park around the world while International Union for Conservation and Nature (IUCN) has listed Khirthar National Parkas category type II of protected area lies25°42′ North and 67°35′ East in Jamshoro district and covers an area about 3,087 square kilometers from south-west to north-east. The Khirthar National Park is the only National park in Sindh, Pakistan which is surrounded with Mahal Kohistan and Hub Dam wildlife sanctuaries.

2. MATERIALS AND METHODS

The material used for this research was Landsat satellite orbits at 705 km altitude with 16 days revisit time cover 185km swath. Theremotely sensed Landsat TM having seven spectral bands sensor dataof dates 27of April 1992, 17 of April 2000 and 29 of April 2010 and OLI & TIRS having eleven spectral bandssensor data of 9thJune 2019 were downloaded from Earth Explorer website with cloud free and clear atmospheric conditions having path 152 and row 042 and 043 which were later mosaic to subset and clip the study area. After clipping the study area region of interest were applied to the study area for extracting the different land use land cover types using supervised classification Maximum Likelihood Algorithm. The remotely sensed satellite data used for the assessment of land use/land cover changes at study area are showed in **(Table 1).**

Table 1: Satellite data acquisition

Landsat Sensor	Date of acquisition	Path	Row	Source
TM	27-04-1992	152	042& 043	USGS website
TM	17-04-2000	152	042& 043	USGS website
TM	29-04-2010	152	042& 043	USGS website
OLI & TIRS	09-06-2019	152	042& 043	USGS website

Supervised classification Maximum Likelihood Algorithm:

Supervised classification mapped the multiple land cover classes (Campbell, 1987) (Thomas, *et al.*, 1987) by applying region of interest on pixels with same reflectance profile for the identification of particular land cover type. Image classification groups all pixels into land cover classes automatically (Lillesand, and Kiefer, 1994). The Maximum Likelihood Classifier has the quality to classify unknown pixels by evaluating variance and covariance of spectral response (Shalaby, and Tateishi, 2007) (Lillesand, and Kiefer, 1994) and that is why it is considered to be most accurate and common classifier (Richards, 1995). In this study the research area was categorized into five classes: Agricultural land, Natural vegetation, water, barren land and uncultivated land. The assessment ofland use land cover typesand results were generated in ENVI 4.7 software using supervised classification.

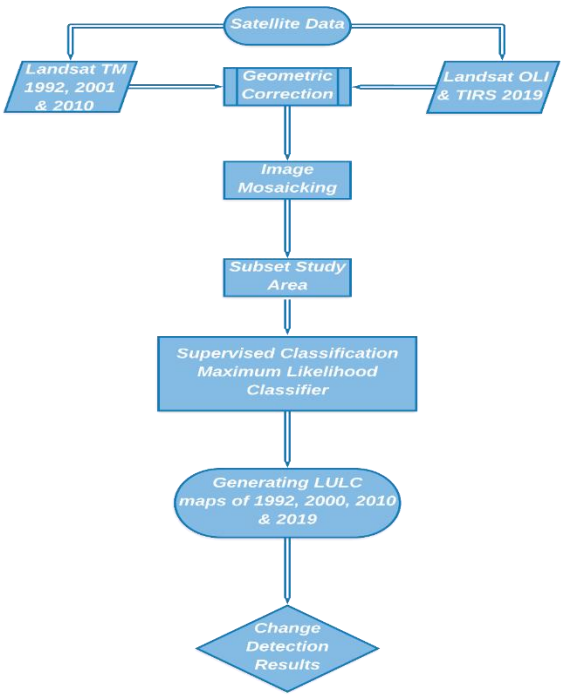


Fig.2 Data Analysis Flowchart

3. RESULTS AND DISCUSSION

The land use land cover generated maps of Khirthar National Park from remotely sensed satellite data of 1992, 2000, 2010 and 2019 using supervised classification Maximum Likelihood Classifier in ENVI 4.7 software. The classification has divided the study area into five land use land cover classes: Agricultural Land, Natural Vegetation, Water, Barren Land and Uncultivated Land. The Kappa statistics value and overall accuracy achieve is excellent along with all land use land cover types as showed in error matrix **(Table 2, 3, 4 and 5).** The LULC maps are shown in **(Fig.3)** while the precipitation and temperature data collected from NASA (Agro-climate data) has been graphically represented.

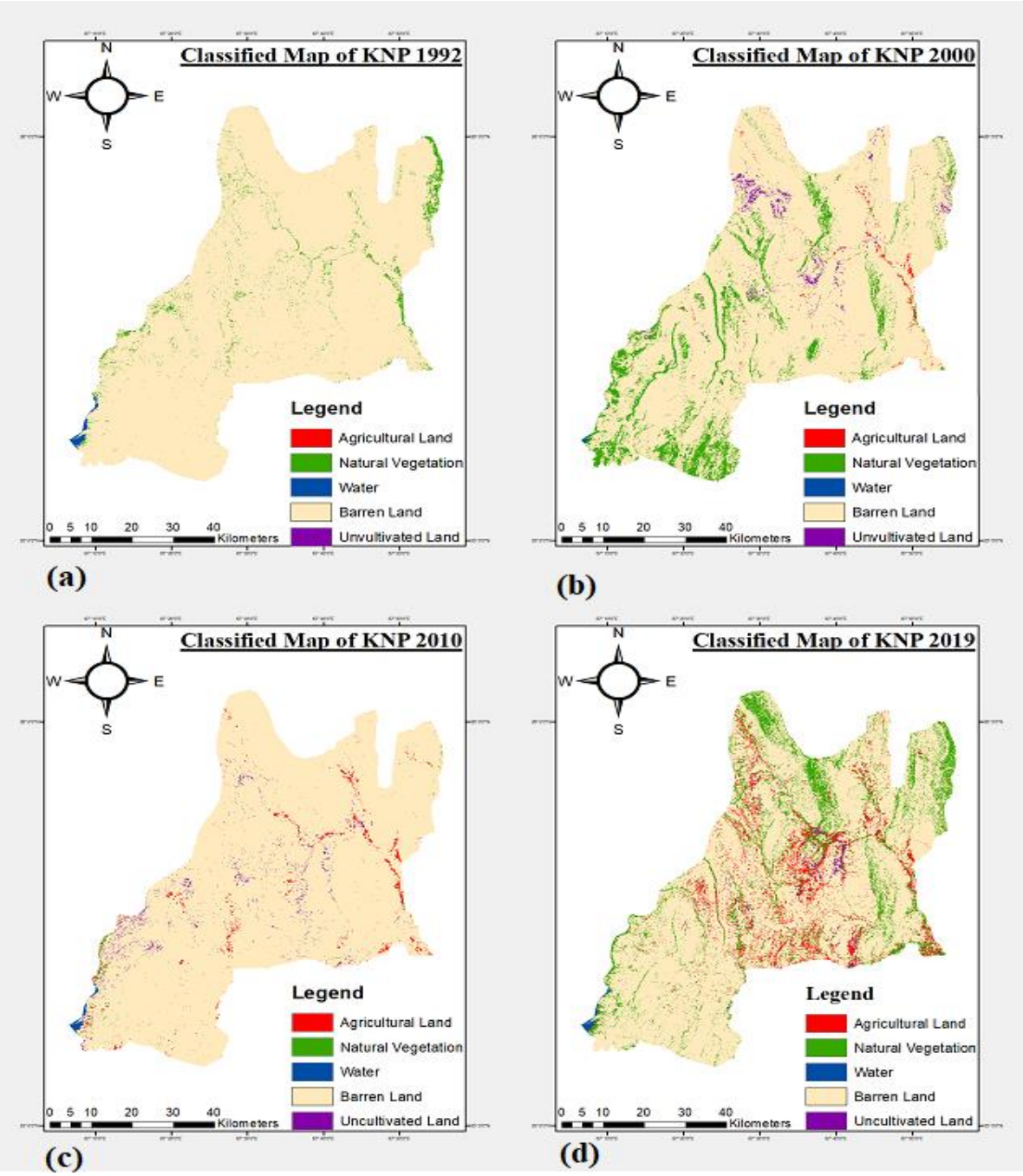


Fig. 3: The LULC maps of Khirthar National Park of year (a)1992, (b) 2000 and (c) 2010 using Landsat TM and (d) 2019 using Landsat OLI & TIRS.

Table 2: Classification accuracy assessment for the year 1992

	Statistical results of 1992							
# Classes	Agriculture	Vegetation	Water	Barren	Uncultivated	Totals	User's Accuracy	Overall Accuracy
Agriculture	78	2	0	0	0	80	97.50%	
Vegetation	0	695	0	3	0	698	99.57%	
Water	0	0	27	0	0	27	100%	
Barren	0	0	0	1153	0	1153	100%	
Uncultivated	0	0	0	0	0	0	0%	
Totals	78	697	27	1156	0	1958		
Producer's Accuracy (%)	100%	99.71%	100%	99.74%	0%			99.74%
Kappa Coefficient (%)	99.51%							

Table 3: Classification accuracy assessment for the year 2000

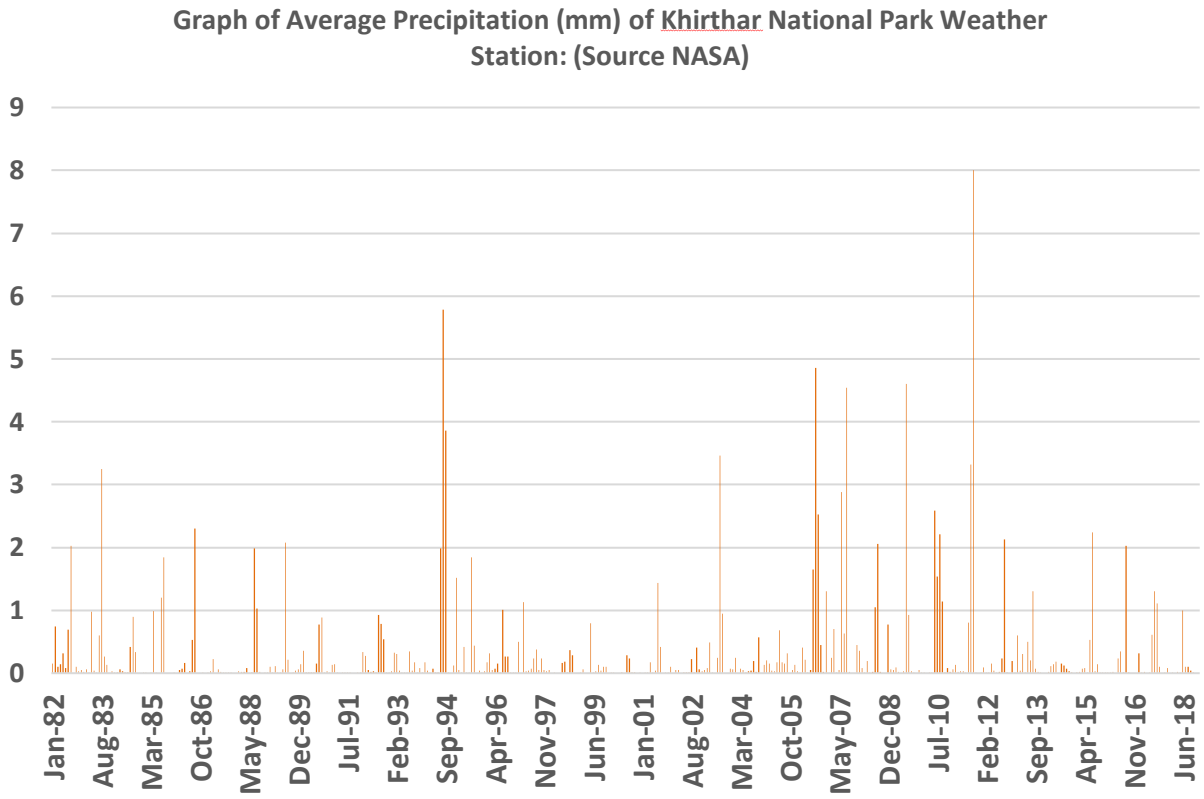
	Statistical results of 2000							
# Classes	Agriculture	Vegetation	Water	Barren	Uncultivated	Totals	User's Accuracy	Overall Accuracy
Agriculture	64	2	0	5	0	71	90.14%	
Vegetation	1	63	0	0	0	64	98.44%	
Water	0	0	154	0	0	154	100%	
Barren	0	0	0	1062	0	1062	100%	
Uncultivated	0	0	0	0	113	113	100%	
Totals	65	65	154	1067	113	1464		
Producer's Accuracy (%)	98.46%	96.92%	100%	99.53%	100%			99.45%
Kappa Coefficient (%)	98.79%							

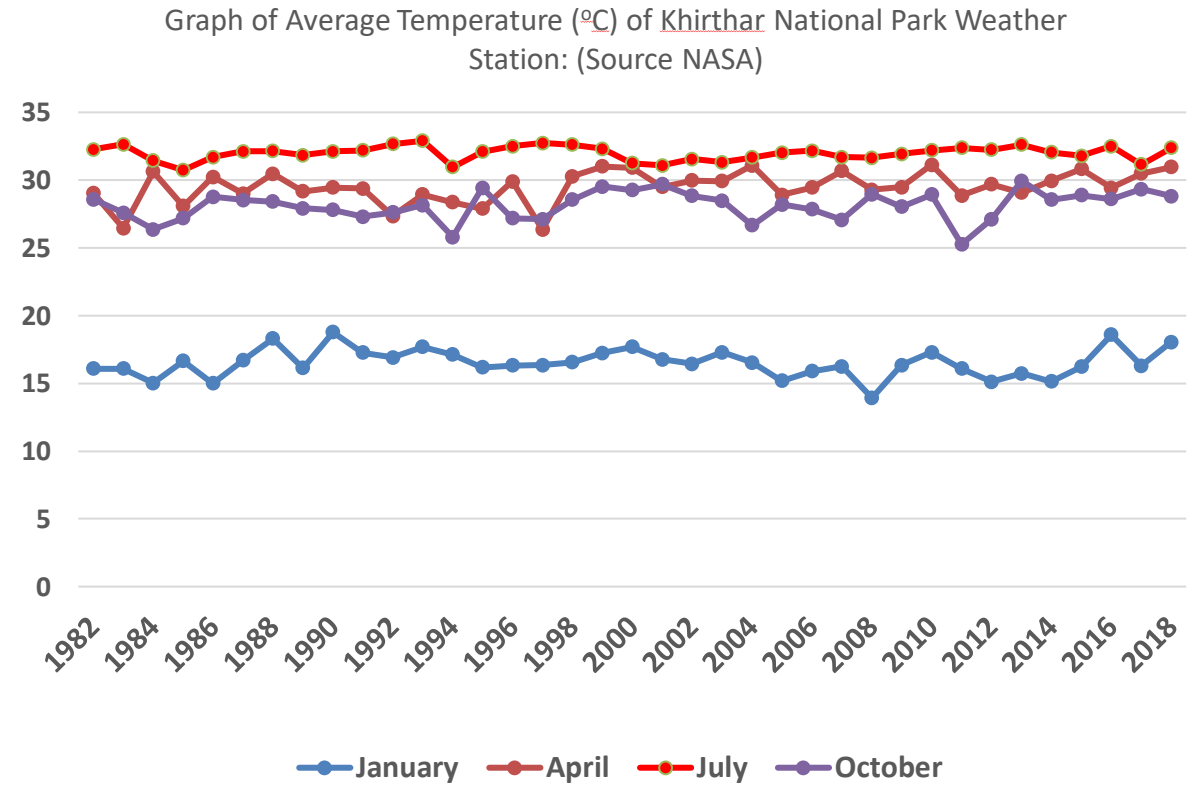
Table 4: Classification accuracy assessment for the year 2010

	Statistical results of 2010							
# Classes	Agriculture	Vegetation	Water	Barren	Uncultivated	Totals	User's Accuracy	Overall Accuracy
Agriculture	598	2	0	1	0	601	99.50%	
Vegetation	14	192	0	2	0	208	92.31%	
Water	0	0	384	0	0	384	100%	
Barren	0	0	1	25940	1	25942	99.99%	
Uncultivated	0	0	0	75	182	257	70.82%	
Totals	612	194	385	26018	183	27392		
Producer's Accuracy (%)	97.71%	98.97%	99.74%	99.70%	99.45%			99.64%
Kappa (%)	96.48%							

Table 5: Classification accuracy assessment for the year 2019

	Statistical results of 2019							
# Classes	Agriculture	Vegetation	Water	Barren	Uncultivated	Totals	User's Accuracy	Overall Accuracy
Agriculture	267	39	0	10	0	316	84.49%	
Vegetation	18	415	0	3	9	445	93.26%	
Water	0	0	81	0	0	81	100%	
Barren	0	0	0	311	0	311	100%	
Uncultivated	0	0	0	0	1280	1280	100%	
Totals	285	454	81	324	1289	2433		
Producer's Accuracy (%)	93.68%	99.41%	100%	95.99%	99.30%			96.75%
Kappa Coefficient (%)	95.03%							


Graph of Average Precipitation (mm) of Khirthar National Park Weather Station: (Source NASA)
9
8
7
6
5
4
3
2
1
0
Jan-82
Aug-83
Mar-85
Oct-86
May-88
Dec-89
Jul-91
Feb-93
Sep-94
Apr-96
Nov-97
Jun-99
Jan-01
Aug-02
Mar-04
Oct-05
May-07
Dec-08
Jul-10
Feb-12
Sep-13
Apr-15
Nov-16
Jun-18


Graph of Average Temperature (ºC) of Khirthar National Park Weather Station: (Source NASA)
35
30
25
20
15
10
5
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
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2002
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2006
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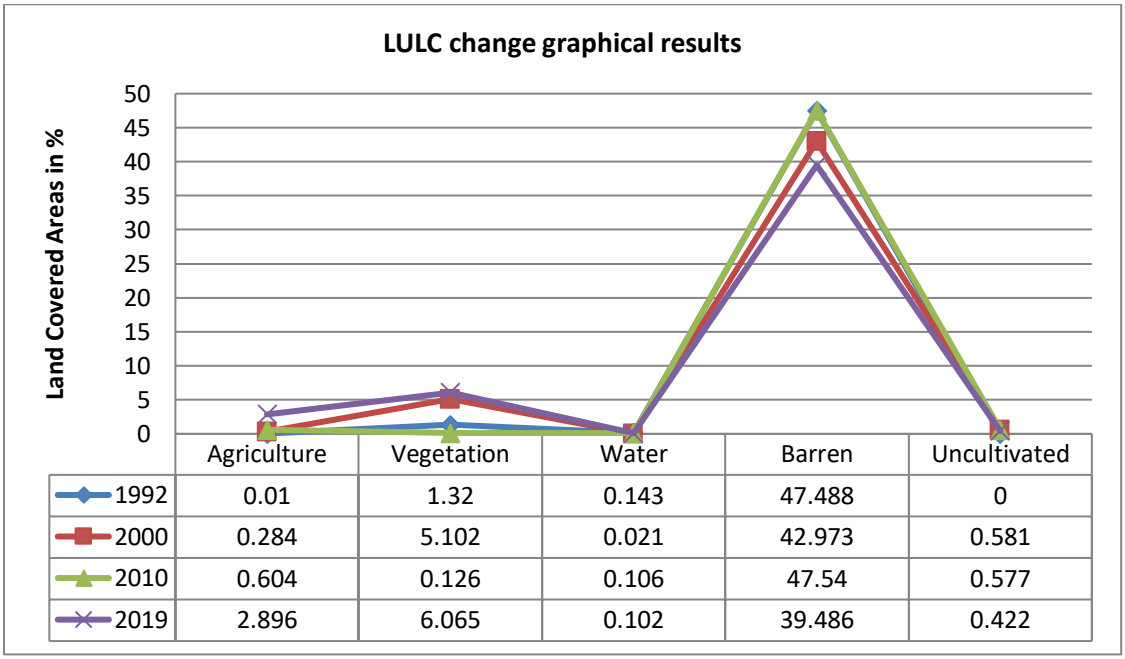
January
April
July
October



	Agriculture	Vegetation	Water	Barren	Uncultivated
1992	0.01	1.32	0.143	47.488	0
2000	0.284	5.102	0.021	42.973	0.581
2010	0.604	0.126	0.106	47.54	0.577
2019	2.896	6.065	0.102	39.486	0.422

5. CONCLUSION

This research study has integrated remote sensing and GIS in the assessment of land use land cover change at Khirthar National Park using supervised classification Maximum Likelihood Classifier by acquiring land sat satellite data of year 1992, 2000, 2010 and 2019. Different change detection methods have been applied to identify the natural and anthropogenic change but the image classification results quantitatively and qualitatively. The supervised classification in this research has revealed drastic changes at study area during the study time period and has achieved high overall and kappa coefficient values in 1992 99.7446% and 0.9951, 99.4536% and 0.9879 in 2000, in 2010 99.6495% and 0.9648 while in 2019 96.7530% and 0.9503. This research study has revealed unexpected changes at khirthar National Park from 1992 to 2019 which is a clear evidence of less interest of decision makers and unplanned development at such protected areas which are enriched with a variety of plant and animal species.

As far as this research study is concern, the study has concluded the absence of monitoring and assessment of land cover changes in Khirthar National Park which may in future will completely vanish all plants and animal species. This research study recommended the national and international scientist community for more comprehensive research study at Khirthar National Park and toprevent from further loss of biodiversity and natural environment of National Park which will helps take holders in proper policies making and geared towards sustainable development of natural resources.

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