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Monitoring land use land cover change dynamics using geospatial technique- A case study of Saran Plain, Bihar, India

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Abstract: *Digital techniques for change detection by using multi-temporal satellite imagery aids in understanding landscape dynamics. The present study illustrates the spatio-temporal dynamics of land use/cover of Saran Plain, Bihar. Landsat satellite imageries of two different time periods, i.e., MSS of 1980 and 2017 were acquired by USGS and Earth explorer site and the landuse/ land cover changes in the Saran Plain was quantified from 1980 to 2017 over a period of 37 years. Supervised classification methodology has been employed using maximum likelihood technique in ERDAS INAGINE 2014 Software. The images of the study area were categorized into six different classes namely vegetation, agriculture, water body, dry river bed, settlement and open and fallow land. The results indicate that during the last 37 years agriculture land occupies the largest area amongst the all six categories. The results revealed that both positive and negative changes have occurred in land use/ cover pattern of the Saran plain. During the last 37 years settlement and agricultural land have been increased by 7 % and 72%. On the other hand, vegetation, waterbody, dry river bed, open and fallow land have been decreased by 6.71%, 0.48%, 0.50% and 12.97%.*

Key Words: *Land use/ cover, Remote Sensing, Geographic Information System, Landscape pattern change.*

1. INTRODUCTION:

The term land can be defined as "a portrayal figure on the earth surface enclosing all physical attributes of the biosphere and the also the immediate environment which focuses on the soil and terrain forms, major hydrating bodies, (river, shallow lakes, swamps, marshes and even underground water reserves) major biotic communities and their respective distribution and major physical changes due to human activities" ([8]UN, 1994; CSD, 1996). Land is very important when it comes to the existence and development of humans. Land as a factor of production is of great importance. Land can be called the original source of all material wealth. The economic prosperity of a country is closely associated with the realm of its natural resources.

Land cover and land use are terms which are often used interchangeably. Land use /land cover change is a generic term used for the modification of the Earth's terrestrial surface caused due to human actions. Humans have been altering land for the purpose of food and other essential items for a long time, but the extent of change in land use/ land cover induced by human actions in recent times have been far greater than ever before. This is leading to substantial changes in the entire ecosystem and environmental chains, both at global and local level. The ramifications have gone so far that in current times, land use/ land cover changes caused due to constant human intervention is one of the greatest threats being posed to the environment at large.

Land use and Land cover are two essential elements describing the terrestrial environment with reference to human activities as well as natural processes. According to [2]FAO Soil Bulletin No 67 (1993), "Land Use" refers to the function or purpose for which the land is used by the local human population and can be defined as the human activities directly related to land, use of their resources or an influence on them. Land cover refers to objects located on the planet surface which are of either natural or human origin. Land use describes the various ways in which people use the land and their resources. Land use involves the management and the change of natural environment or wildlife into settlements and semi-natural habitats such as wetlands, meadows and managing wood. It is also defined as "the activities, natural resources and arrangements that people require in a particular landcover type".

Pattern of land use/ cover is a result of natural and socio-economic factors and their use by human in time and space. Information on land use / cover and opportunities for their optimal use is important for selection, planning and implementation of land use schemes to meet growing demand for basic needs and well-being of humans. This information also helps in monitoring the land use dynamics as a result of changing demands due to population increase. Changes in land cover affect land use and land use affects land cover. The main objective of this study is to understand the land use land cover dynamics of Saran plain, Bihar with the study of geospatial techniques.

2. LITERATURE REVIEW:

The various reasons for the use of natural resources and human-induced main activities cause remarkable changes in land cover and land use. Large population growth and changing human practices have led to a strong impact on our ecological system. The most noticeable effects of the modification of natural ecosystems by human activity are the change in LULC as it has greatly impacted the environment regionally and globally ([3]Guo et al. 2012). Land use/ cover change is very essential for better understanding of landscape dynamics over a finite period of time for the purposes of sustainable management. Land use/ cover changes is an all-encompassing and evolving process, primarily driven by natural occurrences and human activities which further lead to changes that would affect the natural ecosystem ([6]Ruiz-Luna et.al, Robles 2003 and [7]Turner et.al 2004).

Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Today, earth resource satellites data are very applicable and useful for land use/cover change detection studies ([9]Yuan et al., 2005; [1]Brondizio et al., 1994). With the discovery of remote techniques and Geographic Information Systems (GIS), land use land cover mapping provides a useful and detailed way to enhance the selection of areas designed for agricultural, urban and / or industrial areas within a region. Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy ([4]Kachhwala, 1985) and with GIS it provides suitable platform for data analysis, update and retrieval. The evolution of high spatial resolution satellite imagery and relatively superior image processing and GIS technologies, has fuelled a larger adoption towards more routine and consistent monitoring and modelling of land use/land cover patterns. Remote-sensing has been widely used in updating land use/cover maps and land use/cover mapping has become one of the most important applications of remote sensing ([5]Lo and Choi, 2004).

3. STUDY AREA:

The study region, the Saran Plain, lies (25 39’ N to 26 39’ N latitude and 83 54’ E to 85 12’ E longitude) lies in the north-western part of Bihar comprising the three districts of Saran, Siwan and Gopalganj and being geographically also known as the Lower Ghaghara-Gandak daob. It covers an area of 6943.79 km square appearing an isosceles triangle formed by three great rivers, the Ghaghara, the Ganga and the Gandak. The region lies in the Ganga alluvium deposited by the Ganga and its tributaries. The alluvium itself is divided into two groups-older of the Bangar (old soil) and Khadar (new soil). Climatically, the mean temperature varies from 17.86°C in December to 11.57°C in January, but by February it begins to rise and reaches its maximum in the last week of May (35.30°C). The region lies in the zone of moderate rainfall (100 cm) but the annual rainfall of the region is 114.37cm. Almost 88% of the total rainfall is concentrated in the rainy season and packed in a few rain hours during 40 to 45 rainy days. The plain has total population of 8,115,688 with the population density of 1174 persons/ sq. km.

4. OBJECTIVE OF THE STUDY:

The objective of this paper is to classify and chart the land-use/land-cover of Saran Plain using remote sensing and Geospatial Information System (GIS) techniques in order to perform accuracy assessment for finding out how precise the classification procedures was performed and also to understand how to interpret the application aspect of the classification. This chapter covers two sections: 1) Land use/Land cover (LULC) classification and 2) Accuracy

This change can only be determined on the basis of satellite imagery of 37 years ago and of the contemporary time. Thus the images were procured from the United States Geological Survey (USGS) website in order to generate precise LULC maps to understand the paradigm shift. Land use land cover change has been detected from these satellite imageries in the digital form using ERDAS IMAGINE 2014.

5. RESEARCH METHODOLOGY:

A. Data Sets

For appropriate use in the current study, good quality, cloud free data, in the form of two satellite images that is, Landsat 5 with (MSS) and row and Landsat 8 with Operational Land Imager and Thermal Infra-Red Sensors (OLI-TIRS) on board path and row for the 1980 and 2018 respectively, both having a spatial resolution of 50 metres and 30 meters each, were downloaded from the United States Geological Survey (USGS), Earth Explorer website of NASA i.e., National Aeronautics and Administration. Both the images were chosen of the October months. Landsat 5 MSS images comprise of seven spectral bands and Landsat 8 OLI-TIRS images comprise of 11 bands, wherein the panchromatic band 8 has a resolution of 30 meters (USGS) ([10]https://earthexplorer.usgs.gov/). The details of satellite data collected, are shown, Table 3.1

Table 1: Details of Satellite Images

Sr.No.	Satellite	Dates of Pass	Characteristics
1.	Landsat 5 MSS	1980	Spatial resolution=50m No of Bands= 7
2.	Landsat 8 OLI/TIRS	2018	Spatial resolution=30m No of Bands= 11

B. RESEARCH TECHNIQUE

It comprises of several steps in order to meet the pre-decided objective of detecting the changes in LULC over a specific span of 37 years. Land use and the Land cover map has helped to know the present land use practices. The images have been visually interpreted and the variation in the image characteristics like tone, texture, pattern etc. has been used to identify various land use classes. Supervised classification technique has been used to prepare different classes of land use and land cover using ERDAS IMAGINE 2014. The process of preparation of land use and land cover maps of two different years with a time difference of around 37 years is being followed by accuracy assessment, kappa statistics to see the nature of change.

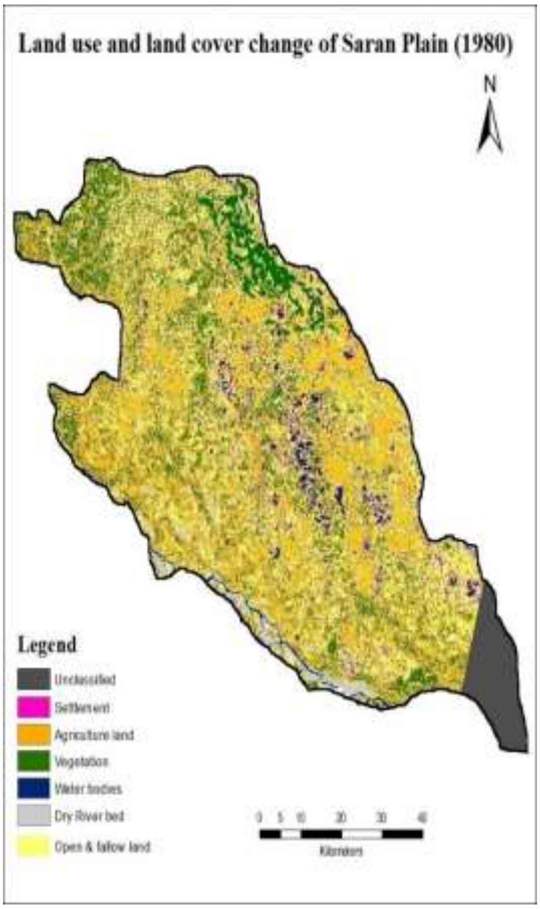
Land use and the Land cover map has helped to know the present land use practices. The pixels identified in the respective classes were validated using Google Earth for both the two time periods. The classification techniques may be categorized either on the basis of the training process (supervised and unsupervised) or on the basis of the theoretical model (parametric and non-parametric). Multiple classification algorithms (classifiers) have been created under this categorization. For example, one of the popular supervised parametric algorithms is Maximum Likelihood Classifier (MLC) whereas k-means clustering is an unsupervised parametric algorithm. Training, allocation and testing are the three distinct stages of supervised classification. In the training stage, a sample of pixels from known class membership is taken from reference data such as existing maps, aerial photographs and ground knowledge. Statistical parameters like mean, standard deviation etc. are derived using these training pixels for each land cover class and these statistics are an input for the second stage of the classification. In the second stage which is allocation, the pixels of the image are tagged to the land cover class with which greatest similarity is displayed based on the statistics. The accuracy of classification is determined in the final stage to verify the outcome of the previous stages. A comprehensive accuracy assessment was done on both the classifications generated during the present study. Accuracy assessment is the methodology used to quantify the extent of reliability of a classified image. The standard accuracy assessment procedure is to develop an "error matrix." This is a square matrix in which the rows and columns represent the identified land cover classes from the classified image. In the case of the present study, there are 6 classes; hence an error matrix with six rows and six columns was constructed.

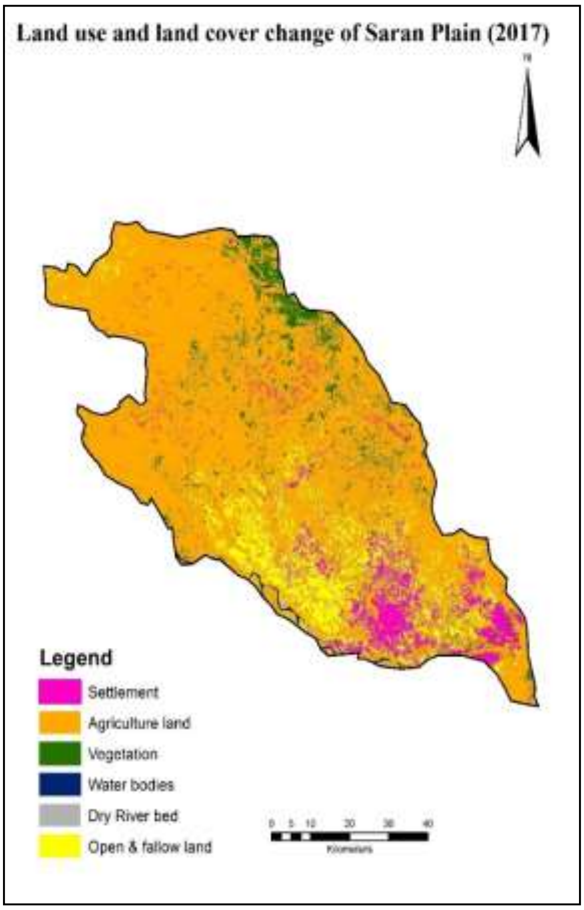
6. RESULTS DISCUSSION AND ANALYSIS:

The results outcome developed through land Use/ land cover change analysis of multi-temporal satellite images are presented in Table 2. The interest of analysing the study of land use land cover dynamics in Saran plain has been taken into account by the supervised classification technique which is a human guided pixel based approach. The classification results show that the six LULC categories (vegetation, agriculture, open and fallow land, water body, settlement and waterbody) has been identified in the area based on the tone, texture that could be identified in the study area. Agriculture land occupies the largest area amongst the all six categories. Open and fallow land is the second dominant land cover type in the study area.

A. Land use/ cover status

Accuracy assessment has been performed on the classified LULC maps over the ERDAS IMAGINE window for each time period. The overall accuracy for each time period i.e. for 1980 and 2017 has been found to be 93.40% and 94.80 % respectively. The Kappa coefficients for 1980 and 2017 maps were 0.8164 and 0.8569. Area and amount of change in different land use and land cover categories in Saran Plain during 1980 to 2017 is shown in table 2. These data reveal that in 1980 about 5.54 % area of saran plain was under settlement, 51.59 % under agriculture land, 15.17 % under vegetation, 3.88% under waterbody, 2.04% under dry river bed and 21.79 % under open and fallow land. During 2017 the area under these land categories was found about 7% area of saran plain was under settlement, 72.36 % under agriculture land, 6.71% under vegetation, 0.48 % under waterbody, 0.50 % under dry river bed and 12.97 % under open and fallow land.





Source: Landsat 3 *Source: Landsat 8 OLI/ TIRS*

Fig: Land use/ Cover Map of Saran Plain

B. Land use/ cover change

Land use / cover modification Data registered in Table 2 revealed that both positive and negative changes have occurred in the land use / cover pattern of Saran Plain. During the last 37 years the settlement in the study area has increased from 5.54% in 1980 to 7 % in 2017 which accounts for 1.46 % increase in the total area. The agriculture has increased from 51.59% in 1980 to 72.36 % in 2017 which accounts for 20%. The vegetation has decreased from 15.17% in 1980 to 6.71% in 2017 which accounts for 8.96%. The waterbody has decreased from 3.88% in 1980 to 0.48% in 2017. The dry river bed has decreased from 2.04% in 1980 to 0.50% in 2017. The open and fallow land has decreased from 21.79% in 1980 to 12.97%.

Table 2: Area and amount of change in different land use and land cover categories in Saran Plain during 1980 to 2017.

Land Use/ Land Cover	1980			2017			Change 1980 - 2017	
	Area (ha)	Area (Percent)		Area (ha)	Area (Percent)		Area (ha)	Area (Percent)
Settlements	35395	5.54		46624	7.00		11228.69	1.46
Agricultural Land	329553	51.59		482161	72.36		152607.78	20.77
Vegetation	96879	15.17		44696	6.71		-52183.38	-8.46
Water Body	24776	3.88		3184	0.48		-21592.25	-3.40
Dry River Bed	13015	2.04		3309	0.50		-9705.97	-1.54
Open & Fallow	139181	21.79		86401	12.97		-52780.01	-8.82
Total	638799	100		666374	100			

7. CONCLUSION:

The study was carried out in the north western parts of Bihar comprising three districts. The study clearly established that satellite remote sensing together with GIS can be a powerful tool for mapping and evaluating land use / changes in the land cover of a given area. Significant changes in land use / land cover during the study period between 1980 and 2017 recorded some interesting observations. The study reveals that the major land use in the study area is agricultural land. The area under agriculture and settlement has increased and on the other hand waterbody, dry river bed and open and fallow land has reduced. Thus, the present study illustrates that remote sensing and GIS are important technologies for analyzing spatial techniques and quantifying spatial phenomena, which is otherwise not feasible by traditional mapping techniques. With this technology it is possible to detect changes at low cost and with low accuracy

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