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Land use land cover change detection analysis using multi temporal satellite images: A case study of Bankura district, West Bengal, India

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Abstract
This study is carried out to analyze the different land use and land cover (lulc) changes over the period of thirty years in Bankura district, West Bengal. The estimation of land use and land cover and their relation with land conversion is one of the important studies in this region. Satellite Remote sensing and GIS techniques have played a key role in studying different types of lulc changes and different causes behind the conversion of land that have been increased in recent years. Multispectral temporal satellites data are the best options to monitor assess and estimate the changes. The land use land cover map and different indices (NDVI, NDWI, and NDBI) are calculated for further analysis. Different image processing software's was used to analyze and execute the overall study. Finally, a change detection map was obtained by integrating different indices. The overall analysis shows that there is a high declination rate of vegetation areas that has been entirely changed into different man-made structures.

Keywords: land use land cover; landsat; image classification; change detection; NDVI, NDWI, NDBI

Introduction

For the studies of regional, local and global level environmental change the satellite remote sensing technology has played an important role. This study is an urgent need for conservation measures of different lulc classes in the study area (Acharyya, 2019) [1]. Land use refers to the man-made structures that how humans have used the land for their development, needs and different necessity purposes. Land use includes different recreation areas like, different constructions, wildlife habitats, crop land, and built-up areas (Reis, 2008) [14]. It is imperative to consistently observe the land use changes so that the decision makers and planners can estimate the impacts of change and suggest the alternative options for development which will in turn help policy making and implementation process (kafi, 2014) [10]. Land change detection requires accurate, thorough, and regular monitoring process, which is the main motivation of the study for sustainable development of the region (Alshari, 2021) [2]. The main objective of this study is to evaluate pattern of land use/ land cover change using remote sensing techniques for sustainable management of the study area and enhancement of its productivity (Andualem, 2018) [4].

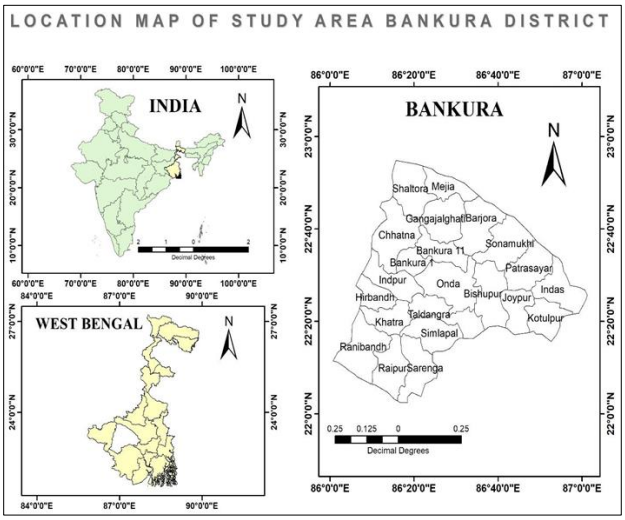

Fig 1: Location map of the study area

Study area

The study area Bankura district geographically located between 22°38´N to 23°38´N latitude and 86°36´E to 87°46´E longitude (SOI.1978) (Fig:1).

It has an area of 6882 square kilometres. Bankura district is one of the largest districts in W.B. carrying 6925.01 Sq km of geographical area and is located in the western part of West Bengal. River Damodar flows along the northern boundary of the district. It has a tropical dry sub-humid area with an average temperature of 40°C and rainfall between 1100 mm and 1400 mm annually (Pani, 2021) [13]. The adjacent districts are Bardhaman in the north, Purulia in the west, Paschim Midnapore in the south and Hooghly in the south-east.

Materials and Methods

In this study, 10 years interval multi-spectral Landsat TM, ETM+ and Landsat 8 OLI imageries of 1990, 2000, 2010 and 2020 were used for analysis the LULC change and its impact. The classification scheme was designed primarily and main application classes were water body, soil, agricultural land, settlement, dense vegetation, mixed vegetation and barren land area. All the images were downloaded from USGS Earth Explorer (https://earthexplorer.usgs.gov/) web site. Information of the acquired images for change analysis is given in Table 1. The ground truth data was also collected using Global Positioning System (GPS) in the form of reference data for image analysis and accuracy assessment.

Table 1: Information on the acquired images of different years

Satellite	Sensor	Acquisition Year	Spatial resolution (m)	Data source
Landsat 5	TM	1990	30	USGS Earth Explorer https://earthexplorer.usgs.gov/
Landsat 5	TM	2000	30	
Landsat 7	TM	2010	30	
Landsat 8	OLI	2020	30	

Methodology usually refers to the specific steps, tools and procedures used to collect and analyze the data. Overall methodological framework and data analysis is presented in Fig. 2. The detailed methodology for the study is as follows.

Image pre-processing

Due to acquisition system and platform movements, satellite images are generally geometrically distorted (Hassan, 2016). For this reason the image pre-processing is an important part before entering the change detection analysis and so on. The satellite images were imported in ERDAS 2014 software for geometric and atmospheric correction. After this process, the images were converted into terrain related geometric distortions rectified image, and subset the image on the basis of boundary of the study area.

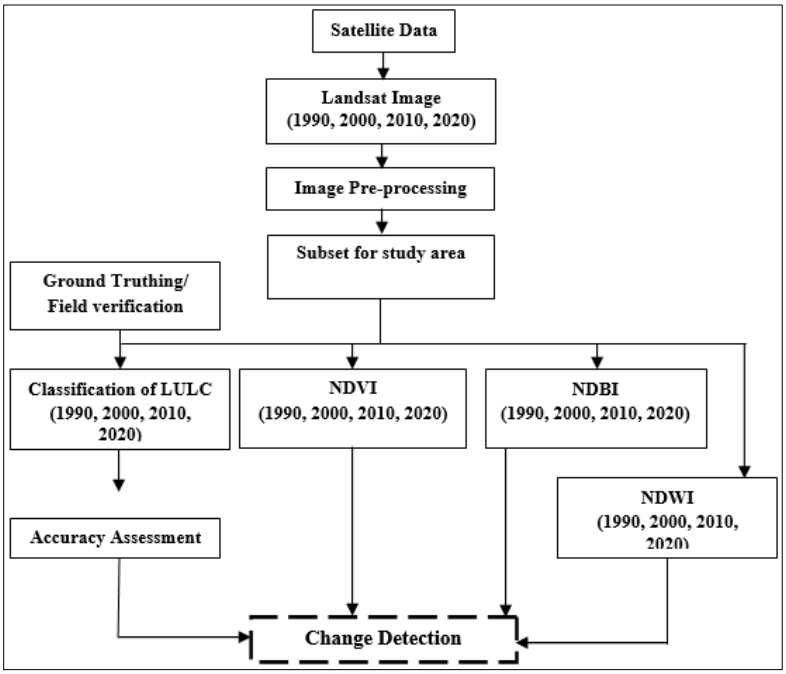

Fig 2: Methodological Flow Chart

Normalized difference vegetation index (NDVI)

NDVI is commonly and widely used index for vegetation extraction and measuring different plant properties and its spatio-temporal changes (Anderson, 1993, Avtar, 2014) [3, 5] which is applied in the study area. Rouse *et al*. (1974) for the first time used this equation to extract the NDVI. The NDVI is generated from near-infrared (NIR) and red band and it ranges from positive one (+1) to negative one (-1), whereas-1 to zero (0) represents water body to the wet surface and +1 represents the dense forest. It is calculated by the following equation:

NDVI = (NIR-RED) / (NIR+RED)

Normalized difference built-up index (NDBI)

NDBI is a widely used index for evaluation built up status (Grover, 2016, Jalili, 2015) [7, 9] and also it quantitatively estimated the area. NDBI measures the medium infra-red (MIR) and near infra-red band (NIR). As well as being useful for mapping human settlements (He, 2010), it is also useful for some elements of surrounding constructions. It is calculated by the following way:

NDBI = (MIR–NIR) / (MIR+NIR)

Normalized difference water index (NDWI)

NDWI measures changes related to water bodies, using green and near infra-red (NIR) wavelengths and its ranges from positive one (+1) to negative one (-1) (McFeeters, 1996) [11]. It is calculated by the following method:

NDWI = (Green-NIR)/ (Green+NIR)

Land use land cover classification

Land use land cover classification has been generated using the downloaded Landsat data from USGS. At first the data were applied the pre processing techniques to get the both radio metrically and geometrically corrected images. For this study; the supervised classification method was applied in ERDAS Imagine software using the known ground sampling points. The Google earth image was also used to validate the ground truth samples and also for training samples. The maximum likelihood algorithm is used to execute the overall classification process in the software. Different classes like water body, soil, agricultural land, settlement, dense vegetation, mixed vegetation and barren land area were classified using the unique signature classes of each class. The training samples of each class were selected before executing the classification process.

Result and Discussions

These study results provide a major platform for the successive analysis of land use land cover changes over the years (Twisa, 2019) [18]. The images are classified into major seven classes and changes in the classes over the years are analyzed and it is realized that the highest loss of land use/land cover class has occurred in case of agricultural and barren land classes and highest gain of the same has occurred to settlement classes. The Phenomenon has been occurred due to high growth rate of urban settlement, and low dense settlement area to high dense settlement area followed by population growth which creates pressure on land (Sankhala & Singh, 2014) [17]. Water body, forest area, open land and agricultural land have been decreasing rapidly. Table 2 along with Figure 3,4,5,6 summarise that the trend of LULC changes from 1990 to 2020 based on 7 classes extracted from multi dated satellite imageries over the periodic 30 years.

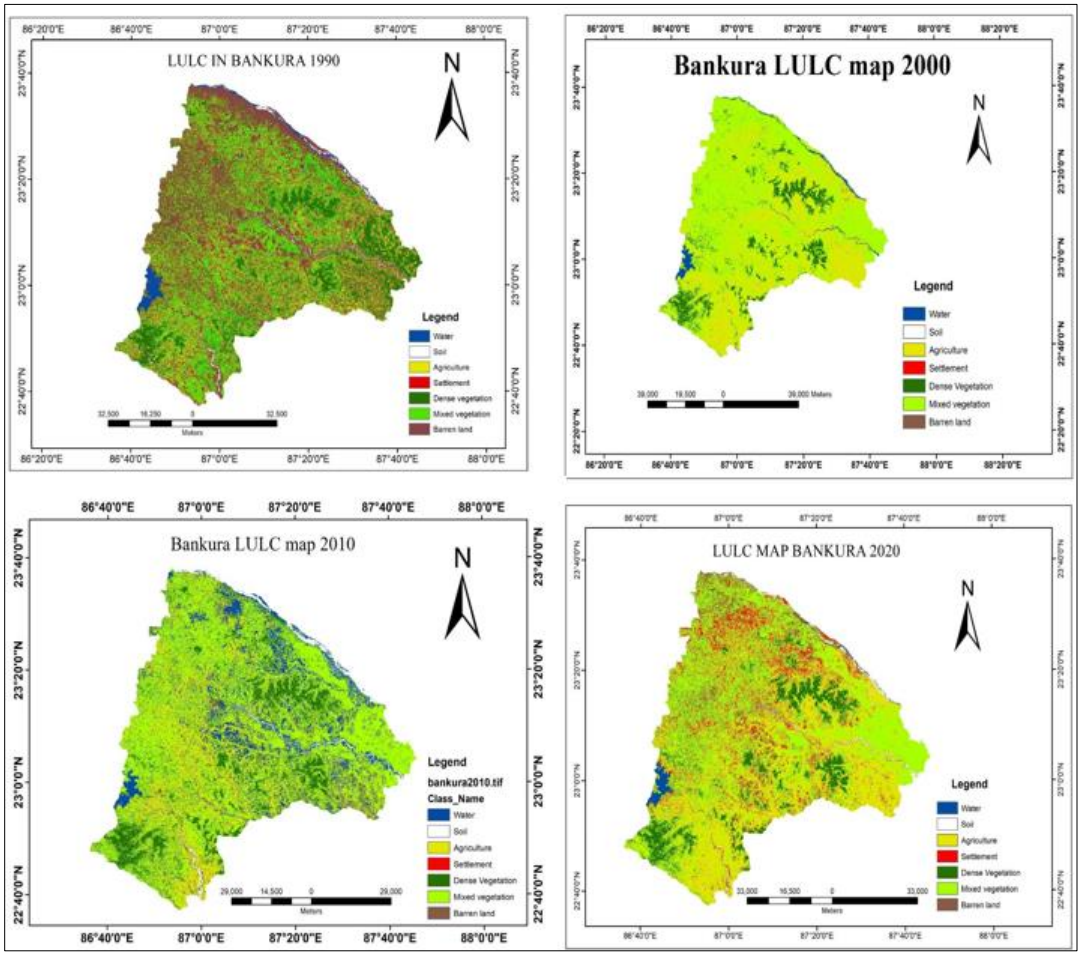

Fig 3: LULC map of Bankura District, 1990, 2000, 2010, 2020

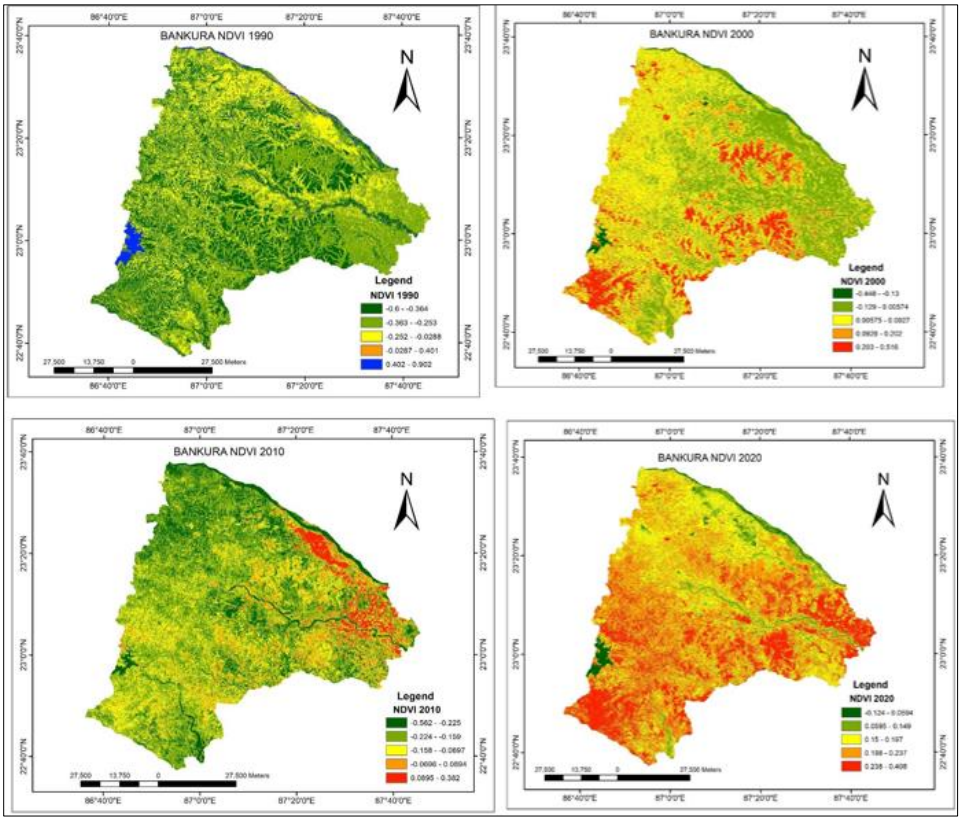

Fig 4: NDVI map of Bankura District, 1990, 2000, 2010, 2020

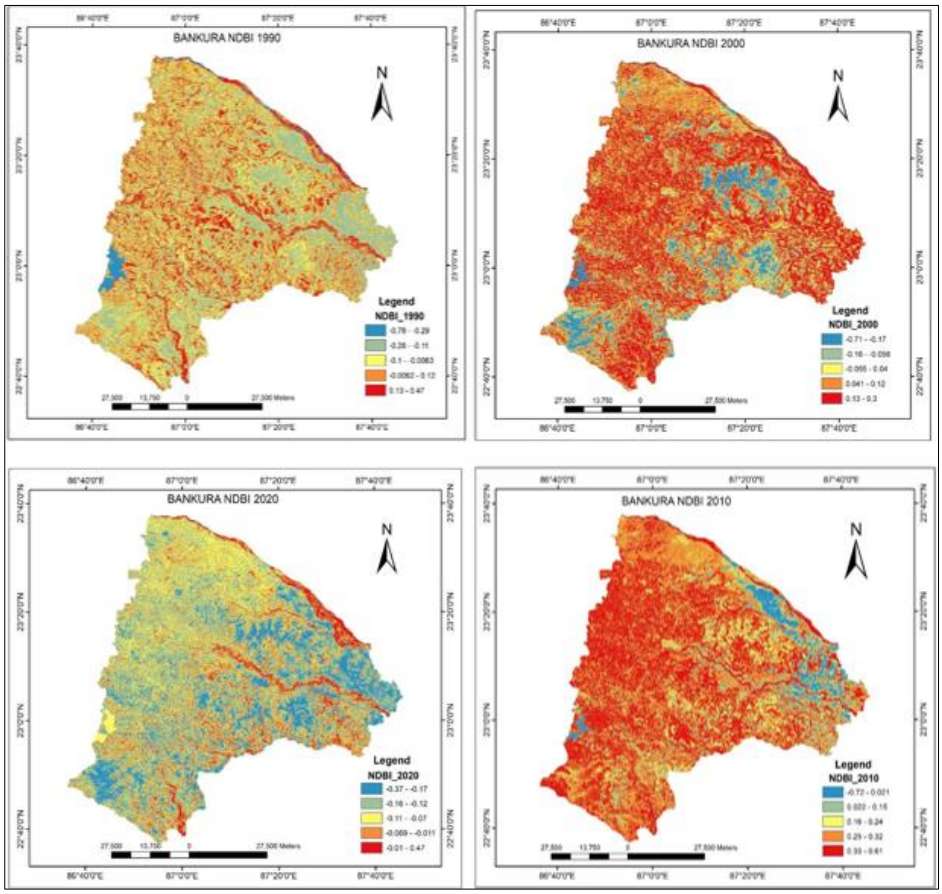

Fig 5: NDBI map of Bankura District, 1990, 2000, 2010, 2020

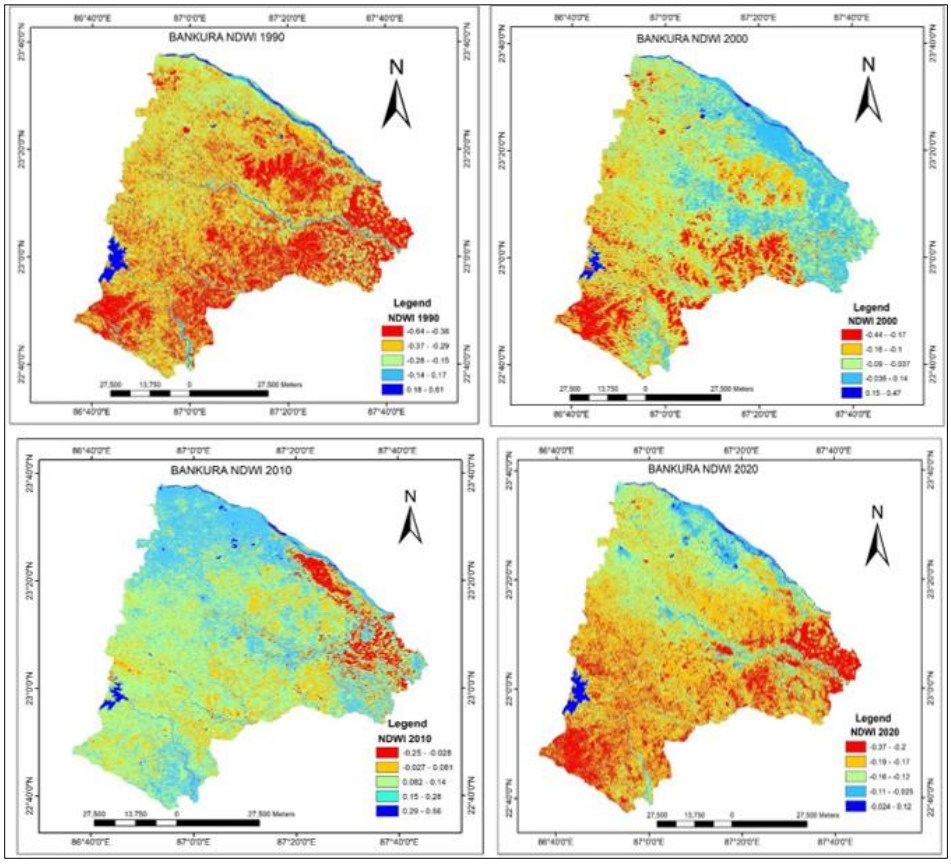

Fig 6: NDWI map of Bankura District, 1990, 2000, 2010

From the decadal growth it is observed that in the year 2000, urban area has been increased to building area, recreational area along with positive changes of decadal growth rate has also been observed. It has been increased by 10 percent from the year 1990 to 2020. Therefore, from the urban growth rate statistics it is clear that urban area has been increased drastically in west, south-east, north and north-west directions. Hilly land sometimes acts as a resistant factor for spreading the city in eastern and north-eastern direction and due to high pressure of populations on open land it is converted into built-up areas. In the period of time (1990-2020) it is observed that large portions of dense forest areas have changed into man-made features (built-up areas). Dense forest on the southern part has been decreasing because city is growing towards the southern and south-western directions.

Table 2: Year wise area covered by different LULC classes

Year	1990		2000		2010		2020	
Class Name	**Area (Ha)**	**%**	**Area (Ha)**	**%**	**Area (Ha)**	**%**	**Area (Ha)**	**%**
Agricultural Land	113187.4979	16	456806.5082	65	98890.5983	14	169092.6702	25
Barren Land	267969.086	38	11834.78332	2	34428.9201	5	37231.58492	5
Dense vegetation	111858.1293	16	102020.7281	15	91959.6883	13	58955.94198	8
Mixed vegetation	177709.7324	26	97820.23089	14	354088.1435	52	345382.0631	50
Settlement	5609.969025	1	12446.96659	2	92071.26716	13	69721.46845	10
Soil	5721.561202	2	9292.905582	1	16245.19314	2	7106.412442	1
Waterbody	13845.33618	1	5677.234445	1	8216.672566	1	8408.189996	1

As barren lands are not generally suitable for agriculture, open lands are converted into urban area during this period (Mozumder & Tripathi, 2014) [12]. Wet lands areas have changed into agricultural lands and built-up areas due to demand for food and construction purposes to fulfil the needs of the growing population and these converted lands are utilized by local communities. Due to demand of food, the extent of agricultural land is also increasing but at the same time agricultural land has also been converted into some built-up areas.

Build-up area index was also analyzed in the study area from the year of 1990 to 2020 and it is also observed that the NDBI value is increasing with year by year as the human settlements have been increased drastically. In case of water body monitoring the NDW index of the study area was applied and it is noticed that it has been decreased from -0.64 in 1990 to 0.12 in 2020. The reason behind the drastic change in NDWI is that of the enormous pressure on wet land and water body due to new construction of settlement. This change positively affects the increasing trend of land surface temperature also. NDVI techniques were applied to monitor and measure the vegetation health status over the years in the study area. It is also observed from the study that NDVI values have decreased from 0.90 in 1990 to 0.41 in 2020. The

main reasons behind the phenomenal change of NDVI are that of deforestation in the area, cutting down plantations for construction of National Highway, rapid urban growth and pressure on agricultural land. Vegetation cover has significantly decreased all around the district.

Conclusion

On the basis of multi-dated remotely sensed data over the periodic time of 30 years, the land use land cover change is detected. The 10 years interval data were analyzed in different land use land cover classes and quantitatively measured its change. The overall results of the research study indicated that there is a remarkable land use land cover change over the period of 30 years. The 7 major classes in the Bankura district that is agricultural land, Barren land, soil, waterbody; dense vegetation, mixed vegetation, and settlement have been analyzed and estimated. It is also revealed that the highest positive rate of change has occurred in the case of urban area classes consistently. The vegetation areas were basically changed to built-up land and other man-made features due to an increase in population growth lead to high demand for settlements in the area which creates pressure on land. The urban area has been increased significantly in the west, south-east, north, and north-west direction of the district. Hilly area becomes a resistant factor to stop the spread of urban growth in eastern and north-eastern directions. Therefore, this study revealed that there is a decreasing trend of agricultural land which needs attention for the enhancement of the production of crops.

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