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Land Use and Land Cover Change Detection of Gosaba Island of the Indian Sundarban Region by Using Multitemporal Satellite Image

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Abstract

Gosaba is an island of the Indian Sundarban region located just above the core region of mangrove forest. This zone is suffering from many natural hazards and disaster such as storms, cyclones, floods and erosion. The study area is seriously affected by the severe cyclone Aila in 2009. The present study aims to study the land use/cover changes through exploratory analyses, land cover classification, and change detection analyses conducted on multitemporal Landsat satellite data (1989, 2001 and 2010). Based on the quantitative analysis of the LULC, it is observed that a rapid growth in built-up land between 2001 and 2010 due to population pressure. It is expected that the expansion of built up area will follow the same trend from the year 2010 onwards. In 2001 habitation with vegetation cover was 14.52 percent which increased into 20.35 percent in 2010. With population explosion agricultural land is decreasing day by day. Landsat satellite data using remote sensing and GIS also proved that the model can be employed under different climate changes as well as management scenarios for developing adaptation strategies for this study area.

Key words: Gosaba Island, Landuse Landcover, Change Detection.

Introduction: The Sundarbans is the world's largest continuous mangrove area, covering some 10,000 km^2 of land and water within the Ganga Delta, with some 62 percent located in Bangladesh and the remainder in the Indian state of West Bengal. The Sundarbans has a population of over 4 million according to census 2011, but a large part of the area is free of permanent human habitation. Various non-timber forest products and plantations help generate considerable employment and income generation opportunities for at least half a million poor coastal population. The Sundarbans was declared a reserved forest as early as 1878 under the 1865 Forest Act. In 1987, parts of the Indian Sundarbans - the Sundarbans West Wildlife Sanctuary (133,000 ha) - became a UNESCO World Heritage Site, and parts of the Bangladeshi Sundarbans - the Sundarbans Wildlife Sanctuaries (140,000 ha) – received the same status in 1997. The purpose of this study was to investigate common people conceptions on global warming and climate change. The study was descriptive in

nature and reflected a cross-age design involving the collection of qualitative data from different C.D Blocks of the Indian Sundarban Region. These data were analyzed for content in an inductive manner to identify different common people conceptions that is students, service man retired persons, daily laborers, farmers etc.

Change detection can be defined as the process of identify differences in the state of an object or phenomenon by observing it at different times. This process is usually applied to Earth surface changes at two or more times. The primary source of data is geographic and is usually in digital format (e.g., satellite imagery), analog format (e.g., older aerial Photos), or vector format (e.g., feature maps). Ancillary data (e.g., historical, economic, etc.) can also be used. Land use is obviously related with environmental factors such as soil characteristics, climate, topography, and vegetation. But it also reflects the importance of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation, and water catchment and storage. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses. Landuse is a product of interactions between a society's cultural background, state, and its physical needs on the one hand, and the natural potential of land on the other (Ram and Kolarkar 1993). In many remote sensing change detection studies, land use and land cover change often are used interchangeably . During the last two decades, numerous studies have been published concerning accuracy assessment of land cover classifications. The present study aims to examine the land use land cover change of Gosaba Island since 1989 by using satellite imagery.

Study Area: The Gosaba Community Development Block ($22^0$9’47” N, $88^0$48’10” E) consists of 51 mouzas with an average area of 5.6 ha. It is an administrative division in canning subdivision of South 24 Parganas district in the Indian state of West Bengal. It is located 67km from Alipore, the district headquarters. During 1946-1950 the Tebhaga movement in several parts of the 24 Parganas district led to enactment of the Bargadari Act. Although the Bargadari Act of 1950 recognised the rights of bargadars to a higher share of crops from the land from the land that they tilled, it was not implemented. Large tracts, beyond the prescribed limit of land ceiling, remained with the rich landlords. In 1967, West Bengal witnessed a peasant uprising, against non implementation of land reforms legislation, starting from Kheyadaha gram panchayat in Sonarpur CD Block. From 1977 onwards major land reforms took place in West Bengal under the Left Front Government. Land in excess of land ceiling was acquired and distributed amongst the peasants. Subsequently, “Operation Barga” was aimed at securing tenancy rights for the peasants. In Gosaba CD Block 13,608.84 acres of land was acquired and vested. Out of these 13,084.85 acres or 96.15% of the vested land was distributed amongst the peasants. The total number of patta holders was 26,176. Sambhunagar, a constituent panchayat of Gosaba block, is located at 22°12′44″N 88°46′42″E. Gosaba CD Block is bounded by Sandeshkhali II CD Block in North 24 Parganas district in the north and Basanti CD Block in the west. It bounded by the Sundarbans forests in the east and south. On the east, across the forests,

there is the border with Satkhira District of Bangladesh. The Raimangal and Kalindi rivers run along the India-Bangladesh border.

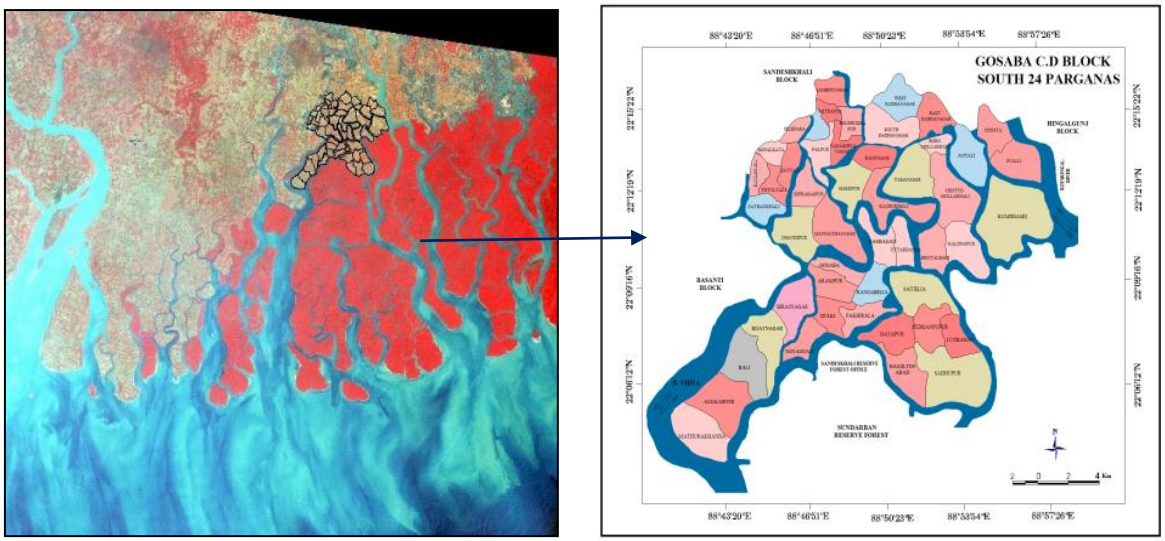


Fig: 1 Location Map of the Study Area

Rainfall and Climate: As per the Köppen–Geiger climate classification system, the climate of SBR is sub-tropical.

The SBR is characterised by 3 seasons: (i) Winter (November-February), (ii) Summer (March–June) and (iii) Rainy season (June- September) with Nor'wester storms locally called as "Kal-baisakhi" or the 'fateful thing' of the month of Baishakh (April 15-May 15). Annual average rainfall is 1920 mm and average humidity is 82% as per the data recorded for the last 50 years. The average annual maximum and minimum temperatures are 35°C and 17°C respectively. The SBR is the largest coastal marine eco-system of India prone to frequent cyclones, storms and other natural calamities. The physical development processes along the coast are influenced by a multitude of factors, comprising wave motions, micro and macro tidal-cycles and long shore currents typical to the coastal track. The shore currents vary greatly along the monsoon. These are also affected by cyclonic action. Erosion and accretion through these forces maintaining varying levels, as yet not properly measured, of physiographic change whilst the mangrove vegetation itself provides a remarkable stability to entire system. During each monsoon season almost all the Bengal delta is submerged, much of it for half a year. The sediment of the lower delta plain is primarily adverted inland by monsoonal coastal set up and cyclonic events. One of the greatest challenges peoples living on the Ganga Delta may face in coming years in the threat of rising sea levels caused mostly by subsidence in the region and partly by climate change.

In a study conducted in 2012, the Zoological Society of London (ZSL) found out that the Sundarban coast was retreating up to 200 meters in a year. Agricultural activities had

destroyed around 17179 hectares of mangroves within three decades (1975-2010). Shrimp cultivation had destroyed another 7554 hectares.

Researches from the School of Oceanographic Studies, Jadavpur University, estimated the annual rise in sea level to be 8mm in 2010. It had doubled from 3.14mm recorded in 2000. The rising sea levels had also submerged around 7500ha of forest areas. This coupled with around 105^0 C rises in surface water temperatures and increased levels of salinity have posed a problem for the survival of the indigenous flora and fauna. The Sundari trees are exceptionally sensitive to salinity and are being threatened with extinction.

Geomorphology and Soil Type: A complex network of geomorphic environments characterise this region. Tidal rivers are generally muddy systems barring some sandy flats that occur in the midchannel bars and sandy bars at the mouth of rivers. The creeks are absolutely muddy systems. Mangrove swamps occur on the intertidal mudflats of estuaries, creeks and inlets. Soil of this region is basically fine alluvium soil but muddy swamps also found. Salinity of the soil ranges between 4.5-5.8ppt and the pH is slightly alkaline ranging between 8.0-8.3. The soils of this area are mostly of heavy texture (silty clay to clay loam) hence have low hydraulic conductivity and often causes water logging that destroys the crop especially in the summer growing season. It contains 30-45% sand, 42-46% silt and 10-26% clay. The soil of Sundarbans can be segregated into three major divisions- Fine pale brown to grayish black silty clay in northern most part, Peat deposits in the middle and Swampy areas along with sand and sandy clays at the sea-face. The soils are in general rich in potassium (K) and moderate amount of available phosphorus (P) but low in nitrogen (N). The organic carbon content of the study area ranges from 0.73-0.78 which is comparatively low resulting in slightly higher pH values. This is accompanied by occurrence of high amount of water soluble salts in the soil as evident from the Electrical conductivity (EC) values- Gosaba: 4 and Lahiripur: 10.08 mmhos/cm. (Sarkar et al. 2000). The forested areas have much higher organic matter, may be due to the poor decomposability of plant matter due to lignin and wax content and high soil salinity which helps in maintaining higher range of water holding capacity and thus lesser concentration of soluble salts but higher available nitrogen and phosphorus content in the soil. The high salinity gives a whitish colour to the top-soil. The siltation in the Sundarbans has increased and sediment trapping has been aided by pneumatophores and dense roots of mangroves.

Drainage System: Gosaba Island of the Sundarban region is covered by river Bidya, River Gomor and river Roymongal and many others creeks. All rivers and creeks are affected by tidal surges. The water of the whole drainage system is saline.

Methodology: Research methodology is a way to systematically solve the research problem. The present study examines the perception of global warming and climate change of the common people of the Indian Sundarban region. Hence the methodology includes analysis of data and facts on the different parameters related to the study by pre field work, field work and post field work. In pre field work review of relevant text, collection of data, maps and ultimately formulation of whole research planning has been done. LANDSAT

imagery for the year 1989, 2001 and 2010 were used for the present study. False colour composite of the Gosaba Island was generated with the band combination of 3, 2, and 1 in Red Green Blue LANDSAT satellite imagery data. Satellite imagery of January month of 1989, 2001 and 2010 has been collected from USGS Earth Explowrer Website of path/ row 138/045. Land use/land cover map of the Gosaba Island was then prepared by onscreen visual interpretation method using RS-GIS software. Different land use/land cover classes like agricultural land, settlement with vegetation, fallow land, mangrove vegetation, and river were then identified using visual interpretation keys such as colour, tone, texture, pattern, size and shape. Then area of the each class and percentage of coverage was calculated for each year.

Change Detection by Using Remote Sensing Data: Change detection is the measure of the distinct data framework and thematic change information that can guide to more tangible insights into underlying process involving land cover and land use changes than the information obtained from continuous change. Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Change detection is useful in such diverse applications as land use change analysis, monitoring shifting cultivation, assessment of deforestation, study of changes in vegetation phonology, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes (Singh, 1989). The Landuse and land cover change detection using remote sensing data in Gosaba Island for the year 1989, 2001 and 2010 is shown here. Land cover map serves as a basic inventory of land resources for all levels of Government. Total area of Gosaba Island is 29600ha. without river. In the present study 39757.23ha. area of Gosaba Island with rivers is selected to delineate the Land use Land cover change detection. The study revealed that nearly 9190.92ha. of the total area covered by water bodies, 2766.93Ha. by mangrove vegetation, 5791.42ha. by settlement with vegetation,1805.48ha. by agricultural land and 4040.48ha. by fallow land in 1989. In 2001, this changed into 9109.89ha. in water bodies, 3840.66Ha. in mangrove forest, 5772.06ha. in settlement with vegetation, 16465.14ha. in agricultural land and 4569.48ha. in fallow land. In 2010, this changed into 8774.46ha. in water bodies, 2646.72ha. in mangrove forest, 8090.68ha. in settlement with vegetation, 15435.63ha. in agricultural land and 4809.74ha. in fallow land. Due to population explosion habitation with vegetation cover changes from 14.52% in 2001 to 20.35% in 2010. This region faced a devastating natural disaster as severe cyclone Aila on 25th May 2009 with high tidal surges. Due to saline water flood large amount of agricultural land converted into fallow land in 2010. Amount of fallow land was 11.49 % in 2001 which increased into 12.10% in 2010. Amount of agricultural land decreased into 38.73% in 2010 from 41.42% of total area in 2001.

Table: 1 LULC Coverage in Hectare

Class Name	Area in hectare		
Year	**1989**	**2001**	**2010**
River and Water bodies	9104.92	9190.89	8774.46
Mangrove Forest	2766.93	3840.66	2646.72
Habitation with Vegetation	5791.42	5772.06	8090.68
Agricultural Land	18053.48	16465.14	15435.63
Fallow Land	4040.48	4569.48	8409.74
Total Area	39757.23	39757.23	39757.23

Table: 2 LULC Coverage in Percentage

Class Name	Area in percentage		
Year	**1989**	**2001**	**2010**
River and Water bodies	22.9	22.91	22.07
Mangrove Forest	6.96	9.66	6.66
Habitation with Vegetation	14.57	14.52	20.35
Agricultural Land	45.41	41.42	38.73
Fallow Land	10.16	11.49	12.1
Total Area	100	100	100

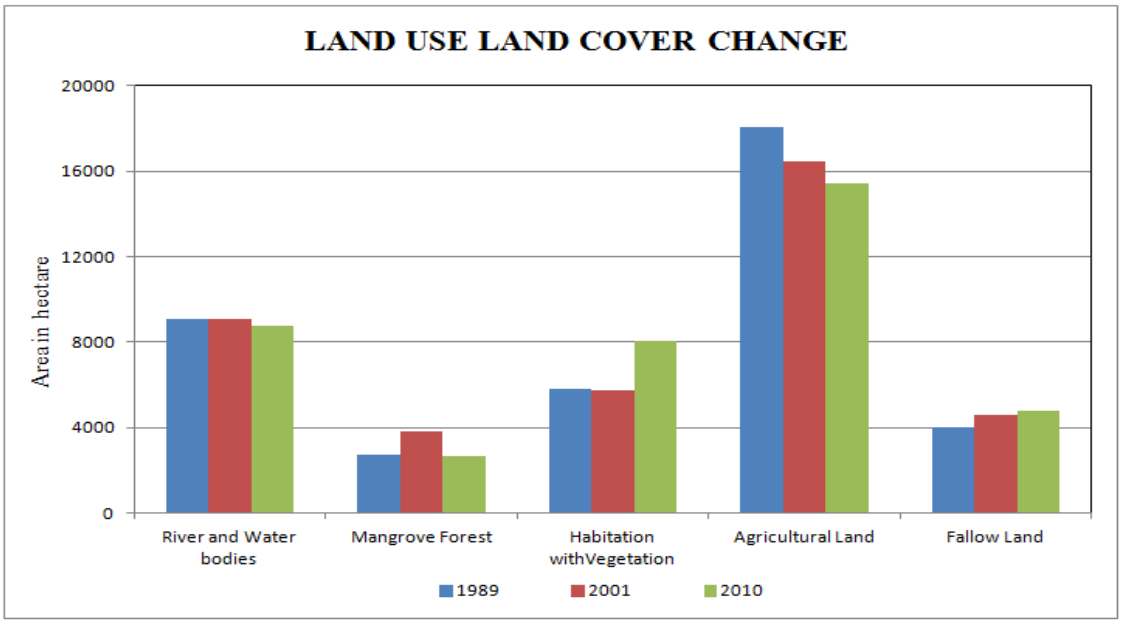


Fig:3 LULC Change in hectare.

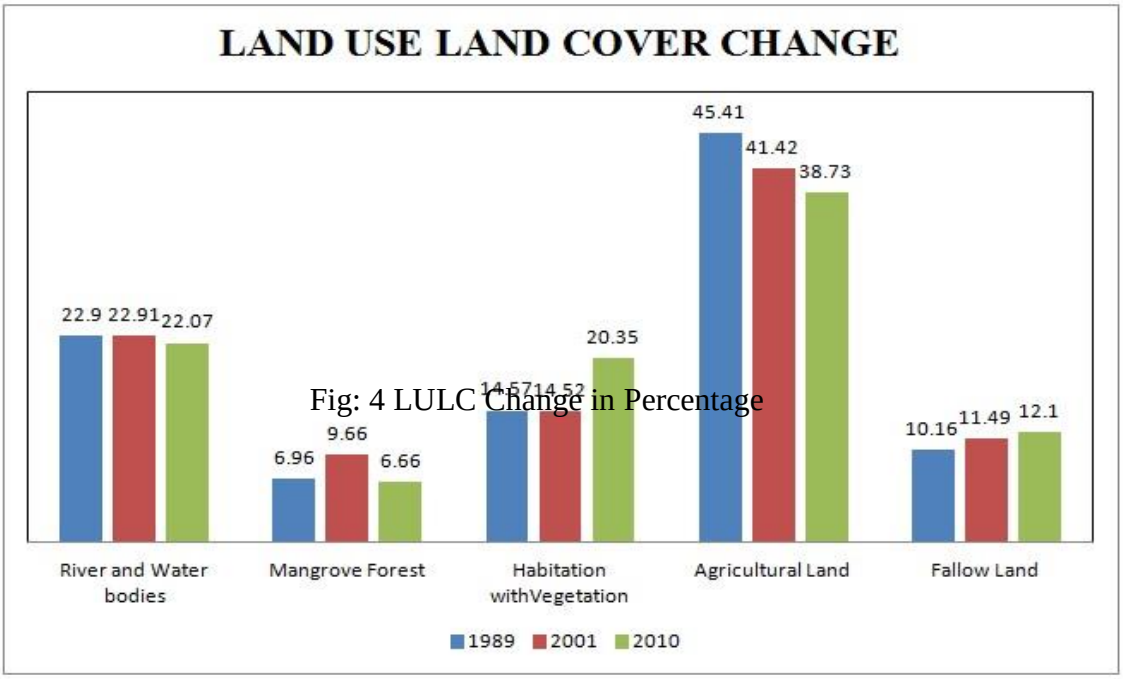
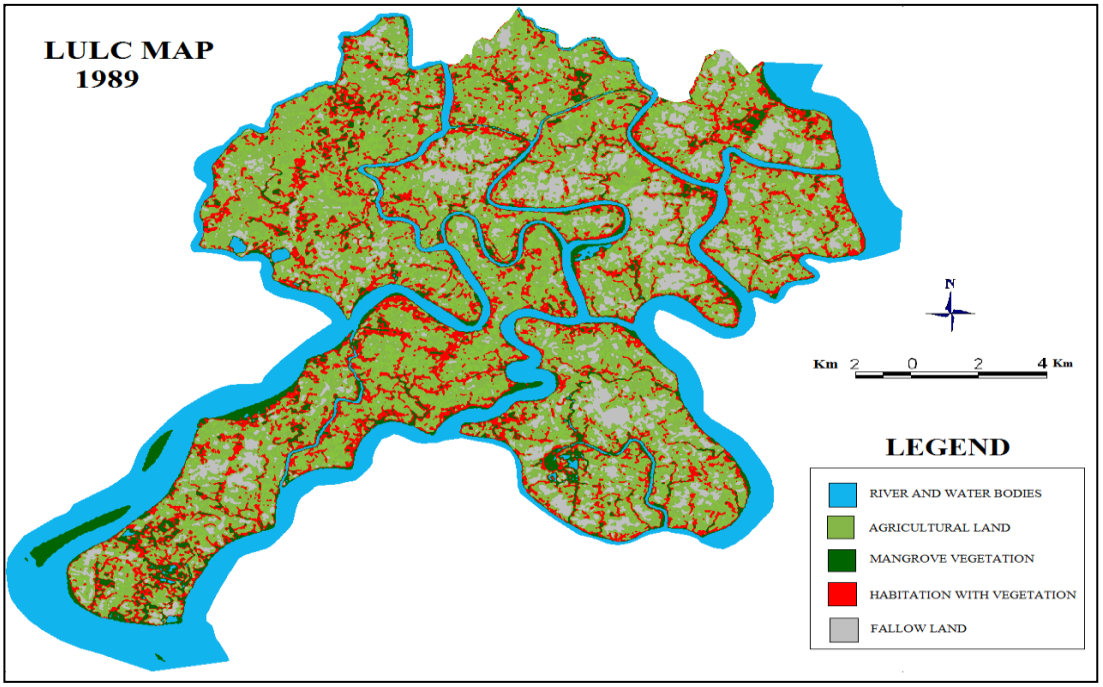


Fig: 4 LULC Change in Percentage



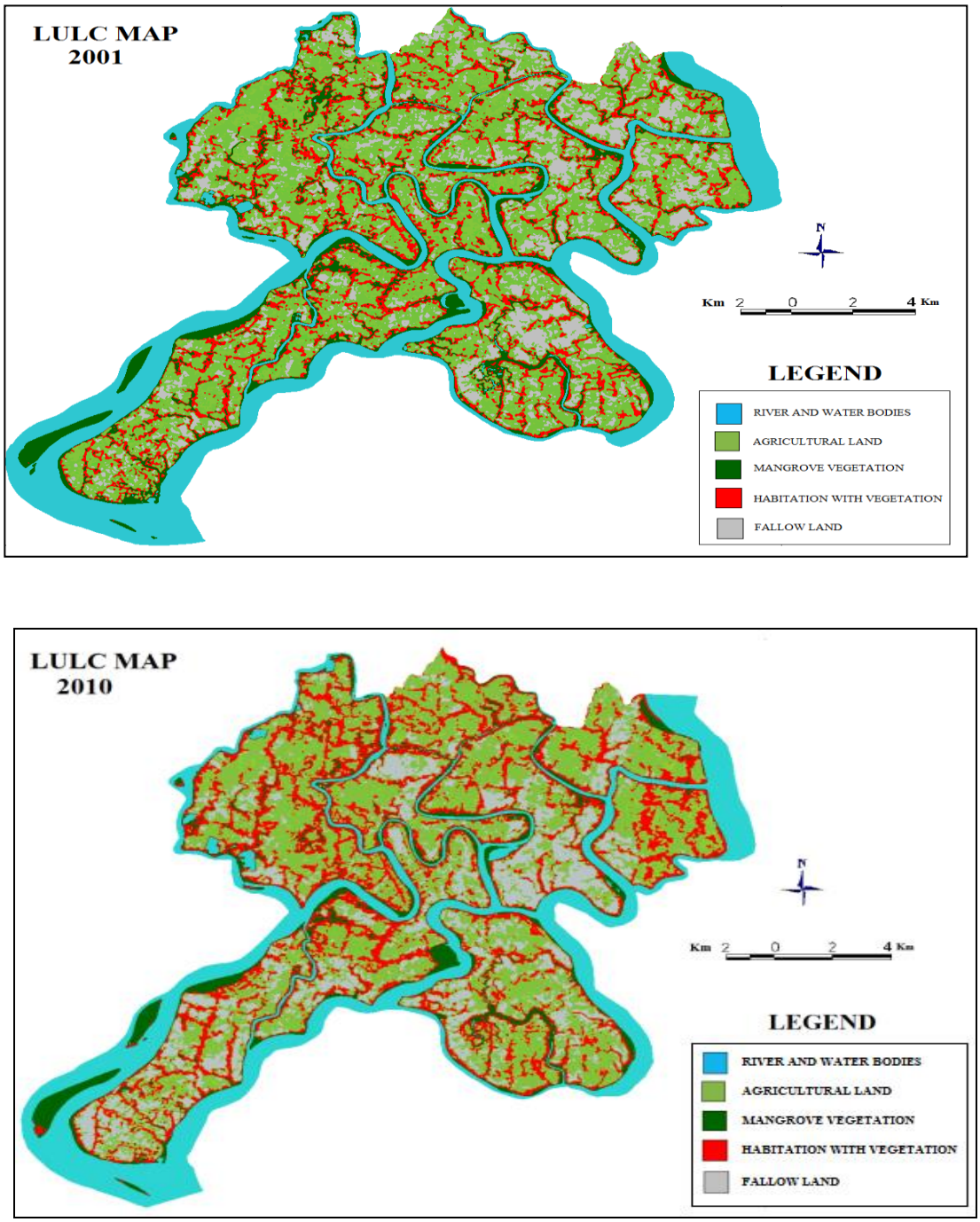


Fig: 5 LULC Map of Gosaba Island, 1989, 2001 and 2010.

Conclusion: The present study reveals that the Gosaba Island and its surroundings still retain more agricultural land when compared to all other land use/land cover features, though the rate of conversion of agricultural land for other purpose of settlement were increased highly for the past few years. And this island is also affected by various types of natural hazards like tidal surges, floods, severe cyclones huge amount of agricultural land converted into waste land.

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