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LAND USE/LAND COVER CHANGE DYNAMICS IN COASTAL ECOSYSTEM OF SUNDARBAN DELTA, WEST BENGAL- A CASE STUDY OF BALI ISLAND

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Abstract: The present study was carried out in Bali Island of Sundarban delta, Gosaba block, 24 Parganas (South) district of West Bengal to analyze changes in land use/land cover features between the time period of 2005 and 2015 using high resolution satellite images combined with ground truth data. Time line analysis of land use/land cover of the study area reveals that agricultural land are converted into aquaculture ponds (20.04 ha) and settlements (48.87 ha) with positive change in rabi cropped area that increased by 206.92 ha. in the year of 2015. The mangrove forest area (12.29 ha) has been found to be converted into deforested lands. Advancement in geospatial techniques and easy availability of high resolution satellite data facilitate precise change monitoring amongst the land use/land cover features between two time period.

Keywords: Change dynamics, geospatial techniques, Sundarban, Bali island, land use/land cover.

1. Introduction

Sundarban is the largest mangrove wetland in the world. The world's heritage site, Sundarban, declining its glory due to numbers of causes including gradual clearance of the forest area has occurred due to the increase need for fuel wood for increasing population. Sundarbans is also highly susceptible to natural disasters. It covers an area of about 1 mha, of which 60% is located in Bangladesh and the remaining western portion, comprising 40%, lies in India. Mangrove ecosystems are of great ecological significance in the tropical and sub-tropical coast (Biswas et al., 2007; Islam and Peterson, 2008). Successful crop cultivation in this coastal region hinders due to the adverse climatic characteristics, soil and water as high soil salinity, heavy texture of soil, shallow water table enriched with salts contributing to salinity build-up in soil during winter and summer seasons, influence of tidal waves and

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periodical inundation by tidal water, low-lying situation of the land, poor surface and sub-surface drainage conditions, lack of good quality irrigation water during summer and winter seasons, short winter and prolonged monsoon, heavy and intensive rains during monsoon resulting in deep water logging of cultivated fields, frequent cyclonic storms along with heavy rains causing damage both to rice and upland crops. These problems turn almost the entire region as mono cropped growing mostly traditional rice with low productivity during kharif (monsoon) season (Mondal, 2015).

Temporal and spatial monitoring of Land use/land cover (LULC) changes plays a major role in the study of global change. Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as arable fields, pastures, and managed woods. Land cover is the physical material at the surface of the earth, include grass, asphalt, trees, bare ground, water, etc. The major consequences of Human/natural modifications of LULC are deforestation, biodiversity loss, global warming and increase in natural disaster like problems (Selcuk, 2008; Dwivedi et al., 2005). These environmental problems are often related to LULC changes. Information about land use and land cover changes is significant for many perspective planning and natural resource management initiatives. Geospatial techniques now a day's become basic tool for mapping and monitoring LULC associated with agriculture, urbanization, identification of different sites of human interest and its impact on flora and fauna. In addition, with the remote sensing techniques one can study the complex land use/land cover system of a difficult terrain and prepare comprehensive management plans.

Geospatial technology is the integration of Remote sensing (RS), Geographic Information System (GIS), Global Positioning System (GPS) and Internet Mapping Technologies and play a fundamental role in providing precise and near real time information on nature, extent, and spatial distribution of land resources to assess their potentials and limitations for planning, monitoring and management. Especially remote sensing techniques have reduced our field work to a considerable extent and features boundaries are more precisely delineated than in conventional methods. Hence it is a highly proven technology that is effective for mapping and characterizing land resources (Thilagam et al., 2013). To identify the changes amongst the LULC features at different time, numerous methodologies and techniques, utilizing remotely sensed data, like pixel based/object based analysis have been developed (Masroor et al., 2013). Very high resolution satellite images can be effectively employed in LULC mapping and change monitoring using visual interpretation techniques in coastal areas

(Prabhaharan et al., 2010; Jacobson et al., 2015). Present paper emphasize on visual interpretation of multi temporal satellite image in combination with cross checking with very high resolution satellite images of google earth (Fritz et al., 2011) and rigorous ground truth data of entire island. Spatial distribution of various LULC features and their change detection between two time period would be the critical input for decision-making of environmental management and planning for the future (Fan et al., 2007; Prenzel, 2004). The statistics of LULC and its change would help administrators in land management and crop planning in the island.

2. Materials and Methods

2.1. *Setting*

Bali Island located between 22°9′53″ to 22°32′4″ N latitude and 88°47′27″ to 88°47′49″ E longitude, spread over 4430 hectare (ha) as Total Geographical Area (TGA) of island in Gosaba block, 24 Parganas (South) district of West Bengal (Fig.1). Geologically the area comprises of sub-recent and recent alluvium of the Ganga river system. The coastal alluvium is of the Holocene period. The recent alluvium formations are mainly the mixture of sand, silt and clay materials of varying proportions. Mean annual rainfall is 1800 mm, 80% of which is received during June to September. Mean maximum temperature is 35.4^{0}C and mean minimum temperature is 13.5^{0}C. Two growing seasons prevail in the Island i.e. Kharif (July to November) and Rabi (November to March). Occurrence of natural calamities and sea water inundation are the characteristics feature of the area.

2.2. *Data used*

Multi-temporal geo-referenced merged LANDSAT-8 OLI/TRIS (B3: 0.53-0.59 μm, B4:0.64-0.67 μm, B5: 0.85-0.88 μm merged with B8: 0.50-0.68 μm a panchromatic, 15 m spatial resolution) with spatial resolution of 15 m acquired during kharif , rabi and ziad season of 2015-2016, Google Earth images of 2005 and 2015 of have been used for delineation of different features within the specified LULC categories. Google Earth provides the high resolution image data (spatial resolution of 10 m or better), is free, easy to use and has the potential for LULC mapping (Jacobson et al. 2015). Table 1 shows details of multi temporal satellite data used in the study.

Table 1: Satellite data used in the study area
(Sources: US Geologival Survey; Google Earth).

Sensor	Path/Row	Date of Pass		
		Kharif	Rabi	Zaid
Google Earth	--	10th Oct. 2005	7th Feb. 2006	--
LANDSAT-8 OLI/TRIS	138/45	18th Oct. 2015	10th March 2016	27th April 2016
Google Earth	--	24th Oct. 2015	13th March 2016	9th April 2016

2.3. *Ancillary and ground truth data*

Ancillary data in the form of Survey of India (SOI) topographic maps (1:50000 scale), existing available LULC map, geology, drainage etc. used for georeferencing the satellite data and marking/ delineating the permanent features. High accuracy Geo-tagged camera was used for ground truth data collection, it provide a photograph which is consisting geospatial metadata as latitude, longitude, altitude, direction which act as location-specific information was used in process of satellite data georeferencing and also used for cross checking of features identification/delineation in the satellite data. While study area visit during February-March-2015, entire area get traversed and field information along with field photographs get collected. These geo-tagged photographs then converted in to location information as point .shp file in GIS environment using ArcMap 10.3.1 software. This point file get attached with all locational field attributes like latitude, longitude, crop sown, crop stage, field condition, irrigation, site information, date of observation and so on. This information played key role in features identification and validation of results while image interpretation and change monitoring analysis.

2.4. *Image classification and change analysis*

Visual image interpretation technique was utilized (Petit and Lambin, 2001) to classify the images in to different LULC categories. In order to classify the rectified images, eight classes were delineated in the study area namely, agriculture (kharif and rabi), aquaculture/farm ponds, mangroves, waterbody/river, mudflat, settlement with vegetation and roads along with statistics. While interpretation of Google Earth data the study area boundary was overlaid on the image in Google Earth interface and then features delineated as deductive logic approach. Same approach maintained for LANDSAT-8 images using cut polygon tool in ArcMap 10.3.1 software. Flowchart of methodology adopted for LULC mapping and change monitoring analysis is shown in Fig.2. The LULC map prepared for the year 2005, 2015 and change monitoring map derived from these two LULC maps. Ancillary data like SOI toposheet and terrain features (Boyed et al., 1996) along with ground truth information were also used for improving the classification accuracy. The LULC map describes the spatial distribution and extents of features in the study area for both the time period.

Change monitoring analysis describes the trend and amount of LULC alteration between the two time periods. Overlay analysis operation utilized (Petit and Lambin, 2001) for change analysis in ArcMap 10.3.1 and generated the feature transformation matrix between LULC 2005 and 2015 vector data using 'union' analysis tool which computes a geometric intersection of the input features and all features will be written to the output feature class as a new file with the attributes from the input features, which it overlaps.

3. Results and Discussion

LULC categories mapped in Bali island are agriculture (Kharif- single cropped area), agriculture (Rabi- double cropped area), aquaculture/farm ponds, mangroves, water body/river, mudflat, settlement with vegetation and road network for the year of 2005 and2015 (Fig. 3 and 4 respectively). The spatial extend in the form of statistics for each categories for both the time period (Table 2) was analyzed to derive the change scenario (Table 3, Fig.5). The entire study area was observed during the field survey as mono cropped area with kharif paddy a major land use and about 70 % area of island is under agricultural practice. The study area is rich in natural resources, but present study reveals that there is gradual alteration in LULC features within ten years due to natural as well as anthropogenic activities as a increasing demand for growing population. The alteration across each category is discussed as under.

3.1. *Kharif: Single cropped area*

It is observed as a major category in the island, occupying the area of 2834.80 ha (63.99 % to TGA) in the year of 2005. About 22.86 ha (0.52% to TGA) area of this category get converted into aquaculture/farm ponds whereas 49.08 ha (1.11% to TGA) converted into settlement with vegetation category within a span of ten year in 2015 (Table 2).

3.2. *Rabi: Double cropped area*

The positive alteration was observed during 2015 for this category which presently occupied the area of 458.18 ha (10.34 % to TGA), against 251.26 ha (5.67 % to TGA) in 2005. The increase in this category is mainly due to increase in farm pond which suffice the irrigation requirement of rabi crops (Paddy). As the soils of island is acidic in nature farmers use to collect the rain water in ponds which is utilized for irrigation in rabi season.

3.3. *Aquaculture/farm ponds*

The maximum change in the island is reported in agricultural categories, which converted in to aquaculture/farm ponds category. About 252.66 ha (5.70 % to TGA) area observed in increasing order in the year of 2015 as it was 229.80 ha (5.19 % to TGA) in the year of 2005. The farm ponds offered the irrigation in next season's crop as well as fish cultivation round the year as it serve up the food requirement of the island. The increase in this category indicates the enhanced demand for food of growing population on the island.

3.4. *Mangroves*

The significant change that has noticed in the island is partial deforestation of existing mangroves and the area converted into aquaculture/farm ponds category (0.72 ha). Almost 12.29 ha area is decreased within ten years as it was 196.69 ha (4.44 % to TGA) in 2005 and 184.40 ha (4.16 % to TGA) was observed in the year of 2015. About 11.57 ha mangrove area is converted into deforested land category.

3.5. *Settlement with vegetation*

As the population pressure increased in island, mainly agriculture land 48.87 ha get converted in to this category which is clearly evident from Fig.3 and Table 3. Spatial extent of settlement with vegetation category increased to 798.26 ha (18.02 % to TGA) in the year of 2015 as it was 749.18 (16.91 % to TGA) in 2005.

The other categories also shows marginal alteration as the expense of agriculture categories like road get expand to 49.71 ha (1.12 % to TGA) in 2015 from 47.49 ha (1.07 % to TGA) in the year of 2005. The waterbody/river category also increased to 69.96 ha (1.58 % to TGA) in 2015 from 67.52 ha (1.52 % to TGA) in 2005.

4. Conclusion

Present paper aims to mapping and monitoring the change dynamics of land use/land cover features in Bali island between time span of 2005 and 2015 using geospatial techniques. Result reveals that the major change was observed in agricultural land that converted into settlement and farm ponds with a positive change that single cropped area (kharif) converted into double cropped area (rabi), the Bali island have further scope to increase this area with suitable land use planning. The mangroves area in the island getting decreased considerably which may require prime attention as it contributes the ecological balance in the Sundarban delta. The present study also found that the high resolution satellite images from Google

Earth interface found much suitable and easier way to map the LULC and to monitor the changes amongst the land features between the time intervals. The result outcomes may help to administrators to take necessary reclamation measures to preserve the resources through the optimum land use planning in coastal area of sundarban as a world heritage site.

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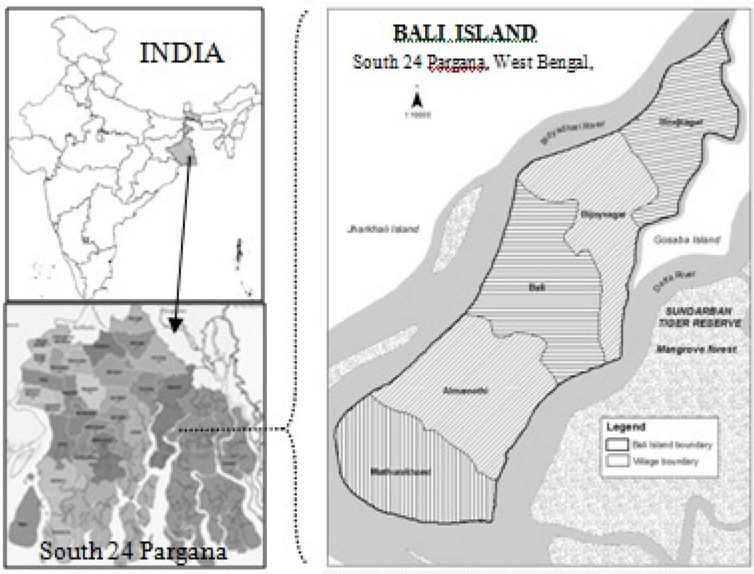

Figure 1: Location map of the study area

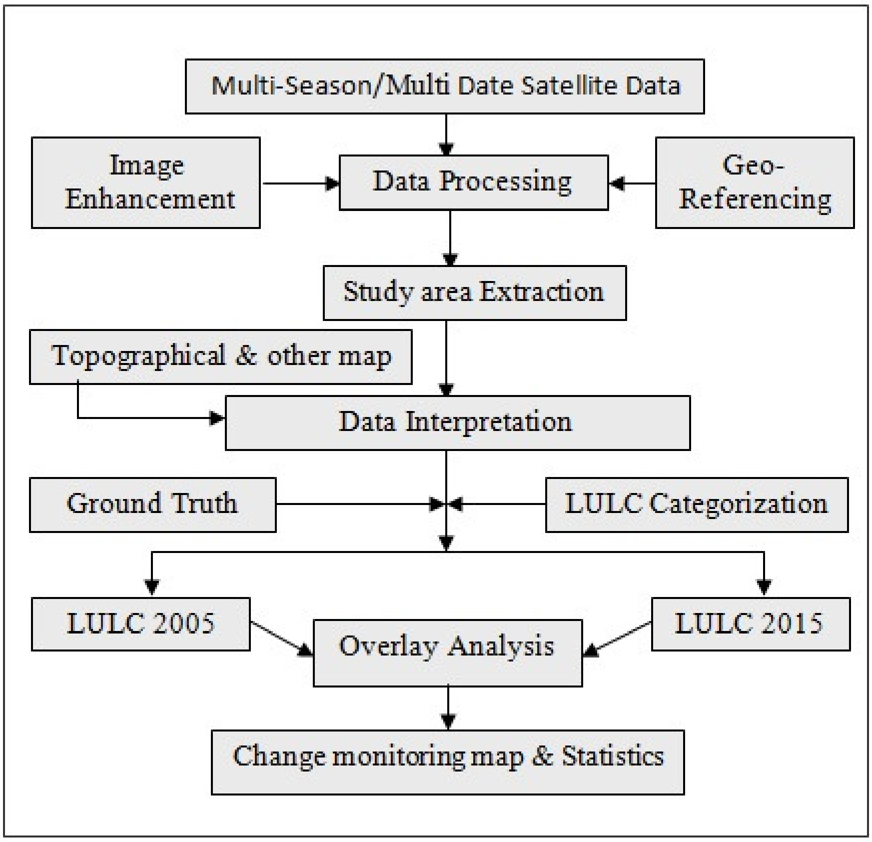

Figure 2: Flow chart of methodology adopted for Change monitoring

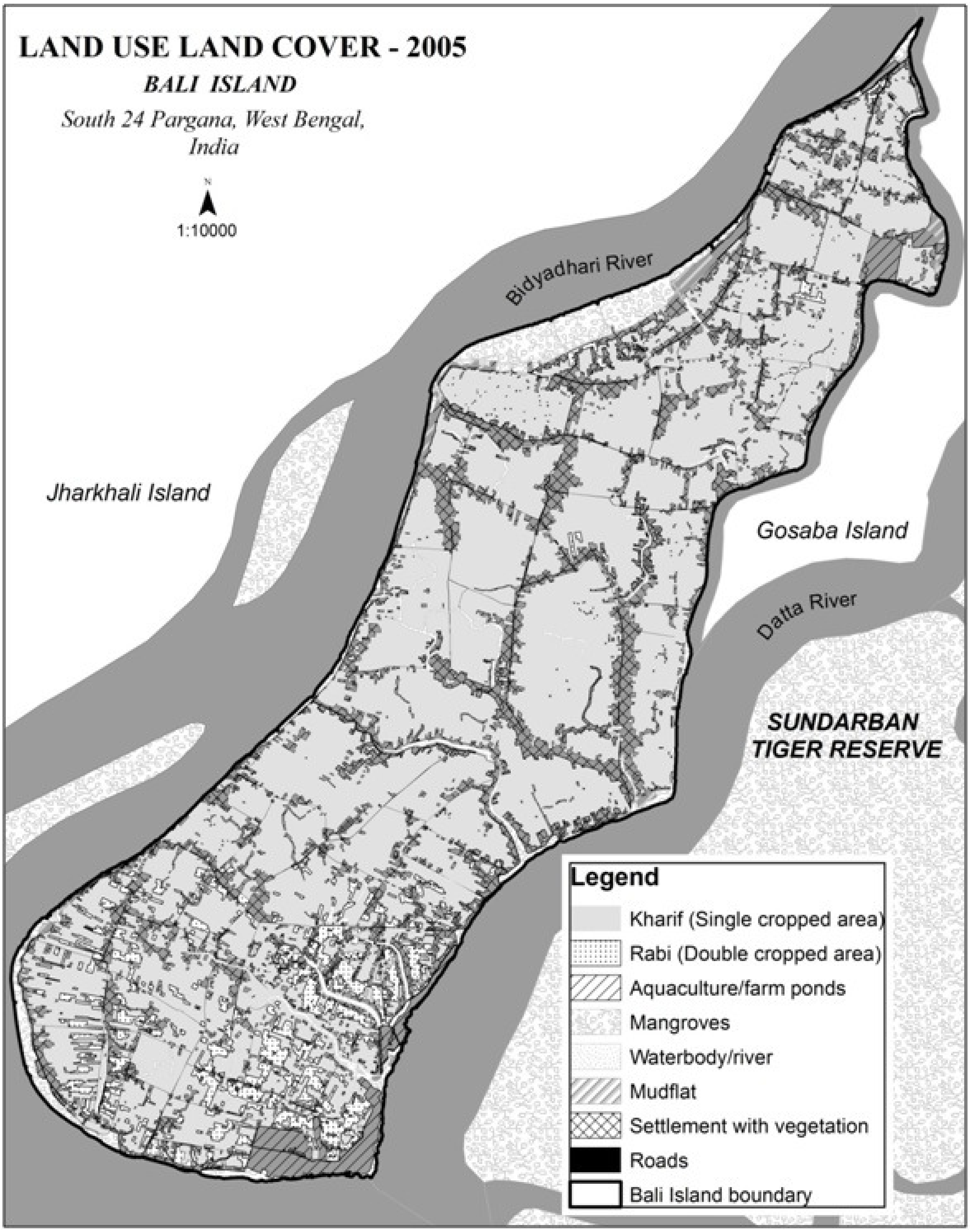

Figure 3: Land use/land cover map of Bali island (2005)

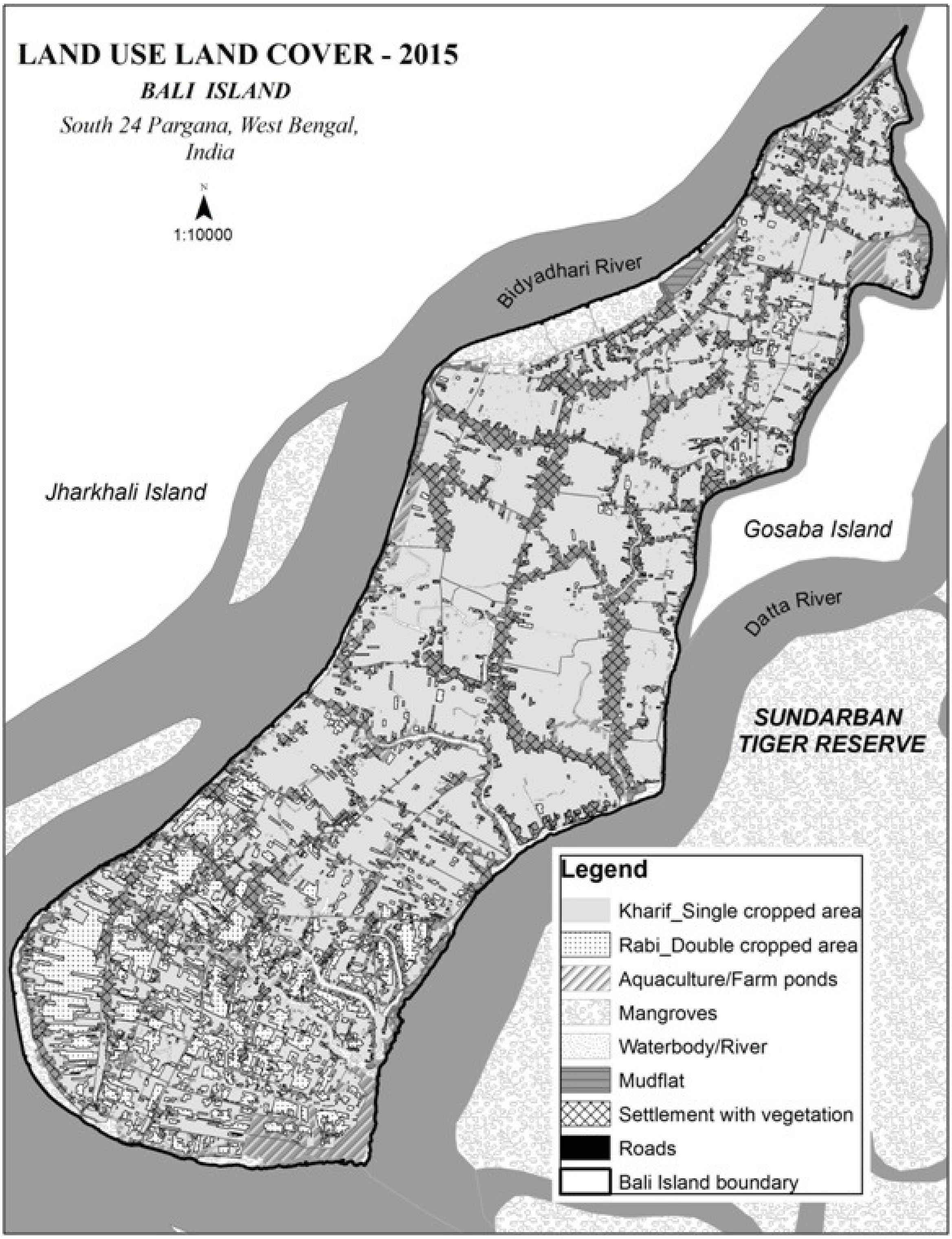

Figure 4: Land use/land cover map of Bali island (2015)

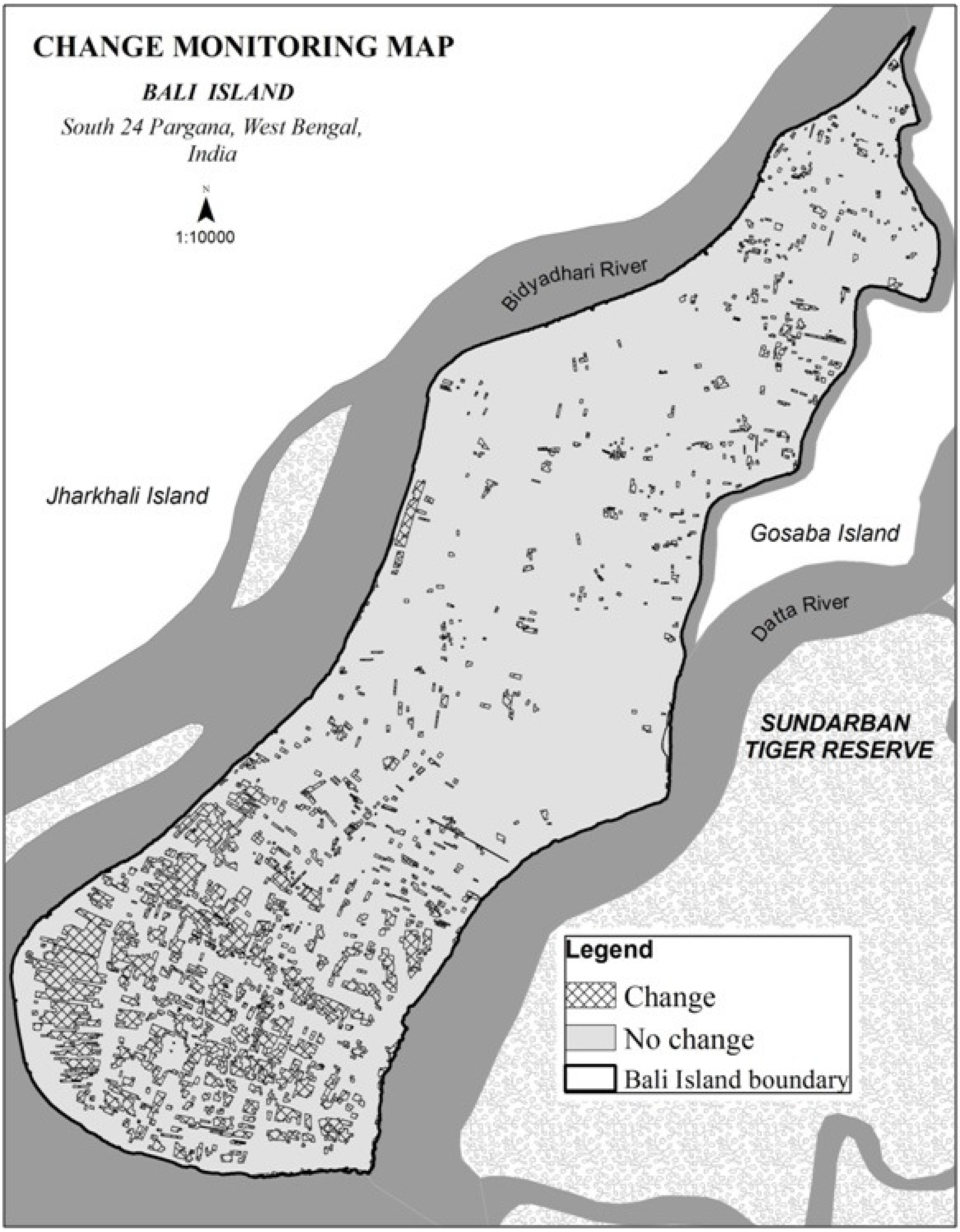

Figure 5: Change monitoring map of Bali island (between 2005 & 2015).

Table 2: Area and amount of change in different land use land cover categories in Bali island (2005-2015).

Sr. No.	land use /land cover categories	Area ha. in 2005	% TGA	Area ha. in 2015	% TGA	Change 2005-2015	
						Area	% TGA
1	Kharif_Single cropped area	2834.80	63.99	2553.63	57.64	-281.17	-6.35
2	Rabi_Double cropped area	251.26	5.67	458.18	10.34	206.92	4.67
3	Aquaculture/Farm ponds	229.80	5.19	252.66	5.70	22.86	0.52
4	Mangroves	196.69	4.44	184.40	4.16	-12.29	-0.28
5	Waterbody/River	67.52	1.52	69.96	1.58	2.44	0.06
6	Mudflat	53.26	1.20	50.91	1.15	-2.35	-0.05
7	Settlement with vegetation	749.18	16.91	798.26	18.02	49.08	1.11
8	Roads	47.49	1.07	49.71	1.12	2.22	0.05
9	Deforsted lands	..	..	12.29	0.28	12.29	0.28
	TGA	4430.00	100	4430.00	100.00		

Table 3: Land use land cover change matrix in Bali island (2005-2015)

	LULC categories – 2005 (area in ha.)								
↓ LULC categories 2015	1	2	3	4	5	6	7	8	9
1	2834.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	199.67	251.26	7.15	0.0	0.10	0.0	0.0	0.0	0.0
3	20.04	1.80	229.80	0.72	0.0	0.30	0.0	0.0	0.0
4	0.0	0.0	0.0	196.69	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	67.52	1.54	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	53.26	0.0	0.0	0.0
7	48.87	0.0	0.21	0.0	0.0	0.0	749.18	0.0	0.0
8	0.82	0.0	0.0	0.0	0.09	0.60	0.0	47.49	0.0
	0.0	0.0	0.0	11.57	0.0	0.0	0.0	0.0	0.00

1: Kharif_Single cropped area, 2: Rabi_Double cropped area, 3: Aquaculture/Farm ponds, 4: Mangroves,
5: Waterbody/River, 6: Mudflat, 7: Settlement with vegetation, 8: Roads, 9: Deforsted lands