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Land use and Land cover Change detection and Its Environmental Impact on South Andaman Island, India using Kappa coefficient Statistical Analysis and Geospatial Techniques.

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Abstract: *South Andaman Island is located in the southernmost part of Indian sub-continent and surrounded by Bay of Bengal and Andaman Sea. This paper presents the time-series analyses of the land use and land cover (LULC) of the island for the four decades of 2010, 2013, 2017 & 2020 by using multi-temporal satellite data. Land use and land cover change has become a central ingredient in current strategies for managing natural resources and monitoring environmental damage. IRS LISS IV of the year 2010 and 2013, Sentinel 2A of the year 2017 and 2020 optical real time satellite data has been use for Land use and Land cover change detection. Maximum Likelihood classifier is used in the supervised classification method in this particular study. Stratified Random Sampling Method has been use to create signature file. The study area has been divided into 5 LULC classes namely Barren Land, water body, Forest, Planation and Settlement. In the year 2010 the forest covers and plantation was 68% and 8% Respectively but in the year it become 46% and 28%. Due to increasing attraction on tourism and development in hotel business in the S. Andaman Island most of the forest areas are destroying every year. Kappa coefficient method has been used to make accuracy assessment and the change shows huge change in the LULC classes. The Kappa coefficient accuracy of the LULC of the year 2010, 2013, 2017 and 2020 are 85%, 87%, 85.53% and 90% respectively. The above mentioned results indicate that there is significant change in the Land use and Land cover which made a massive impact on environment and its surrounding ecosystem. This study will help the government and EIA personnel to make better sustainable development plan.*

Keywords: GIS, Supervised Classification, LULC Change detection, kappa Coefficient Statistical Analysis and Environmental Impact.

1. INTRODUCTION:

Land use and land cover change has been variously linked to several aspects of its impact on the global environment. Accordingly, land use and land cover changes have impacts on such environmental and landscape attributes as water quality, land and air resources, ecosystem and its function and the climate system itself. Land Use and Land Cover (LULC) changes have attracted world attention due to its importance in global and regional environmental change [6, 15]. The LULC changes of an area contemplate the assimilated product of the relation between physical environment and human activity during development [8]. In the study of land use and land cover change, it is essential that knowledge of the nature of their configuration across spatial and temporal scales is hence indispensable for sustainable environmental management and development. South Andaman Island has experienced multiple land encroachment activities and repeated deforestation, leading to extensive land-use and land-cover change (LULCC) during the past Three decades [2]. This research aimed at establishing the extent to which changing land use and land cover pattern has affected the coastal ecosystem and its surrounding environment. The paper has also been revealed how the land degradation and tourism made a negative impact on south Andaman Island.

Land degradation is becoming one of the major environmental issues all over the world and affects also the Indian sub-continent [13]. Land deterioration is hence an interactive process involving many causal factors, among which climate change, increasing population, tourism and land management policy play a significant role [3, 5, 12]. The population growth has led to a rapid change in land-use and land cover (LULC) as a result of urbanization and increasing in attractive tourism sector. Although the changes in LULC do not directly indicate a degradation of the land, under definite circumstances, improper handling of land use leads to a “landslide effect” that results in new problems. In the Islands, inappropriate deforestation and land use practices have led to accelerated erosion, which then further contributed to flash floods in the lower plains and Landslides in higher topography [9].

Ancillary land degradation drivers include drought, the natural or human-induced reduction in vegetation cover, poor agricultural practices determining soil organic matter losses leading to salinization, which are all factors contributing to increase the land degradation sensitivity of an area [14]. In the past, the impact of human activities on the S. Andaman Island landscapes has increased considerably causing, among others, biodiversity loss, deforestation, and soil erosion [4].

Land Use/Land Cover Changes represent one of the most important consequences of the increasing human pressure and huge built-up [1], since reflect changes in both the rural system and settlement patterns. Remote sensing and Geographic Information Systems (GIS) are powerful techniques to execute accurate and timely information on the spatial distribution of LULC changes [10, 11]. Remote sensing data and GIS techniques have been utilized in legionary studies for Island land use and land cover mapping and monitoring in South Andaman Island, India [7, 16].

2 STUDY AREA:

The Andaman and Nicobar groups of Islands, a union territory of India consists 572 islands among which 37 are inhabited with land area extending up to 8,249 km2 and a coastline stretch of 1,962 km; the Andaman Islands constitute 6408 km^2 and the Nicobar 1841 km^2.The remote Andaman Islands stretches like a green and white gleaming necklace along the western edge of the Bay of Bengal, with North Andaman emerging from the Andaman Sea near the Myanmar coast and ending with Little Andaman in 10 degree Channel, that separate the archipelago from the Nicobar Island chain further South. This is the most isolated and beautiful territory of India, unspoiled and picture perfect for vacationing in paradise These two groups of island situated in the Bay of Bengal between 6°N to 13°N (740 km) and 92°E to 93°E (190 km). South Andaman Island has undulated topography with small terrain tracts and coastal low-lying land, particularly the coastal areas having dense population due to their economic importance (Fig.1). Climate is tropical hot humid type with average temperature ranging from 18^{0}C to 36^{0}C. ANI receives rainfall for eight months in a year with average rainfall ranging from 3000 to 3500 mm.

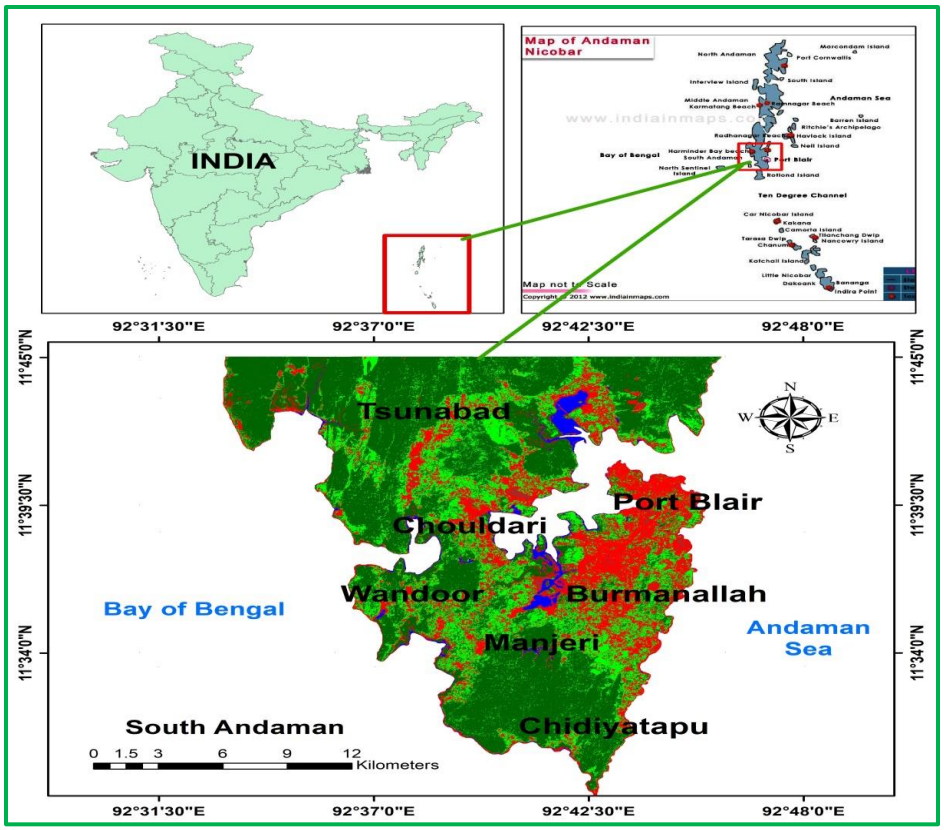

Fig.1.Study Area Map of South Andaman.

3. MATERIALS AND METHODS:

3.1. Land use and Land cover Classification:
In this study four datasets are used namely IRS LISS IV (Indian Remote Sensing Satellite) of the 2010 and 2013 with a spatial resolution of 5.6 meters and Sentinel 2A satellite data of the year 2017 and 2020 with a resolution of 10 meters (Table.1). Geo-processing and image rectification have been done of ERDAS imagine GIS platform. Maximum Likelihood classifier is used in the supervised classification method in this particular study. Stratified Random Sampling Method has been use to create signature file. From each stratum (LULC classes) 50 sample is collected to operate classification process. The study area has been divided into 5 LULC classes' namely barren land, water body, forest, plantation and built-up area.

3.2. Accuracy Assessment:

Accuracy assessment is the most important aspect to assess the reliability of map. No image classification is said to be completed unless its accuracy has been assessed. Kappa coefficient statistical method has been used to make accuracy assessment and the change shows huge variation of LULC of different time periods. To determine the accuracy of classification, a sample of pixels is selected on the classified image and their class identity is compared with the ground reference data. The technique used for accuracy assessment is the KAPPA analysis. KAPPA analysis is discrete multivariate technique which calculates the producer's and user's overall accuracy, as well as the Kappa accuracy level.

Accuracy Assessment Formula

$$\text{User Accuracy} = \frac{\text{Number of Correctly Classified Pixels in Each Category}}{\text{Total Number of Classified Pixel in that Category (The Row Total)}} x100$$

$$\text{Produser Accuracy} = \frac{\text{Number of Correctly Classified Pixels in Each Category}}{\text{Total Number of Reference Pixels in that Category (The Column Total)}} x100$$

$$\text{Kappa Coefficient(T)} = \frac{(\text{TS x TCS}) - \sum(\text{Column Total x Row Total})}{\text{TS}^2 - \sum(\text{Column Total} - \text{Row Total})} x100$$

Where, TS= Total Sample and TCS= Total Corrected Sample

Table.1 Details of Dataset used in the Study:

SL. NO	Satellite Data	Resolution (Meters)	Period	Sources
1.	IRS LISS IV	5.6 m.	2010 &2013	NRSC
2.	Sentinel 2A	10 m.	2017 &2020	Sentinel Copernicus

4. RESULTS AND DISCUSSIONS:

The classified images obtained from the analysis of multi dated satellite imageries of South Andaman Island are shown. Five different land use types were classified and delineated using image interpretation technique in ERDAS 14 and ArcGIS 10.7 software. The land use pattern in the year 2010 of S. Andaman Island is barren land & sandy beach (3844.26 ha.), forest (25671.01 ha.), plantation (2838.71 ha.), settlement (3468.81 ha.) and water bodies (1896.99 ha.) (Fig2A). During 2013, the area under the land use categories are barren land & sandy beach (2245.31 ha.), forest (23095.25 ha.), plantation area (4932.36 ha.), settlement (6101.68 ha.) and water bodies (1343.45 ha.) (Fig.2B). The area under barren land & sandy beach decreases by 2245.31 ha (4%) in 2013 compare to 2010 due to increase in settlement and plantation. The forest areas also have been decreased by 7 % due to increase in built-up area. The kappa coefficient statistics and overall accuracy of the classified images in the years 2010 is 85% and 88% respectively and for the year 2013 it is 86% and 89% (Table.3).

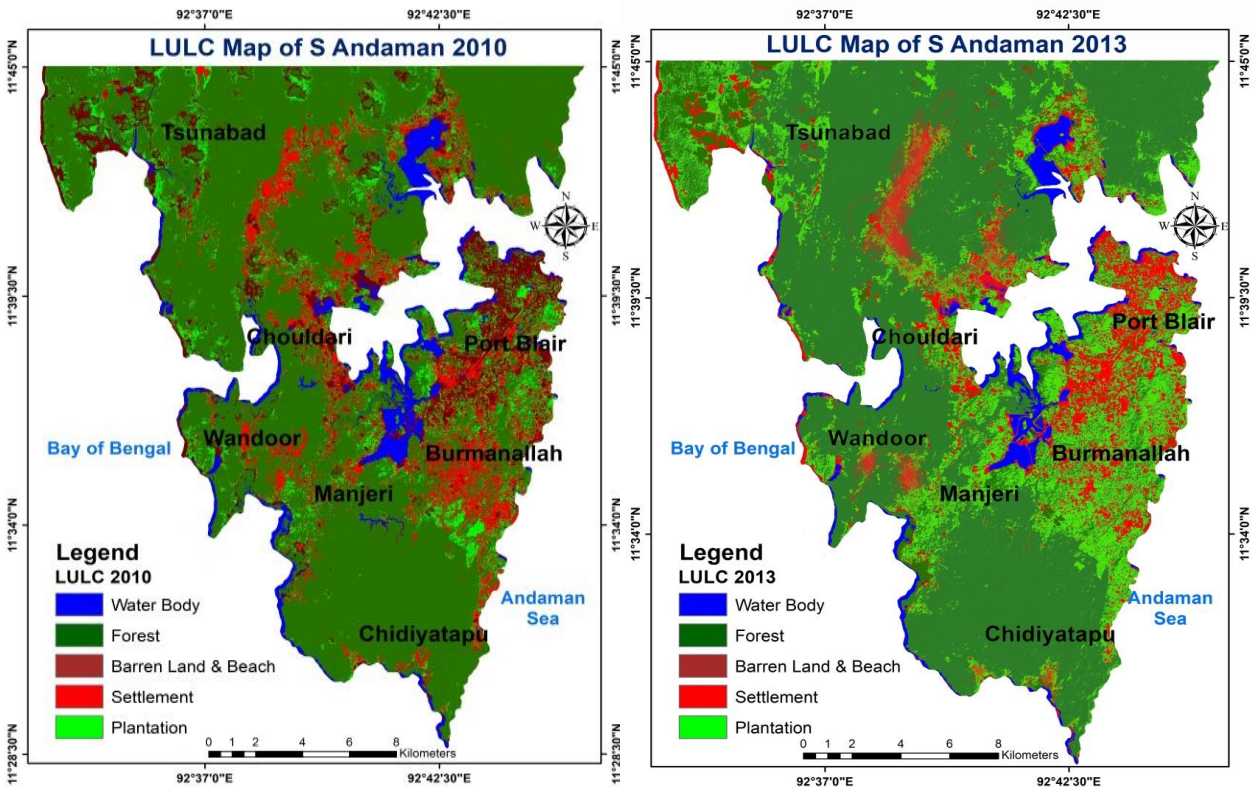

Fig.2. A & B -Land use and Land cover of the 2010 & 2013 of South Andaman Island.

Table.2: Land use and Land cover area and its change between the years 2010 & 2013.

SL. NO.	LULC TYPES	Area in Hectares 2010	Area in Hectares 2013	Area Change in Hectares	Area Change In Percentage
1	Barren Land & Beach	3844.26	2245.31	-1598.95	-4.23 %
2	Forest	25671.01	23095.25	-2575.76	-6.82 %
3	Plantation	2838.71	4932.36	+2093.65	+5.5 %
4	Settlement	3468.81	6101.68	+2632.87	+6.97 %
5	Water Body	1896.99	1343.45	-553.54	-1.46 %

Table.3: Kappa Co-efficient Statistics & Overall Accuracy of LULC 2010 & 2013

LULC Types	Kappa Co-efficient Statistics 85%(2010)		Kappa Co-efficient Statistics 87%(2013)	
	User Accuracy	Producer Accuracy	User Accuracy	Producer Accuracy
barren land & sandy beach	100	50	90.30	70.50
forest	85.71	100	87	90
plantation	80	100	83.20	97
settlement	87.50	77.77	89	85
water body	100	100	100	100
Grand Total 37721.79 ha.	Overall Accuracy-88%		Overall Accuracy-89%	

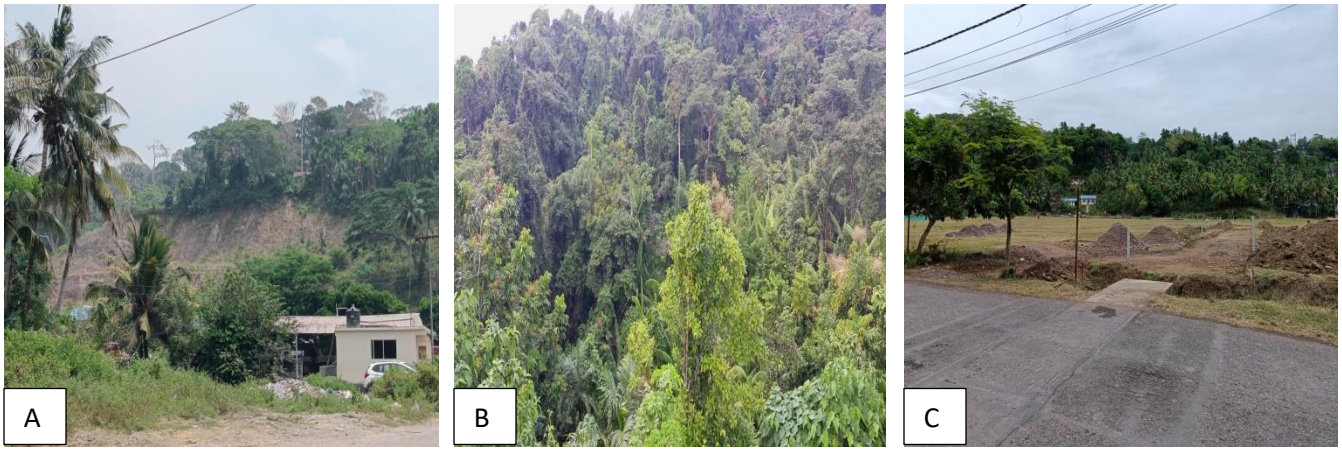

Fig.2.1. A-Hilly tracts is cutting down for Built-Up, B- Forest Area, C- Built-up in the place of Forest and Plantation

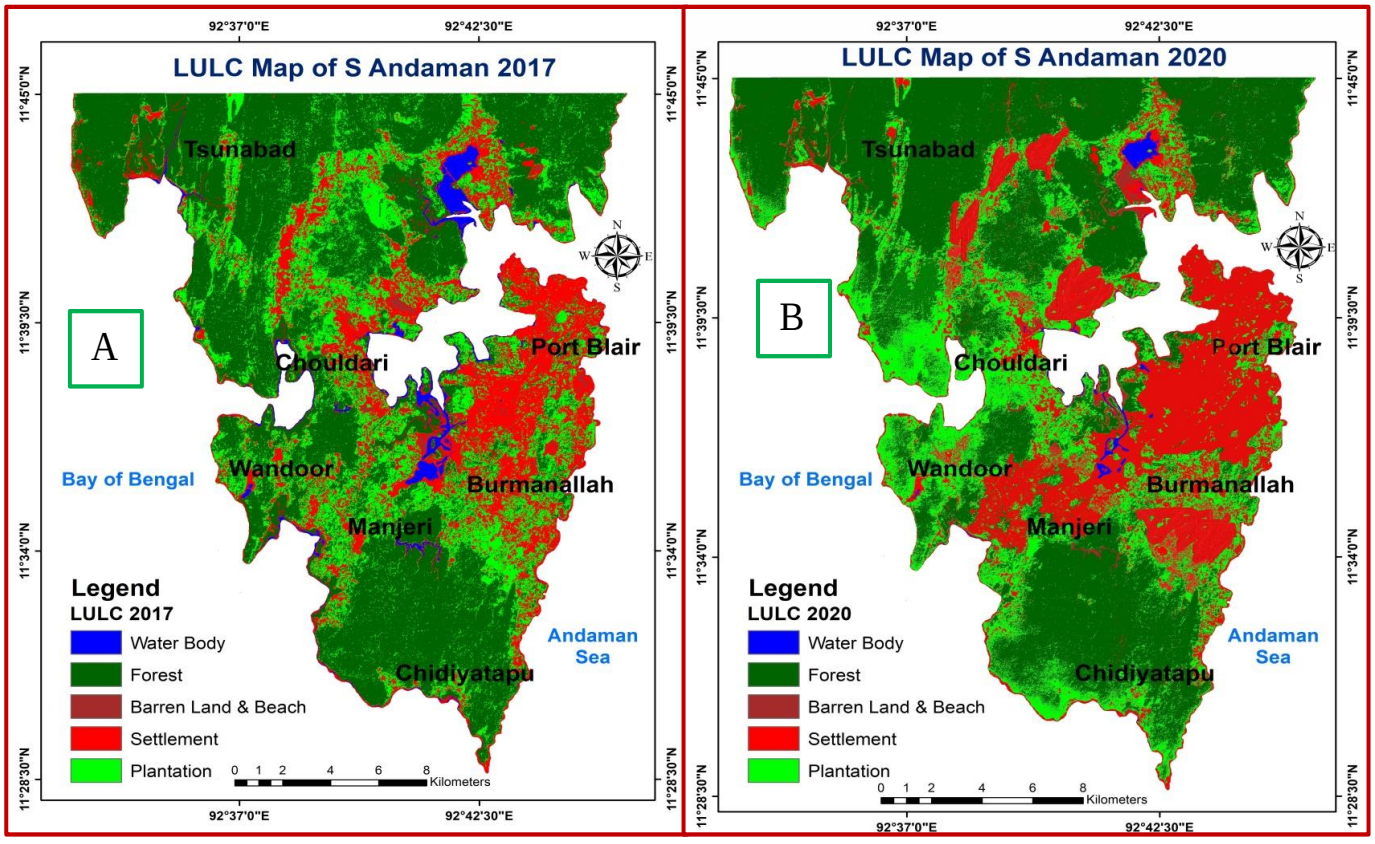

Fig.3. A & B -Land use and Land cover of the 2017 & 2020 of South Andaman Island.

Table.4: Land use and Land cover area and its change between the years 2013 & 2017

SL. NO.	**LULC TYPES**	Area in Hectares 2013	Area in Hectares 2017	Area Change in Hectares	Area Change In Percentage
1	Barren Land & Beach	2245.31	1301.62	-943.69	-2.50 %
2	Forest	23095.25	21235.01	-1860.24	-4.93 %
3	Plantation	4932.36	7231.23	+2298.87	+6.09 %
4	Settlement	6101.68	7279.07	+1177.39	+3.12 %
5	Water Body	1343.45	869.40	-474.05	-1.25 %

The LULC pattern in the year 2017 of S. Andaman Island is barren land & sandy beach (1301.62 ha.), forest (21235.01 ha.), plantation area (7231.23 ha.), settlement (7279.07 ha.) and water bodies (869.40 ha.) (Fig.3A). In the recent year 2020 the LULC of the Island is barren land & sandy beach (453.52 ha.), forest (19271.46 ha.), plantation area (8894.34 ha.), settlement (8679.07 ha.) and water bodies (419.40 ha.) (Fig.3B).Between the year 2017 and 2020 the land use and land cover classification shows that the water body has been decreased by 450 ha. due to land filling of small water body, swampy and marshy area and pressure of increasing population in the settlement areas. The LULC class forest is also decreased by 1963.55 ha. and the plantation area and settlement has been increased by 1663.11 ha. and 1400 ha. in the year 2020 compare to 2017 (Table.5). The kappa coefficient statistics and overall accuracy of the classified images in the years 2017 is 85.53% and 88.57% respectively and for the year 2020 it is 90% and 88.57 %(Table.6). As one of the most beautiful tourist destinations in the country, the South Andaman Islands attract thousands of tourists every year towards its beauty. Within the last 5 years, tourist influx to the ANI has double from over 2 lakh tourists in 2013 to 5 lakhs in 2018 (Directorate of tourism, 2019). Due to increase in tourism sector, the hotel and resort business are also increasing day by day. Forest, barren land and small water bodies are turning into hotels, resorts and restaurants.

Table.5: Land use and Land cover area and its change between the years 2017 & 2020

SL. NO.	**LULC TYPES**	Area in Hectares 2017	Area in Hectares 2020	Area Change in Hectares	Area Change In Percentage
1	Barren Land & Beach	1301.62	453.52	-848.1	-2.24 %
2	Forest	21235.01	19271.46	-1963.55	-5.20 %
3	Plantation	7231.23	8894.34	+1663.11	+4.40 %
4	Settlement	7279.07	8679.07	+1400	+3.71 %
5	Water Body	869.40	419.40	-450	1.19 %

Table.6: Kappa Co-efficient Statistics & Overall Accuracy of LULC 2017 & 2020

LULC Types	Kappa Co-efficient Statistics 85.53% (2017)		Kappa Co-efficient Statistics 90% (2020)	
	User Accuracy %	Producer Accuracy %	User Accuracy %	Producer Accuracy %
barren land & sandy beach	75%	75%	85.71%	100%
forest	100%	100%	77.77%	87.50%
plantation	85.71	85.71	88.88%	88.88%
settlement	87.50	77.77	85.71%	85.71%
water body	87.50	100	100%	100%
Grand Total 37721.79 ha.	Overall Accuracy-88.57%		Overall Accuracy-88.57%	

Table.7: Land use and Land cover area and its change between the years 2010 & 2020

SL. NO.	**LULC TYPES**	Area in Hectares 2010	Area in Hectares 2020	Area Change in Hectares	Area Change In Percentage
1	Barren Land & Beach	3844.26	453.52	-3390.74	-8.98 %
2	Forest	25671.01	19271.46	-6399.55	-16.96 %
3	Plantation	2838.71	8894.34	+6055.63	+16.05 %
4	Settlement	3468.81	8679.07	+5210.26	+13.81 %
5	Water Body	1896.99	419.40	-1477.59	-3.91 %

5. CONCLUSION:

The results obtained from the study confirm that IRS LISS IV and Sentinel 2A data are indeed appropriate for performing regional scale I level LULC assessments, due to its good spatial resolution and excellent overall quality. The methodology used for the study is capable of generalizing quite well over the South Andaman Island, an area of **37721.79 ha.** accurately identifying areas of Barren land, Forest, plantation, Settlement and Water Body. The environmental and ecosystem damage has also been observed due the manmade activity and government unplanned development. Therefore, it is essential to have a broader understanding of historical trends and identify the past drivers of environmental degradation that lead to LULC changes. In this study, we hope that the research methods designed are able to be evaluated to a level where both environmental and ecological systems can support the sustainable development of the region. The study shows that lack of management and spatial information in development projects, which may be alleviated with remote sensing data that can provide opportunities for periodical monitoring of land use/ land cover changes and their spatial ordination.

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