

The Change of Land Cover and Land Use at Sagar Island During 1990-2019

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Abstract:

Sagar Island is the largest and an island in the Ganges delta, lying on the Continental Shelf of Bay of Bengal. Sagar Island is a part of the Sundarban mangrove forest at the mouth of Hugli estuary on the east coast of India. This island developed into CD Block in Kakdwip subdivision of South 24 Parganas district in State of West Bengal, Covering an area of about 250 Sq./km. It is situated at a point where the Ganga River once met the Bay of Bengal and it does not have any tiger habitation or small river tributaries as a characteristic of the overall Sundarban delta. The region also has a rich assemblage of mangrove forests especially along the coast for protection against coastal erosion. The Island is bounded by Hugli River in the western part, whereas Muriganga River in the eastern part and Bay of Bengal in the southern part of the island. This study area is characterized by the ever-changing coastline which is overall deltaic shape lying the study area. This island offers acres of silver sand and clear blue sky, and the calm sea for visitors who would like to spend their weekend in tranquility. Having a coastal location, this island is exposed to severe coastal erosion for the last fifty years. Coastal area in this island falls under coastal regulation zone notification and considerable portions of the island is demarcated as CRZ-1 or no development zone. The island is subjected to severe cyclones. It has a lighthouse on the southwestern shore to guide traffic up the Hugli. Physiographically, the region is a very low plain having gentle slope towards the sea. The average elevation of this island is 4 meter above them and sea level.

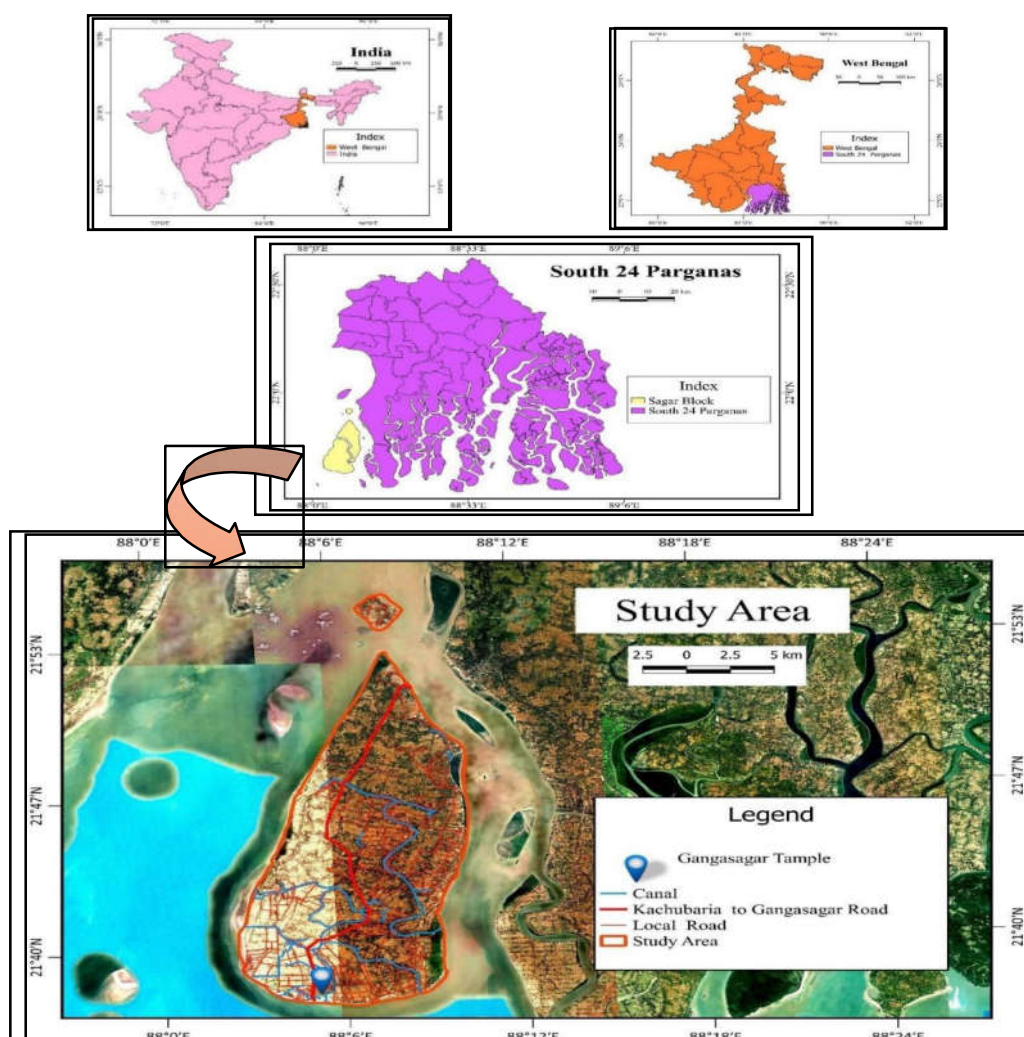
Keywords: Delta, Sagar Island, Coastal erosion, Socio-economic condition, Satellite Images.

Location of the study area:

Sagar island in the Ganga delta lying on the continental shelf of the Bay of Bengal about 100 km (54 nautical miles) south of Kolkata. The nearest busy town is Kakdwip located at a distance of 25 kms which serves as a major transport mode of South 24 Parganas. Furthermore, Kakdwip, Namkhana, Frazergunj are some well-known fishing harbours situated within 30 kms from the study area. Sagar island is having a total area of 340m² and hosts a total population of 212, 037 (2011, Census india.gov.in). Some state highway is the main route to approach the locality from Kolkata, Namkhana and Kakdwip. So far as land use characteristic of the island are concerned the island is characterized by long sea beach, agricultural lands and fallow and barren lands. Agriculture is the main occupational production system that operates in the locale till date. However, a significant portion the local residents also earn their income from marine fishing and hotel business. A significant portion of the island is utilized for hotel construction and a large number of hotels have come up in recent years. This island is a place of Hindu pilgrimage. Every year on the day of "Makar Sankranti" thousands of Hindus gather to take a holy dip at the confluence of river Ganges and Bay of Bengal and offer prayers (puja) in the Kapil Muni Temple.

This island forms the Sagar C.D block in Kakdwip subdivision of south 24 parganas district in the Indian state of West Bengal. Although Sagar Island is part of Sundarban, it does not have any Tiger habitation or Mangrove forests or small river tributaries as is characteristic of the overall Sundarban delta. This island is a place of Hindu pilgrimage. Every year on the day of "Makar Sankranti (January)", hundreds of thousands of Hindus gather to take a holy dip at the confluence of river Ganges and Bay of Bengal and offer prayers in the Kapil Muni Temple. Kolkata port Trust has a pilot station and a light house. As per 2011 census of India, Sagar Island had a total population of 212,037, of which 109,468 (52%) were male and 102,569 (48%) were females. Population below 6 years was 156,476 (84.21% of the population over 6 years). Sagar island is located at

21°39'10"N, 88°04'31"E with an average elevation of 4 meter.



Objectives:

- To find out land use and land cover change at Sagar Island.
- To find out the impact on agricultural land due to salt water intrusion.
- To find out total area of this island.
- To study the hazardous scenario and its impact on local community.
- Protection Against the Economical impact of coastal erosion.
- To evaluate the impact of coastal erosion of Sagar Island in Hugli estuary.
- Rising the sea level in coastal area, and impact on socioeconomic condition of Sagar Island.

Significance:

- In Sagar Island more than half of the land is already underwater so, proper steps should be taken like natural vegetation, coir logs etc.
- Many people on this island lost their agricultural land due to river bank erosion so, they become migrant worker.
- Sagar Island is one of great significance to Hindus. Every January more than half a million pilgrims comes here and that is why here tourism industry is developing.
- This island is under threat, the coastal erosion is happening here faster than anywhere in the world. According to NASA Land sat satellite imagery. So here the land erosion mostly needed.
- Sea level rise inundation of crop land with more and more salt water flooding, transforming agricultural areas into brackish sponges.

Data base and Methodology:

The study is based on secondary data. Literature reviews have been done for understanding the physical set-up and socio-economic issues in the present study area. Socio-economic data have been collected form Census report. Shoreline changed etc for the period of 1990 to 2020 have been analysed based on Satellite images. All collected data related to Socio-economic attributes were tabulated and calculated in Microsoft Excel. These calculated data were graphically represented by different diagrams (Pie, Bar, Column, Line) The data contains population composition and demographic characteristics, while secondary data has been collected from books, census data and previous literature survey reports, which are available in wave site (internet).

Physiography:

The Gangasagar coast of Sagar Island is semi-arcuate in shape along east-west direction. The beach is more or less flat and with gentle slope, varying from 0.42° to 1.51° and width of foreshore ranges between 65 to 382 m. The intertidal zone of Gangasagar coast is mostly veneered by fine to very fine sands with palace mud at places. In the eastern sector, width of the foreshore varies from about 65 to 215 m and beach slope is from 0.78° to 1.51° . A sand bar along with a runnel has been formed at the mouth of the Gangasagar khal. Compared to the western sector, the beach is narrow.

In the eastern sector, in the easternmost part, near Doublet, the width is relatively narrow (65 –68 m). At some places the clayey zone extends further seaward. There are clay balls on the inter tidal zone. At places the clayey zone is being covered by fine to very fine modern sands. The area, south of Gangasagar khal is experiencing recent sedimentation by silty sand. In the eastern sector, sand dunes exist in the backshore. The height of this neo-dune varies between 3 to 11.4 m above MSL. At places the neediness is under attack from strong tidal waves. Matured sand dune belt lying behind the eodune belt is 4.4 to 6.6 m high above MSL and at places are flattened due to anthropogenic activities.

In the western sector, width of foreshore varies from about 85 to 382 m and slope of the beach varies from 0.42° to 1.44° . There are sand dunes in the backshore. Behind this neo-dune matured sand dunes are present with 4 m height above MSL. Comparing with the eastern sector the relief of matured dune is low. Further westward there is no sand dune, where intertidal zone is mostly clayey (sticky). At places remnants of earlier vegetation exists. At present part of the clayey zone is being covered by modern sands. In fact, in the seventies, this area was fairly dense scrub with scattered trees.

Geology of Sagar Island:

The seasonal and diurnal (two high tides and two low tides) fluctuations of sea level and the Hugli discharge with a large amount of silt contribute to the formation of the largest island in Ganga delta. Deposition of sand, silt, clay and mud from south to north is also characteristic of this deltaic island. The 12 km shoreline and its sand ridges are deformed by wind and waves. Mangroves in the swamp, some halophytic plants on the dune sand and different marine organisms on the sea beaches and mud flats are responsible for the development of some micro-morphological features in this western most island of Sundarbans. Land erosion is severe in south east and west of the island. The deposition in old creeks such as Phuldubi, Gangasagar etc. The predominance of new creeks in the southwest of the island are the result of tidal scouring and deposition. The Quaternary sediments of the Sagar Island plain are composed of flood plain and deltaic deposits that are subdivided into two major groups: younger Holocene and older Pleistocene alluvium (Roychoudhuri, 1974). The southern extremity of the Bengal plain is characterized by

the presence of an extensive coastal belt, Sagar Island, being a part of this coastal belt, syn-depositional fluviotidal and marine coastal Sediments (viz. sand, silt and clay) deposited during the Flandrean Transgression around 6000 years BP (the on-lapping sequence) and subsequent delta progradation (the off-lapping sequence). Sagar Island reveals that a number of small isolated islands, earlier separated by tidal Creeks, are now welded almost into a single landmass due to gradual reduction of the Width of the tidal creeks. Coastal marshes, mangrove swamps, tidal flats, mudflats, sand dunes or ridges, Marine terraces and tidal inlets are all coastal features of this island.

Climate of Sagar Island:

Sagar Island sees hot summers with temperatures in the range of 23 to 37 degrees during midday. It is very humid. Sagar Island monsoons begin in June and end in September. Constant rain fall is received during this time. In winter season mild and pleasant in Sagar Island with temperatures falling. In annual, temperature hovers around 26°C and at night it feels like 19°C. In January, Sagar island gets 5.93 mm of rain and approximately 2 rainy days. In this month, humidity is close to 53%. In February, temperature hovers around 28°C and at night it feels like 22°C. In February, Sagar Island gets 10.11 mm of rain and approximately 3 rainy days. In this month, humidity close to 59%. In March, temperature hovers around 31°C and at night it feels like 25°C. In March, Sagar island gets 15.73 mm of rain and approximately 5 rainy days. In this month, humidity is close to 67%. In April, temperature hovers around 32°C and at night it feels like 27°C. In April, Sagar Island gets 25.13 mm of rain and approximately 6 rainy days. In this month, humidity is close to 75%. In May, temperature hovers around 32°C and at night it feels like 28°C. In May, Sagar Island gets 75.86 mm of rain and approximately 10 rainy days. In this month, humidity is close to 78%. In June, temperature hovers around 33°C and at night it feels like 29°C. In June, Sagar Island gets 252.09 mm of rain and approximately 21 rainy days. In this month, humidity is close to 76%. In July, temperature hovers around 31°C and at night it feels like 28°C. In July, Sagar Island gets 418.62 mm of rain and approximately 30 rainy days. In this month, humidity is close to 79%. In August, temperature hovers around 31°C and at night it feels like 28°C. In August, Sagar island gets 424.96 mm of rain and approximately 30 rainy days. In this month, humidity is close to 81%. In September,

temperature hovers around 31°C and at night it feels like 28°C. In September, Sagar Island gets 296.88 mm of rain and approximately 27 rainy days. In this month, humidity is close to 80%. In October, temperature hovers around 31°C and at night it feels like 26°C. In October, Sagar island gets 165.68 mm of rain and approximately 18 rainy days. In this month, humidity close to 73%. In November, temperature hovers around 29°C and at night it feels like 23°C. In November, Sagar Island gets 38.30 mm of rain and approximately 4 rainy days. In the month, humidity is close to 61%. In December, temperature hovers around 27°C and at night it feels like 20°C. In December, Sagar island gets 9.90 mm of rain and approximately 2 rainy days. In the month, humidity is close to 53%. Sagar Island, a gargantuan low-lying archipelago setting on the continental shelf of the Bay of Bengal, is one of the most vulnerable deltas to climate change. Extreme climate-driven multifarious threats, including tidal gushes, deluge with sea water, permanent sub-emergence of land, occurrence of droughts and water scarcity have taken a toll on food and environmental security of the Island. Knowing the trend of long-term weather variables responsible for the climate of the island holds importance in adaptation and mitigation strategies to sustain food production. In the present article, weather variables of the island (1982–2010) have been analyzed to detect the changes in trend using Mann–Kendall non-parametric test and the magnitudes of such Trends have been estimated using Sen's slope. The island receives an annual average rain fall of 1735 ± 352 mm with an inter-annual deviation exceeding 40% and exhibits a decreasing trend ($-5.79 \text{ mm year}^{-1}$). Significant ($P < 0.05$) anomalies in inter as well as intra-annual rain fall distributions (pre-monsoon, monsoon and post-monsoon months) were observed. Contribution of monsoon and post-monsoon months showed a decreasing trend (-3.84 to $-4.42 \text{ mm year}^{-1}$), while pre-monsoon rain fall showed an increasing trend ($+0.98 \text{ mm year}^{-1}$). Wide variability in inter-annual rainy days (76–139 days) and a decreasing trend ($-0.24 \text{ days year}^{-1}$) may further complicate the existing anomalies. The island is experiencing a significant ($P < 0.05$) rising trend of inter-annual mean ($+0.021^\circ\text{C year}^{-1}$) and maximum temperatures ($+0.060^\circ\text{C year}^{-1}$).

Drainage System of Sagar Island:

Sagar Island is the western most island of the Ganges-Brahmaputra delta, West Bengal state, north-eastern India. It lies on the Eastern side of the Hugli River entrance and is flanked on its Eastern side by the Baratala River and on its Western side by Bedford Channel. The Muriganga distributary in the east and the Bay of Bengal in the south. The north-south length of the island is 30 km. It has a maximum width of 12 km. The average elevation of it is 6.5 m above the mean sea level. Fluvial, marine, tidal and aeolian processes are the chief agents actively shaping the narrow coastal belt. The biggest Island in the Ganges Delta, in the lap of Bay of Bengal is Sagardwip, where the River Ganga meets the "Sagar" or Ocean. Sagardwip offers acres of silversand Part of Sundarbans. The main fairway leading into the Hugli River passes close off the SW extremity of this island. The Island does not have any small river tributaries as is characteristic of the overall Sundarban delta.

Soil:

The soils were very deep, moderately well drained-1 to somewhat poorly drained, strongly acidic to neutral in reaction (3.2 to 7.3), moderately-saline (1.0 to 12.5 dSm), brown to dark grey in colour, silt loam to silty clay in texture, sub-angular blocky in structure, low to high inorganic-1+1 carbon content (2.3 to 13.3 g/kg) and low in cation exchange capacity [11.9 to 18.2 cmol (p)/kg] and base saturation (45 to 80%). The soils have high amount of silt and clay fractions which do not show any trend in different depths. Among the exchangeable cations, calcium was found to be high in all soils, followed by sodium magnesium, and potassium. Based on the morphological, physical and chemical characteristics, soils were classified as Inceptisols soil order and further, classified as Typic Halaquepts, Typic Endoaquepts and Fluventic Endoaquepts at subgroup level. Three land capability sub-classes viz. IIIsw (54.15%), IIw (16.73%) and IIws (29.12%) were identified and suitable and use options were suggested.

Vegetation:

The island was dominated by mangroves and about 25 species of mangroves were documented in the southernmost tip of Sagar Island near the light house area. However, due to expansion of shrimp farms in an unplanned manner, particularly in the Chemaguri region (88°09'46.64" E; 21°38'54.86" N), there has been a massive deforestation of mangroves. The intense rates of urbanization, mushrooming of tourism activities and construction of a proposed harbour have reduced the mangrove patches in Sagar Island to a great extent.

Ecological conditions were similar in the restored and natural mangrove forests, though they differed in age and elevation. The restored forest experienced total diurnal inundation, but the natural forest was not fully inundated. Thus, the former was dominated by *Avicennia alba*, *Avicennia marina* and *Porteresia coarctata*, while the latter was dominated by *Excoecaria agallocha*, *Ceriops decandra*, *Acanthus ilicifolius* and *Derris trifoliata*. Similarity and diversity for tree and shrub layers were low and the dominance-diversity curves approached geometric series.

The digital change detection study of mangrove vegetation of Sagar Island, Bay of Bengal, India was carried out by using multi-temporal satellite data of this area. IRS LISS - III images of December 1998 and December 2001 were used in the present investigation. Temporal Image differencing, image rationing, principal component analysis and vegetation index differencing were used for the analysis. The area covered by mangroves in December 1998 was found to be

0.62 km² and that of in December 2001 was 1.66 km² with total increase of 1.04 km². The present study has revealed the possibility of non-conventional methods in surveying biological renewable resources.

Land use and Land cover Change:

The terms Land use and Land cover are often used interchangeably, their actual meanings are quite distinct. Land use refers to the purpose the land serves, for example, recreation,

wildlife habitat or agriculture. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use and to identify the land use changes from year to year. Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Identifying, delineating and mapping land cover is important for global monitoring studies, resource management, and planning activities. Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed and provides the ground cover information for baseline thematic maps.

This knowledge will help develop strategies to balance conservation, conflicting uses and developmental pressures. Issues driving land use studies include the removal or disturbance of productive land, urban encroachment, and depletion of forests.

Materials and methods:

For monitoring LULC change, it is necessary to have at least data of two time periods for comparison. We use Landsat (5,7,8) for our present study. The ortho rectified Landsat data was downloaded from USGS global visualization viewer. The details regarding satellites and their acquisition dates are listed in Table-1

Table-1: Characteristics of satellite data used in present study

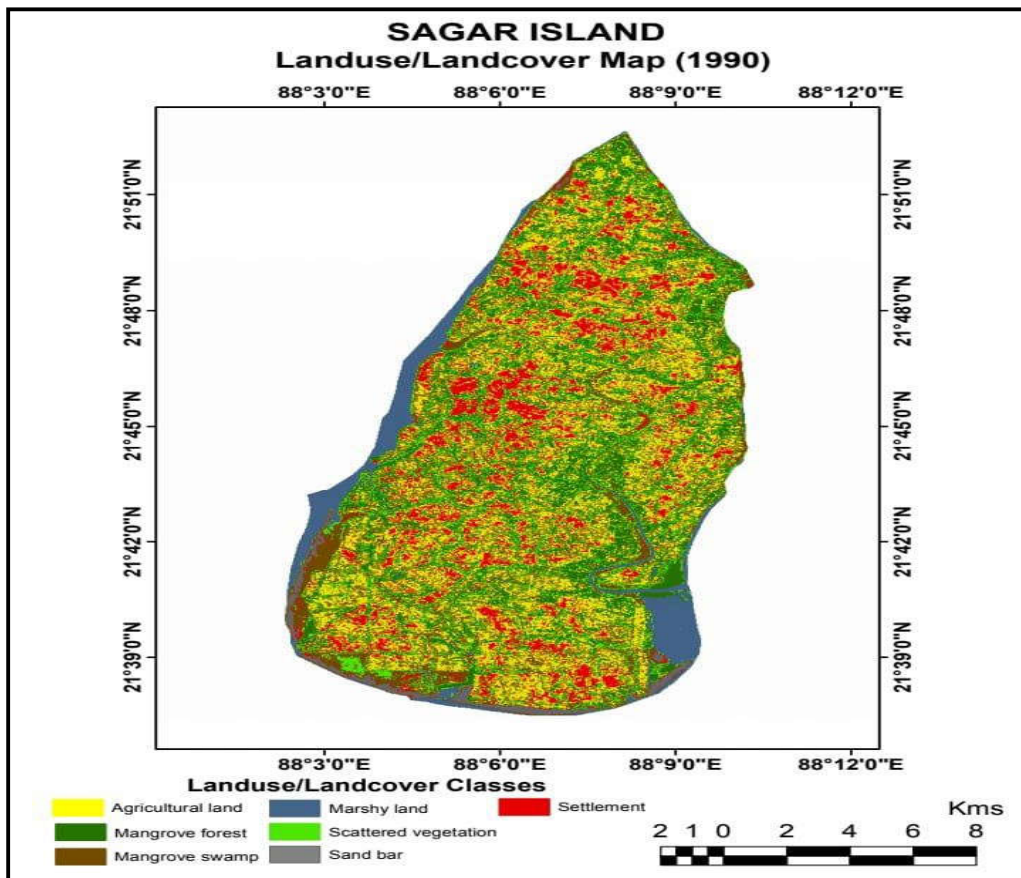
Satellite	Sensor	Date of acquisition	No. of bands	Spatial resolution (m)	Path/Row
Landsat - 8	OLI/TRS	February 15, 2019	11	30	138/45
Landsat- 7	ETM+	March 6, 2000	8	30	138/45
Landsat- 5	TM	January 14, 1990	7	30	138/45

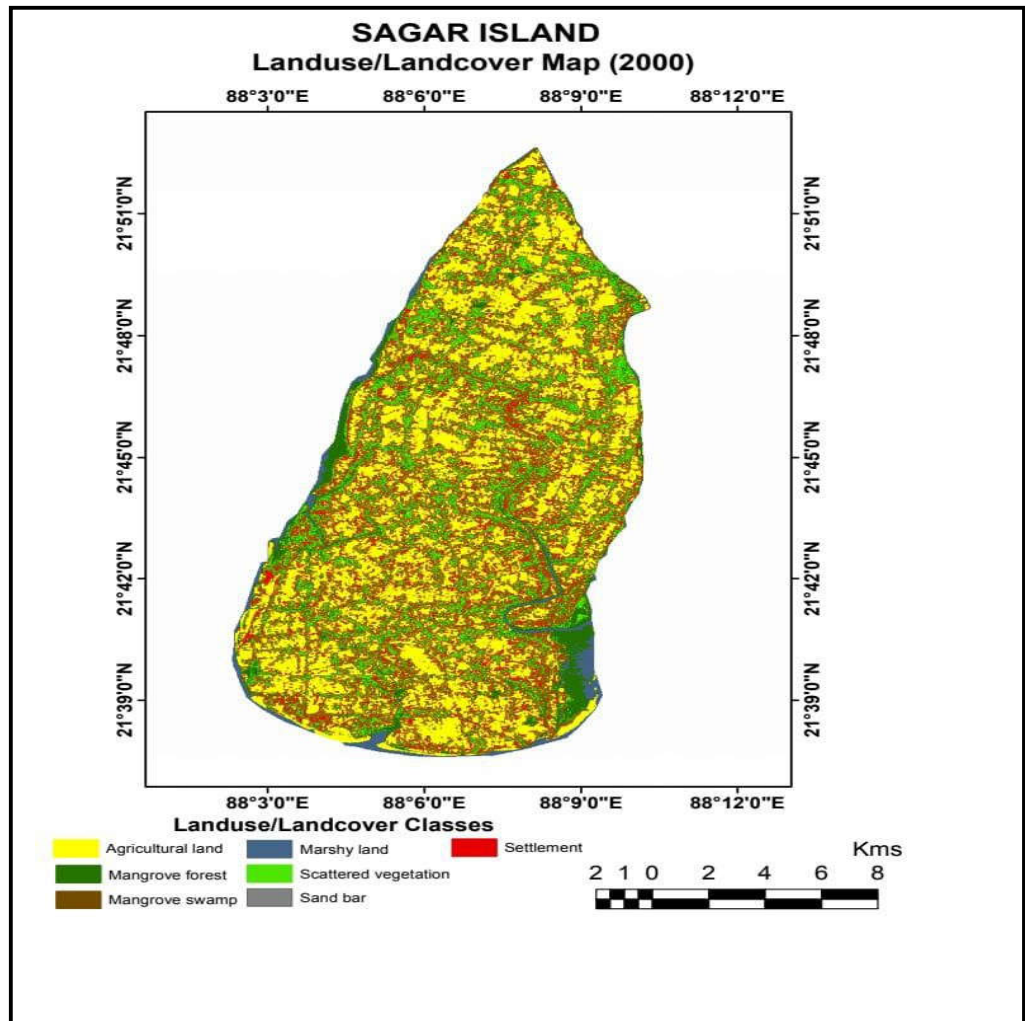
The following steps are followed for the data interpretations:

- Collection of Land sat satellite images from USGS Gov. in
- Image classification in ARCGIS platform
- Interpretation of the classified images

Land use and cover changes (1990, 2000 and 2019):

These three-satellite image Landsat-5 (1990), Landsat-7 (2000) and Landsat-8 OLI merged using ARCGIS. The LULC units and their proportions and observed that the land use pattern has considerably changed from 1990 to 2019.





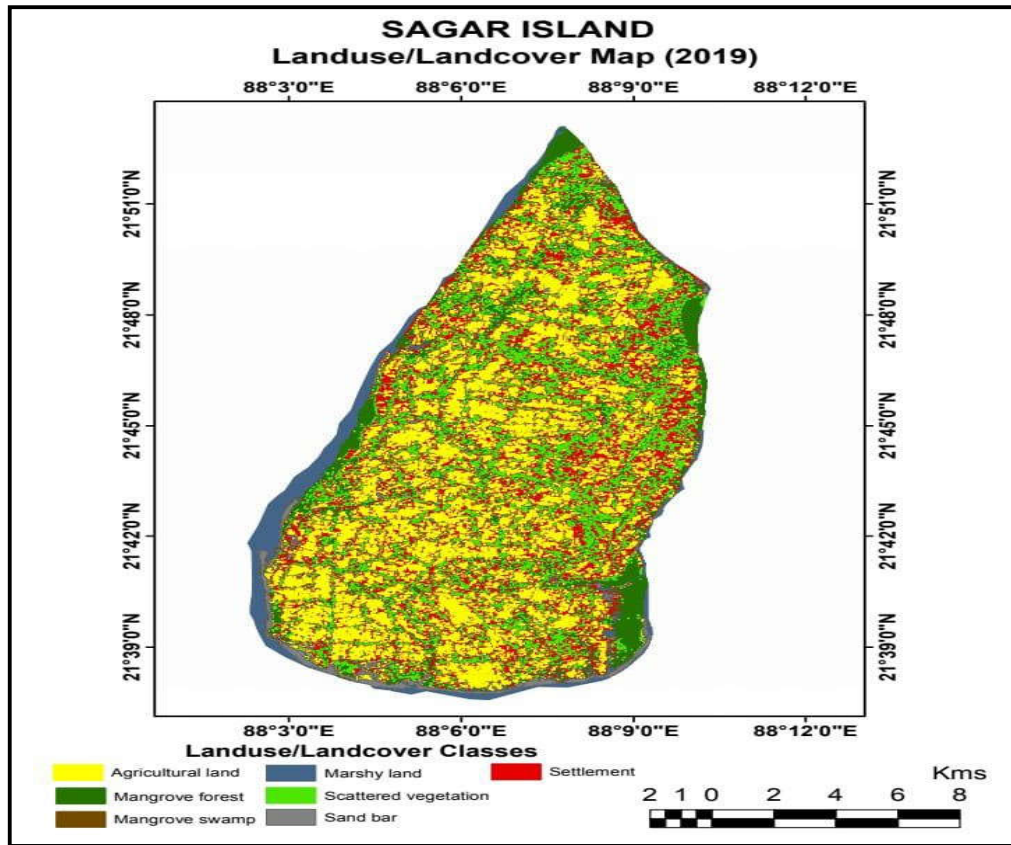


Figure: shows the change of land use and land cover from theyear1990 to 2019.

Table-2: Land use/Land cover statistics of Sagar Island (1990, 2000 and 2019)

Sl.No.	Land use/Landcover Class	Area (%) 1990	Area (%) 2000	Area (%) 2019
1	Marshyland	15.05	2.89	21.85
2	Mangroveforest	25.37	6.82	10.93
3	Scatteredvegetation	10.97	14.53	15.84
4	Mangroveswamp	15.42	29.16	15.50
5	Settlement	11.17	14.11	16.79
6	AgriculturalLand	20.64	32.1	17.17
7	Sandbar	1.38	0.4	1.92

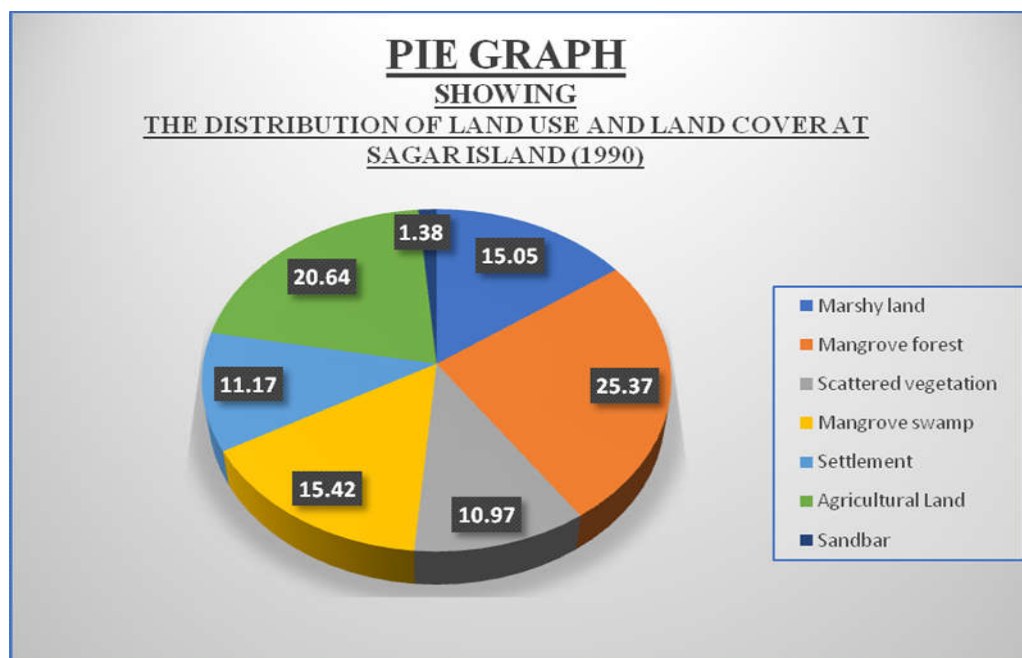


Fig-1

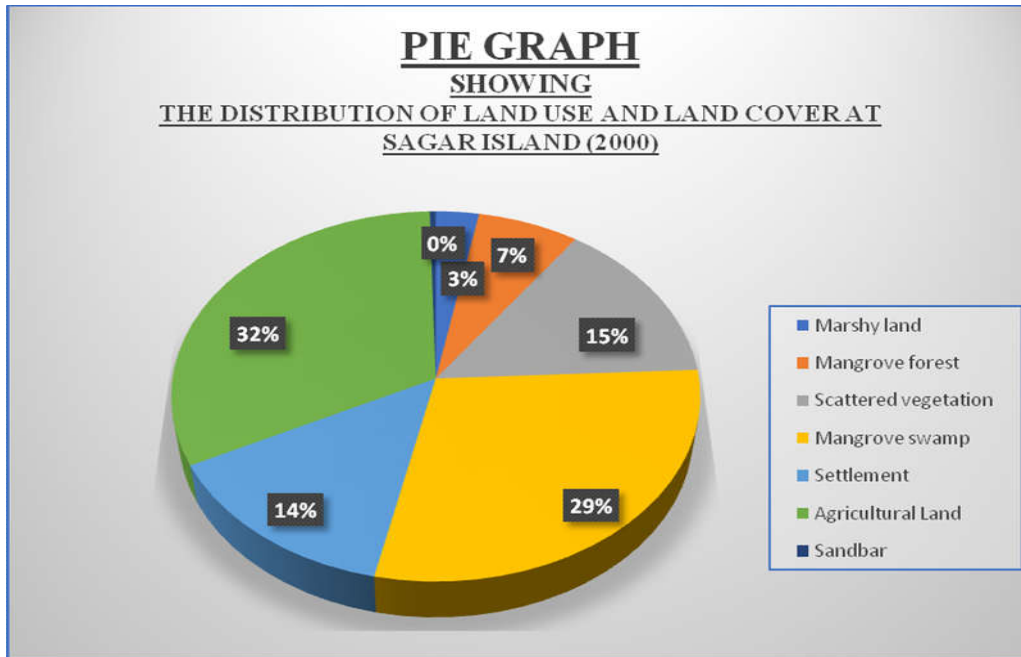


Fig-2

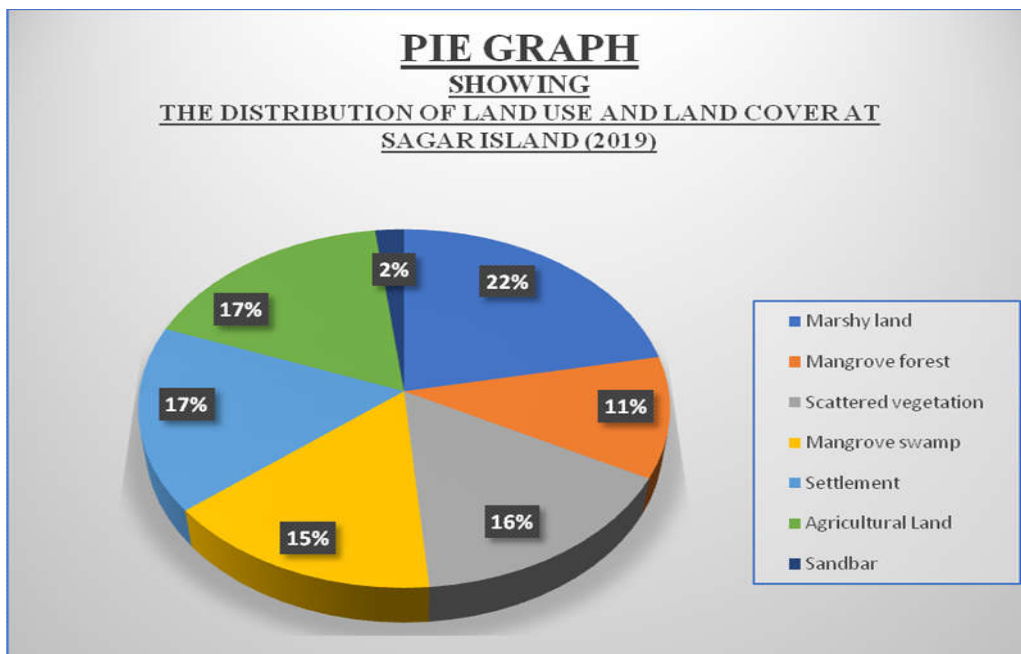


Fig-3

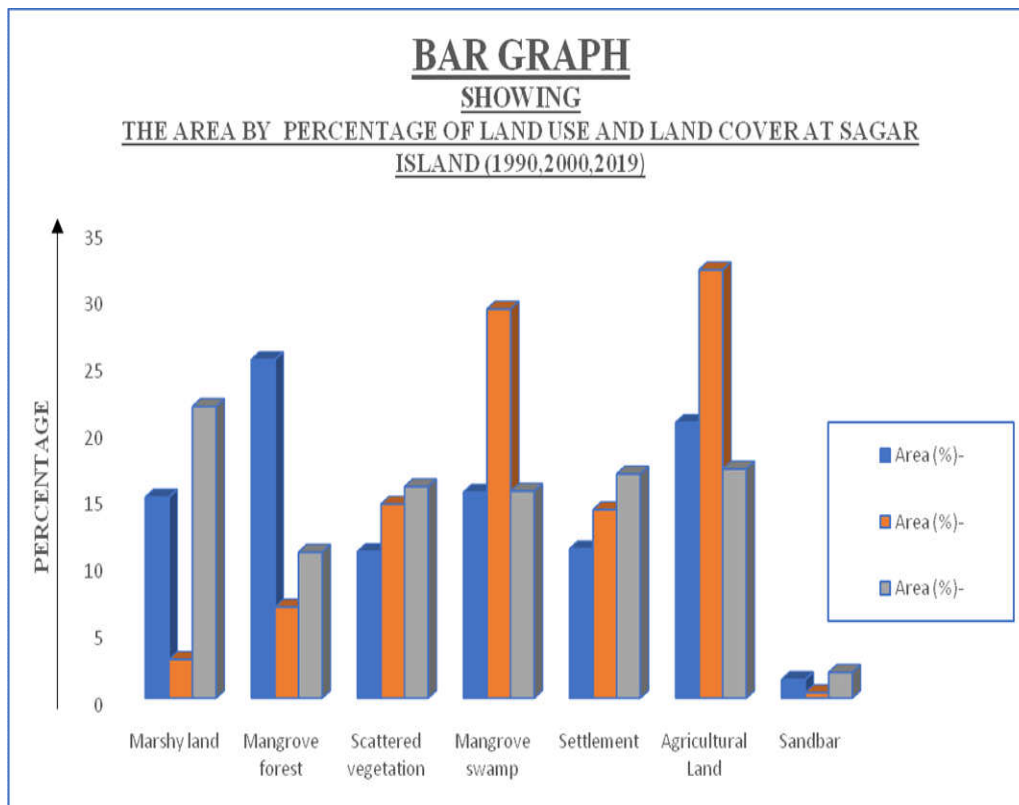


Fig-4

The analysis of LULC based on the satellite data has shown significant changes. Information derived from the analysis of satellite data pertaining to land use land cover revealed that the area covered by marshy land in 1990 was 15.05% which has decreased to 2.89% in 2000 and farther it was increased 21.85% in 2019. During 1990 the mangrove forest was 25.37% which has reduced to 6.82% in 2000 and again increased a little bit in 2019 was 10.93% than 2000. The analysis shows that scattered vegetation was 10.97% (1990) and which have increased 14.53% in 2000 then scattered vegetation increased (2019) was 15.84%. The area covered by mangroves wimp in 1990 was 15.42%, which has increased 29.16% in 2000 and decreased 15.50% in 2019. The agricultural land cover 20.64% area in 1990 and agricultural field increased in 2000 was 32.1% and it was decreased 17.17% in 2019. This analysis showed that the settlement area covered by 11.17% which has increased in 2000 was 14.11% and then increased in 2019 was 16.79%. Lastly sandbar was occupied 1.38% area in 1990, the sandbar area was decreased 0.4% in 2000 farther sandbar area increased 1.92% in 2019 are as I fig-1 to fig-. In 1990 LULC represent that mangrove forest portion of this Island was much larger but

the area of the mangrove forest has been much decreased in 2000 and 2019. Marshyl and is gradually increased the West, South west side of this Island (2019). Agricultural land rapidly changes in 1990 to 2000 and 2019 (fig-4). For the above study the following references are the resources of some information's.

Conclusion:

Sagar island situated in the southern part of West Bengal specially on South 24 parganas district and 150 km away from Kolkata. It has an elevation of 6.5 meter from the mean sea level, laying between $21^{\circ}37'21''$ - $21^{\circ}52'28''$ N to $88^{\circ}2'17''$ - $88^{\circ}10'25''$ E. It is bounded by Hooghly River in the North West, Muri Ganga in the east and Bay of Bengal in the south. The maximum width and length of these islands are 12 km and 30 km respectively and it basically stretched from the north to south direction. In 1951 the Sagar Island covers an area of 285.40 sq.km but in 2015 due to extensive rate of erosion it goes down into 235 sq.km. So the main conclusion is that the land covers area of Sagar Island gradually decreases on time.

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