CHAPTER ONE

INTRODUCTION

1.1 Background of this study

The use of land and land cover is a significant component of global land status understanding; it demonstrates the present and past status of the surface of the earth. Land use and land cover are two separate terminologies which are often used interchangeably (Dimyati *et al.*, 1996). Land cover is a fundamental parameter that assesses the earth's substance, as an essential factor influencing the condition and functioning of the ecosystem. The land cover represents the biophysical status of the surface of the earth and the immediate surface, including soil, vegetation, and water. Land use refers to the human use of land resources, and changes in land cover also represent the most important environmental effects due to excessive human activity. Land use and land cover are dynamic in nature and provide a detailed understanding of the relationship and interaction between anthropogenic activities and the climate (Prakasam, 2010).

In the field of environmental science and natural resource management, land use land cover research plays a vital role worldwide. For environment management; land cover change is an important issue for sustainable management. Due to periodic coverage, data integrity, and provision of data in a wide range of the electromagnetic spectrum, remote sensing techniques have been shown to have a high probability of recognizing land cover patterns and change detection. Remote sensing data, such as aerial photographs and satellite images, are undoubtedly the most appropriate data for understanding land cover spatial and temporal dynamics as well as for extracting information about land cover change. Remotely sensed information can provide valuable multi-temporal data on land cover change processes and trends, and GIS is useful for mapping and analyzing those patterns (Zhang *et al*., 2002)

Analysis of change detection is extremely important for understanding the interactions and relationships between natural phenomena and human activity by accurate detection of the surface characteristics of the earth. Land surveys, current maps, statistical data, existing documents or accessible literature, and remote sensing images are some of the information resources for analyzing land cover changes. While most developed countries are well equipped and updated with comprehensive information on land cover, there is still a shortages and limited access to geospatial datasets in developing countries as Bangladesh (Kumar and Ghosh, 2012). Detection of change is the method of detecting changes in the condition of an entity or phenomenon by analyzing them at various times. A modern strategy into ecosystem management issues is provided by the Remote Sensing (RS) and Geographical Information System (GIS).

The method has been widely used in the tropics to produce useful information on forest cove, type of vegetation and changes in land use (Forman, 1995). Recently, advanced geospatial technologies have further enhanced the efficiency of mapping of land use land cover type at landscape level.

In Asia, there have been dramatic land transformation in the past decades resulting in degradation of soils (Barua and Haque, 2013) and the loss of ecosystem services and economy (Zhang *et al*., 2013). A number of studies have focused in Southeast Asia on the impact of drastic changes in LULC due to increase in cropland while decrease in forest area (Lepers *et al*., 2005; Zhao *et al*., 2006; Inoue *et al*., 2007). The coastal region has also experienced land use changes probably because of economic opportunities attracting growing population (Kurt, 2012).

Coastal zone of Bangladesh is geo-morphologically and hydrologically dominated by the Ganges Brahmaputra Meghna (GBM) river system and Bay of Bengal. Bangladesh's coastal zone covers an area of 47,201 km^2, 32% of the country, with 19 districts being the landmass. The eastern region of coastal zone is covered by hilly area that is more stable (Ahmad, 2019). The eastern coastal regions of Bangladesh including the Moheshkhali Island and Kutubdia are well known cyclonic path that have been suffering severe cyclonic winds, storm surges and tidal waves over many years, originating in the Bay of Bengal. Nearly one million people have been killed in Bangladesh by cyclones since 1820 (Talukder *et al*., 1992) and the after effects of these natural hazards are more common, i.e., their crops and houses, loss of human life, pollution of the drinking water due to the inundation of land and ponds by saline water.

There are diverse interactions of intensity along the coastal belt of Bangladesh. These intensities including different uses and activities occurred in the coastal and maritime regions of a country with diverse land use pattern. Land use is defined as any human or economic activities associated with a specific land pattern, while the term land cover relates to the type of feature present on the surface of the earth (Lillesand *et al.*, 2015).

Coastal zones are now being gradually recognized as functional regions and in order for development to take place on a sustainable basis, coastal areas need effective planning and management. One of the purposes of this work is to examine the problems and causes of changes in coastal land cover. Over those years (2001, 2009, 2019), the island has demonstrated significant morphological and sociocultural changes. The land cover of Kutubdia and Moheshkhali Island has changed dramatically over the last two decades, mainly as a result of reforestation and aquaculture. The applicability of remote sensing techniques for the identification of land cover trends, as well as the detection of land cover change in Moheshkhali and Kutubdia Island, Bangladesh, and the quantitative analysis of land cover changes from 1977 to 1999 were assessed. This type of knowledge allows a greater understanding of the aspects of land utilization. Those kinds of data play an important role in the implementation of the policies and programs needed for development planning.

1.2 Objectives

- To investigate the scenarios (past & present condition) of Moheshkhali and Kutubdia Island on the basis of Land-use / Land-cover data.
- To determine the land use land cover changes of this island within years 2001, 2009, and 2019.
- To identify major land class which dominate these changing trends.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Scenario analysis

Scenarios are considered as the prominent tool which helps scientist to prepare for possible eventualities, makes more flexible and innovative solutions (Hiltunen, 2009). The first goal of scenario techniques is to develop the understanding of the underlying events causal mechanisms, relations and logical sequences, thereby uncovering how a potential world state will unfold. The second goal is to challenge traditional thinking and shift the behaviors of those within organizations; and thirdly, to strengthen decision making in order to upgrade the implementation of strategies (Wright *et al*., 2019). The scenario analysis also reveals the effects of these changes for future inter regional and international trade flows of products based on property. Different influencing variables such as socioeconomic, climatic, geophysical and proximity factors are correlated with the dramatic shifts in land use. In order to assess the trend of potential changes in land use, understanding the driving forces of changes in land use also is important (Samie *et al.,* 2017).

2.2 Land use- land cover

Global environmental change clearly is a unique process which deals with Land-use/land-cover change through the alteration of the land surface and its biotic cover. Land use denotes the human employment of the land and land cover denotes the physical and biotic character of the land surface.

Since 1990, land use and land cover improvement has gained great attention from scientists around the world. Realizing the significance of this shift to other global environmental change and issues of sustainable development (Xiubin, 1996). A major source and component of global environmental change is land cover charges resulting from human land use. Not only are land-use and land cover change information at the global level relatively low, but we need a much clearer understanding of the driving forces behind these changes. Several forces have been suggested as significant, but one-factor explanations of land transformation have proven to be insufficient. (Volk *et al.*, 2017)

2.3 Study area

2.3.1 Kutubdia Island

Munshi *et al*. (2017) conducted a study in Kutubdia Island in which geospatial analysis of land loss, land cover change and land use patterns are showed. Three distinct land cover groups of water, trees and woods, and agriculture were identified using remote sensing analysis and land cover changes were observed from 1972 to 2013. An approximate 9 km^2 of land was lost and major changes occurred from 1972 to 2013. (Munshi *et al*., 2017).

There was also a case study on coastal erosion of Kutubdia Island. It states that from 2006 to 2013 there was excessive erosion in Kutubdia. Coastal erosion, tide, man-made and natural disaster are the major problem here (Salauddin *et al*.,2018).

Islam *et al.* conducted a report in 2014 on shoreline changes on the island of Kutubdia, South East Bangladesh, using a digital shoreline analysis method. The rate of shoreline change is analyzed in four locations of the island. On the entire island, erosion is predominant. The highest erosion rates around the southern part of the island are exhibited by different methods (Islam *et al.*,2014).

2.3.2 Moheshkhali Island

Islam and Murshed (2011) conducted a study about spatial changes of Land Use/Land Cover of Moheskhali Island, Bangladesh since 1972 to 2009 by Remote Sensing Analysis. Eight different land classes (mangrove, salt field, waterbody, hilly forest, agricultural field etc) have been identified from the images of three different years i.e., 1972, 1989 and 2009. The major portion of mangrove is present in the southwestern part of Sonadia Island. In recent years, however, Sonadia Island's mangrove forest has been invaded, mostly for shrimp farming. This class is very crucial for the coastal ecosystem and more significant for saving life and properties of the people living in this area from cyclones and tidal surges. Rapid encroachments of salt field to the cultivable lands are declining food security of this area. In the near future, due to the implementation of the deep sea port near Sonadia, the rest of the agricultural land may also be affected.

2.3.3 Other relevant relevant research in Bangladesh

A research on land use and land cover changes in the coastal region of Bangladesh during the periods 1989-2000-2010 was carried out by Islam *et al* (2011). The Ganges Flowing Floodplain, the Meghna Estuarine Floodplain, Chittagong Waterfront Plain three significant seaside region of Bangladesh which was depicted in this examination. Bangladesh comprises of 30 agro-environmental zones (AEZ) those are covering with one another. The Ganges Tidal Floodplain, the Meghna Estuarine Floodplain, Chittagong Coastal Plain are three of them. The results indicate that a wide area of crops in the Ganges Tidal Floodplain (AEZ 13) and Chittagong Coastal Plain (AEZ 23) have been converted into shrimp fields or salt shrimp farms, while there has been a greater increase in cropland accretion in the Meghna Estuarine Floodplain due to river erosion processes (AEZ 18) (Islam *et al* ,2011).

One of the research was done about simulating land cover changes and their impacts on land surface temperature in Dhaka (Ahmed *et al*., 2013). Four land cover type (Build-up-area, water body, vegetation, bare, soil) was described there. For the duration of 2019 and 2029, this study designs the effects of land cover changes on land surface temperature (LST) in the Dhaka Metropolitan (DMP) area (Ahmed *et al*., 2013).

Rai *et al.,* (2017) conducted a research about Land Use and Land Cover Dynamics during 1930–2015 in Bangladesh. Bangladesh has experienced rapid LULC because of rapid population growth and urbanization, which resulted in sharp contractions in agricultural land, according to this report. The research covers the dynamics of LULC across the country at various spatio-temporal scales from 1930 to 2015. The agricultural land decreased from 67.38% to 62.2% between 1976 and 2014. Several researches were done about LULC of different area in Bangladesh.

CHAPTER THREE

MATERIAL AND METHODS

3.1 Geography of the study area

3.1.1 Area A: Kutubdia Island

Kutubdia is located at 21°49′00″N latitude 91°51′30″E 21.8167°N latitude, 91.8583°E. It has total area 215.8 square kilometers (83.3 sq. mi). Climate change and sea level rise threaten to submerge the island in the Bay of Bengal. Kutubdia Island is about 21 kilometers long and 2 to 6 kilometers wide, aligned roughly parallel to the mainland Chakaria separated by approximately 3 kilometers wide tide dominated channel, 0-7.6 m above sea level elevation (Chowdhury *et al*., 2014). A young coastal plain is adopted by this area which is dominated by unconsolidated sediments. Tropical and subtropical climate are dominated in this island. Most of the people in this area are fisherman and depend broadly in Bay of Bengal. Kutubdia is one of many islands of Bangladesh along the affected by increasingly rapid sediment transport, erosion and some of the fastest recorded sea-level rises in the world, was formed at the mouth of a river system consisting of two channels. This vanishing island is shrinking dramatically. Kutubdia has halved in size in 20 years, to about 100 sq. km. At the current rate of erosion Kutubdia will be off the map within 30 years, along with dozens of other coastal islands (Chowdhury *et al*., 2014).

Kutubdia coast was influenced by both natural and anthropogenic factors, and changed severely by the tidal and wave action of the Bay of Bengal and also internal activity of Kutubdia Channel. The natural factors contain changes of tidal estuary and tidal surge, and the anthropogenic factors consist of population pressure, construction and extension of saline, cultivated fields and human activities. It has great significance to monitor coastline change for Bay of Bengal coastal zone protection and utilization. It is also very important to provide scientific and efficient information for decision-making administrations (Weifu *et al*., 2013).

3.1.2 Area B: Moheskhali Island

The only hilly island in Bangladesh is Moheshkhali. The latitude of Moheshkhali Island is 21⁰20´N-21⁰50´N and 91⁰45´E-92⁰00´E longitude and bordered by Chakaria and Cox's Bazar through the Moheshkhali channel in the north, northeastern eastern and southeastern portion.It is also an upazila that is centered in the Chittagong division of Cox's Bazar district. It is bordered on the south by Cox's Bazar sadar upazila and Bay of Bengal (BOB), on the east by Chakaria and Cox's Bazar Sadar upazila, on the west by Kutubdia upazila BOB and on the north by Chakaria upazila. It is isolated from the main land with the Moheshkhali Channel. The total area is covered by this island approximately 7.70sq. km. A common issue in this region is natural disasters. This region was substantially impeded by the cyclone and tidal bore of 29 April 1991. (BBS, 2011).

On the eastern cliff shore of Bangladesh, Moheshkhali islands exhibit a very complex geological structure characterized by hilly topography surrounded by coastal plains with unique geological, tectonic and geomorphological peculiarities. Landforms are very closely related to the process of geological deposition at a rate of 1.2 sq.km. The coastal plain of the southwest and the coastal plain of the west have accreted huge landmass that ultimately contributes directly or indirectly to the land classes of this island associated with the Landuse/Landcover trend changes in this area Moheshkhali is in the accretionary process, since 1972 per year (Islam and Murshed, 2011).

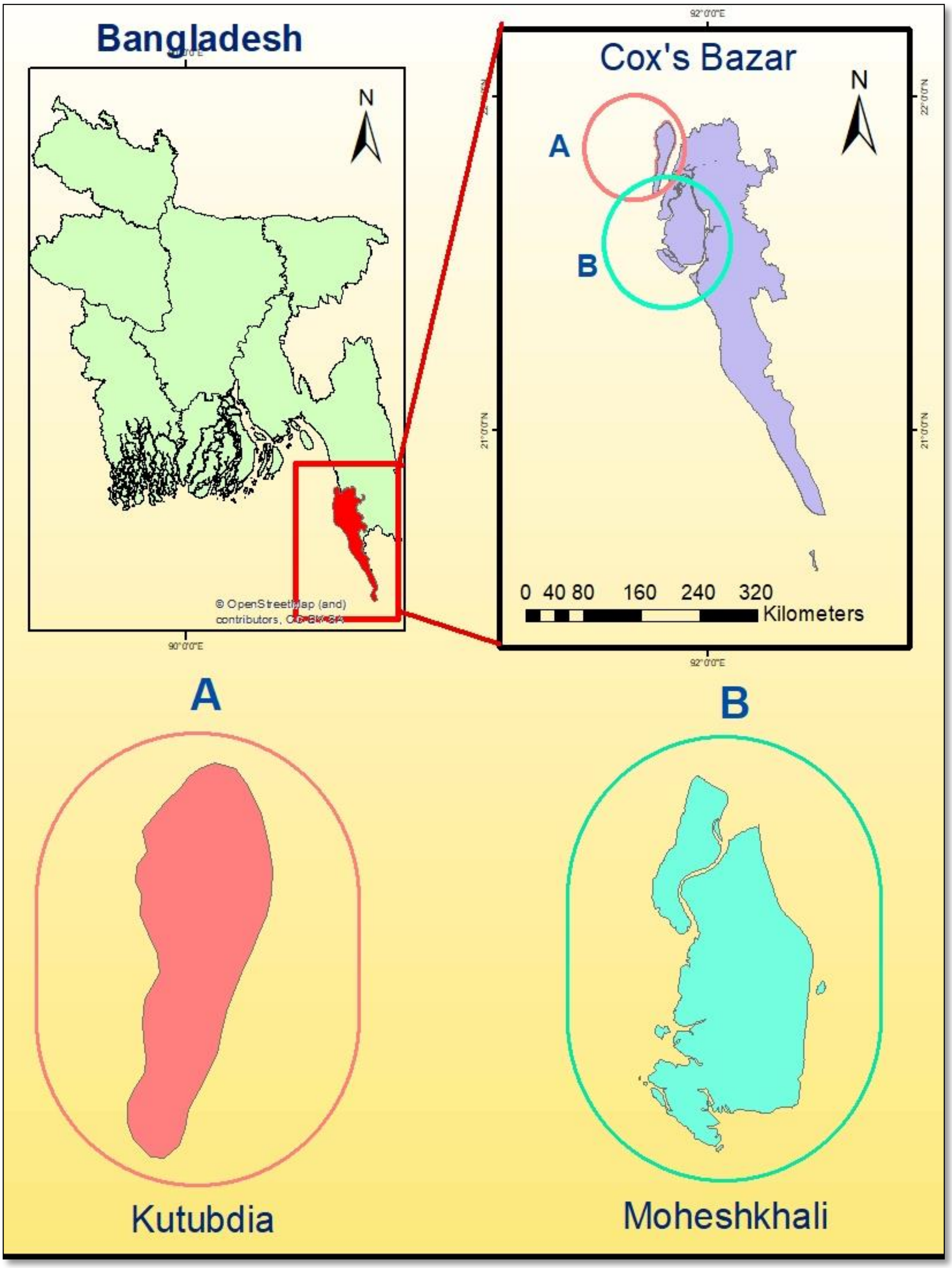

Figure 1 Geographical location of two study area

3.2 The geomorphological structure of Bangladesh's coastal and marine environment

Bangladesh's coastal zone comprises island coastal plains, tidal flat, mudflat, estuaries, neritic and offshore waters. It stretches to the edge of a broad (about 200km) continental shelf. The coastal zone's land area is around 47,201 km^2, 32% of the country. Bangladesh's coast can be divided narrowly into three distinct geo-morphological regions:

3.2.1 The southwestern area that covers the coastline of the Harbanga River from the Tetulia River to the inter-national river. The western area contains the biggest patch of naturally occurring mangroves in the Sundarbon-world. The mangrove forest spreads deeper into India to the west. The mangrove forest spreads deeper into India to the west. The entire coast comes under the tracks of cyclogenesis above the BOB and suffers from extreme cyclone storms almost annually (Hanif *et al.,* 2015).

3.2.2 The central region, including the mouth of the Meghna River, is located between the eastern and western regions, from the Tetulia River to the Big Feni River Estuary. Most of the GBM (Ganges- Brahmaputra-Meghna) system's combined flow is discharged through this low-lying area. Tidal interactions and consequential backwater effects are strongly affected by the lower Meghna river estuary. Strong river sediment inputs result in a coastal zone that is morphologically complex and diverse (Hanif *et al.,* 2015).

3.2.3 The southeastern area extends from the Great Feni River to the southern tip of the mainland, Badar Mokam. This section is more or less unbroken, marked by a degraded natural mangrove forest in the estuarine zone of the Matamuhuri River's muddy flat and sandy beaches. The rivers Karnafulli, Sangu, Matamuhuri, Bakkhali and Naf discharge fresh water through the river networks (Hanif *et al.,* 2015).

3.2.4 Environmental change

The country has a long, dynamic, varied, straight and continuous coast along the area of Cox's Bazar and Khulna, where there are no islands that could serve as wind breakers. The sea remains very rough along the coast of Bangladesh for this reason. Thus, heavy siltation, habitat destruction and resource dislocation are very common and need to be controlled on a regular basis.

3.2.5 Siltation

The oceanographic characteristic of the northern Bay of Bengal is the siltation strike. It has some effect on the fishing ecology of Bangladesh's estuarine and near-shore water bodies. Bangladesh has been one of the most involved areas of sedimentation in the world since prehistoric times. The denudation of the Himalayas contributed to the creation of the largest delta in the world, which is still active at a rate of about 70 cm every 1,000 years (Curray and Moore, 1971). This sediment is carried down and drained into the Bay of Bengal by the Ganges-Brahmaputra river-system. In passing through the depressions (haors) of the sylhet basin, the Meghna system tends to be filtered and contributes less to the process. Per year the Ganges-Brahmaputra riverine system carries a total of 6 million cusecs of water bringing an approximate volume of 2,179 million metric tons of sediments down to the sea (Curray and Moore, 1971).

Other major causes of siltation in the region are increased run off during the rainy season, floods increased erosion on topsoil as a result of coastal and inland vegetation loss. Huge earthworks involved in coastal construction projects and likely also in the rapid horizontal expansion of other land use activities (e.g. aquaculture) to replace current ones have contributed to improvements in the in-shore and estuarine ecosystem siltation processes. In the Chittagong region, mass scale flattening and scarping of hills and foothills must have changed the area's sedimentary process in recent years, although very local effects are expected.

3.2.6 Geo-morphological change

In the vast Ganges-Brahmaputra-Meghna estuary, which makes up about 12800 km^2 of in-shore fish habitat, the accretion-erosion phase of the islands such as Kutubdia, Hatyia, Sandwip and Bhola has indications of a heavy sedimentary process

(Knebel and Creager, 1973). Increases in island erosion over the past few decades have been noticeable. In contrast to the loss of 190 km^2 in the last two centuries, Sandwip lost more than 72 km^2 between 1953 and 1982. In a period of 166 years (1779-1945), Hatyia increased from 307 km^2 to approximately 1070 km^2 and lost all 700 km^2 of accreted land by 1979 (within a period of 34 years only) (Knebel and Creager, 1973).

3.2.7 Impacts of siltation on fisheries

There is a continuous shift in habitat due to heavy siltation in the near shore regions; the bottom topography in particular is subject to continuous alteration. In the recent past, the extensive erosion rate in kutubdia, Hatyia, Sandwip, Bhola and Noakhali, Potuakhali (a few decades) may have altered the bottom condition of the habitat, especially the demersal stock, which may have a significant impact on the fish population.

3.3 Unsupervised classification

This sort of classification is based on the examination of an image by software without the sample classes given by the user. This includes grouping pixels with characteristics that are common. To evaluate which pixels are related, the machine uses techniques and groups them into classes. The user can define the methodology to be used by the software and the necessary number of output classes, but does not otherwise assist in the classification process. Nevertheless, the user must have knowledge of the region being categorized (such as wetlands, developed areas, coniferous forests, etc.)

3.4 Supervised classification

This is based on the assumption that in an image that is representative of specific classes, a user can select sample pixels and then direct the image processing software to use these training sites as guides for classifying all other pixels in the image. Based on the user's experience, training sites or input classes are chosen. The user often sets the boundaries to group them together by how close other pixels must be. These limits are also set on the basis of the training area's spectral characteristics, plus or minus a certain increment. The user also defines the number of classes under which the picture is graded.

3.5 Data Acquisition

Raw data collected from USGS data site which refers earth imagery across available geo-spatial data types. The LP DAAC (Land Processes Distributed Active Archive Center) operates as a partnership between the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA) and is a component of NASA's Earth Observing System Data and Information System (EOSDIS). Data specialists, system engineers, user service representatives, and science communicators work in collaboration to support LP DAAC activities. MODIS data are available in NASA LPDAAC collection. NASA launched Santa Barbara Remote Sensing into Earth orbit. This builds a payload imaging sensor which is called The Moderate Resolution Imaging Spectroradiometer (MODIS). 1-2 days temporal resolution and 250 m (bands 1–2) 500 m (bands 3–7) 1000 m (bands 8–36) spatial resolution imagery are provided by MODIS.

Year 2001, 2009, 2019 images were used as raw in this research. MODIS land cover V6 data sets was used to find this image in Earth explorer. Data sets, acquisition date, coordinates of central area are provided in table 1.

Table 1 List of Satellite imagery of raw data for unsupervised classification

Serial No.	Entity ID	Raw data set	Acquisition Date(mm/dd/yyyy)		Central Coordinates
			Start Date	End Date	
1	MCD12Q1.A2001001.h26v06.006	MODIS MCD12Q1 V6	01/01/2001	12/31/2001	25.0377, 94.2017
2	MCD12Q1.A2009001.h26v06.006	MODIS MCD12Q1 V6	01/01/2009	12/31/2009	25.0377, 94.2017
3	MCD12Q1.A2019001.h26v06.006	MODIS MCD12Q1 V6	01/01/2019	12/31/2019	25.0377, 94.2017

Source: http://glovis.usgs.gov/

Table 2 List of Satellite imagery of raw data for supervised classification

Serial No.	Entity ID	Raw data set	Acquisition Date(mm/dd/yyyy)	Cloud Cover	Central Coordinates
1	L1C_T46QCJ_A019678_20190330T043120	SENTINEL-2A	01/30/2019	0%	21.201602 , 91.6020693
2	L1C_T46QCK_A019678_20190330T043120	SENTINEL-2A	01/30/2019	0%	22.1050053 , 91.5933402
3	LE07_L1TP_136045_19991219_20170215_01_T1	Landsat 7 ETM+ C1 Level1	1999/12/19	0%	21.67200 , 91.54770

Source: http://glovis.usgs.gov/

3.6 Description of LULC classes

About nine major Land Use Land Cover classes were found in Kutubdia and Moheshkhali. Rivers, streams, wetlands and reservoirs, as well as water-logged and swampy areas during the rainy and dry seasons, perennial marshy areas and riparian vegetation during the rainy season were considered as water bodies land class. Plantations contain areas dominated by natural as well as cultivated trees, crop fields and fallow lands.

LULC classes are specified with below mentioned grid values and description (Table 02).

Table 3 LULC classes with description

Class Name	Grid Value	Description
Bare Land	08	An unused land area which has become barren or overgrown
Waterbodies	09	Waterbody describes the surrounded sea area and internal waterbodies as like as pond, river etc.
Plantations	10	Area refers manmade plantation with woody or non woody plant.
Aquaculture/ Salt pan	11	Fish or shrimp culture over the island and also a human interpretation or land use for salt production in dry season.
Mangrove Forest	12	Foe being a coastal area, having mangrove forest with various mangrove trees.
Grass Land	14	Bank of any waterbody dominated by grass group.
Deciduous Needle-leaf Forest	16	Forest having deciduous trees which seasonally shed leaves usually in the autumn. Needle leaf forest also called softwood forest.
Permanent Wetland	17	Wetland areas which are parts of Bay of Bengal
Crop Land	75	Land which is seasonally / permanently used for agriculture
Beach	67	Intertidal area which is prominent at the time of low tide.

3.7 Data processing and analysis

Table 4 Practical use of software during this study

Software	Functions
UCGS	This software was used for image acquisition from MODIS data source.
QGIS	This software helps to extract study area map.
ArcGIS	This software was used to processing of the Data.
Google Earth Pro	Clear and historical images were provided knowledge about the study area which helped to supervised classification.
Microsoft Excel	It was used in producing the bars, charts, and graphs.
SPSS	It is used to run statistical analysis.

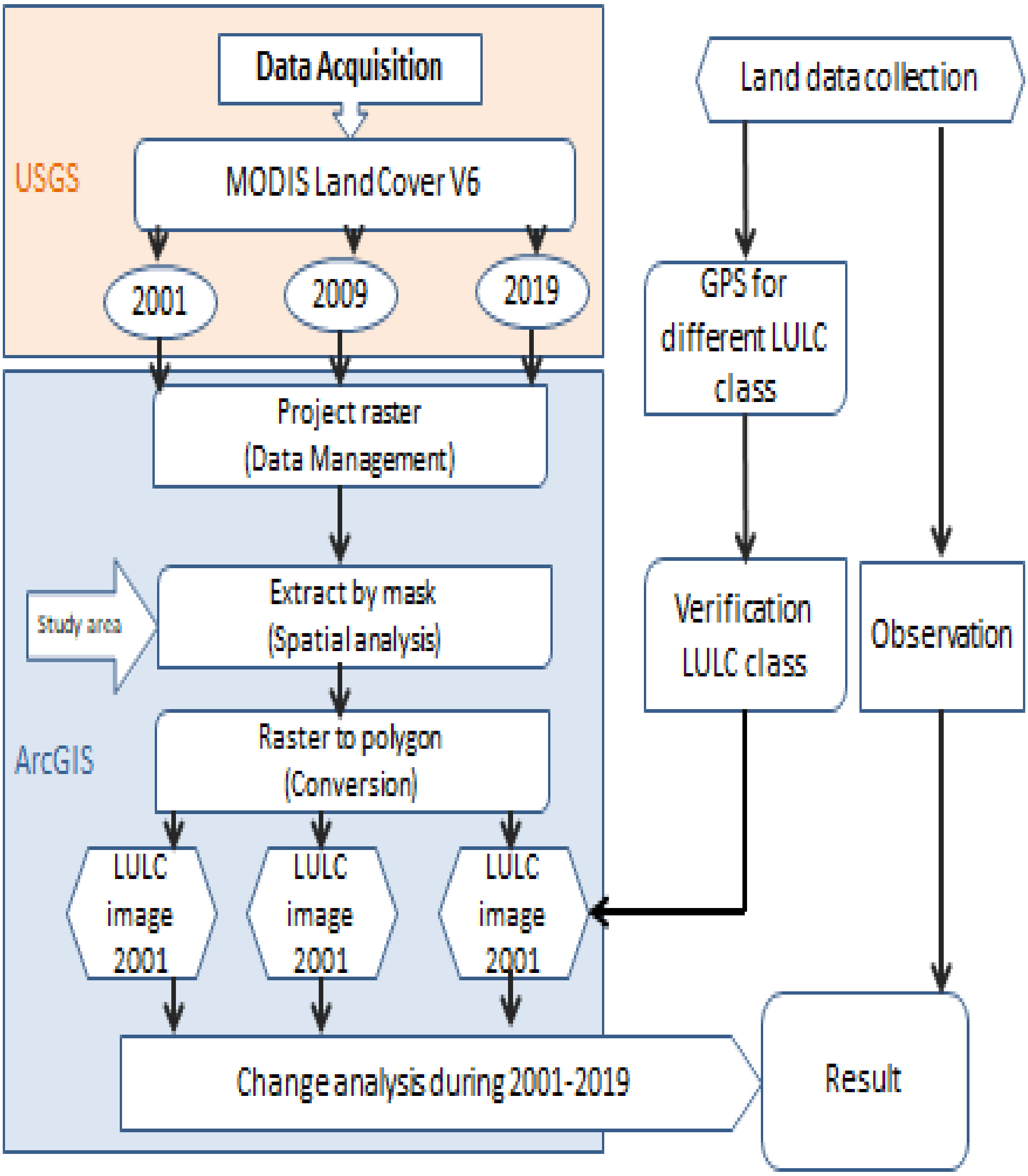

Figure 2 Process of unsupervised classification and LULC change analysis

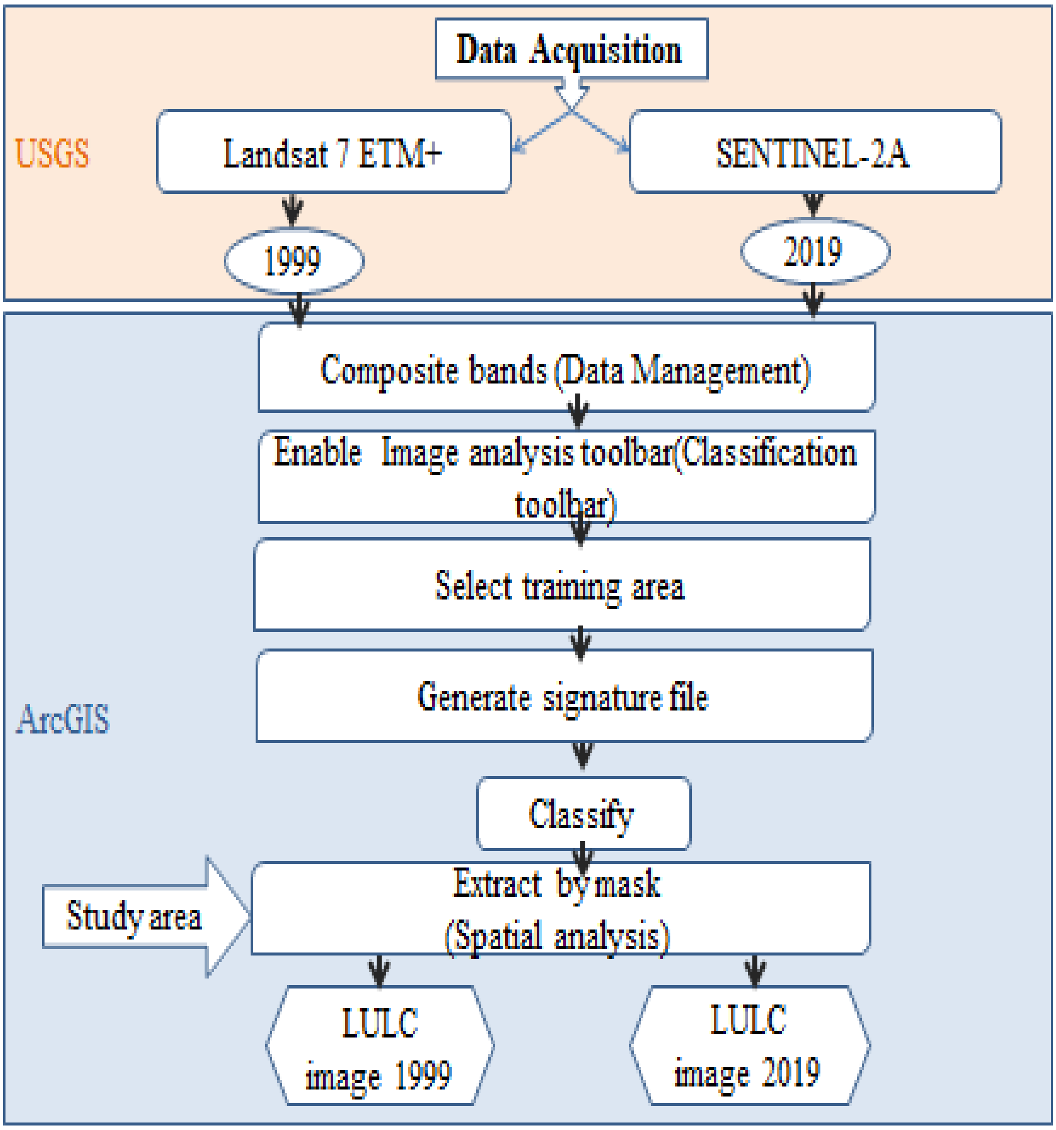

Figure 3 Process of supervised classification

3.7.1 Image pre-processing and LULC class detection

ArcGIS 10.1 version and QGIS 3.4.1 version used to processing these LULC class detection processes. With the help of QGIS software study area shape file was extracted from the imaginary of Bangladesh using WGS84. More than area occupied lands mass were kept in extracted shape file because for shore line area change easily could identify.

From USGS, HDF metadata was downloaded which should be processed for several steps. HDF directly couldn't use for land use land cover classification. By ArcGIS software, further processing of data are finished. First of all, HDF data was added and co-ordinate system must be fixed in WGS 1984 World Mercator by changing layer properties. Then this layer should export twice in time and was created tiff layer which is the main raw product of this research.

3.7.2 Land Use/Land Cover Change processing of unsupervised classification

Land Use Land Cover change processing had to run various successive processes. Some tools were so helpful to follow this classification process. These processing went through step by step procedures and found several layers which provided the final steps to interpretation.

Geoprocessing tools used in ArcGIS

- **Project raster (Data management)**

The project raster use tiff layer as input data and a specific folder should select to save the output file. Again WGS 1984 World Mercator co-ordinate system should be selected in this process. Then output layer extracted as a raster file for further processing.

- **Extract by mask (Spatial analysis)**

In this geoprocessing tool, study area's layer was needed to consider. Then, need to add these layers of interest which was previously extracted by QGIS software. In this process layer found after using project raster tool was used as input data. Study area layer was used as 'Input raster or feature mask data' . After processing in extract by mask tool, a new layer was created which was raw for final tool processing.

- **Raster to polygon (Conversion)**

This tool helped to produce different polygons which finally divided into grid classes. In this process, last processed layer was used as input data and precede the system. A new polygon data was provided as the output of this tool.

3.7.3 Land Use/Land Cover Change processing of supervised classification

<u>Geoprocessing tools used in ArcGIS</u>

- **Composite band (Data management)**
  Bands 1 to band 7 were used to composite and processed a final composite band. A Tiff file was created from that composite file. With the help of classification bar, specific land classes were selected and produced training manager. After having maximum likelihood classification, a final image was found.
- **Extract by mask (Spatial analysis)**
  With the study are of Kutubdia and Moheshkhali island's shape file, final outcomes were extracted by the help of tool extract by mask (Spatial analysis).

3.7.4 Embellishment of final layer

Several properties should be changed and made same layer properties for every year map of Kutubdia and Moheshkhali Island. Layers grid code with all values should be used by changing field value. These values of all LULC class were placed in map as legend. Then all legends name and color were changed for all years' map in same study area. That helped to interpret those maps and calculate the change of land use land cover changes. Finally, world ocean base map was added from ArcGIS server in this map layer. Then page setup was done and was created a JPEG form of this map for the finalization.

3.7.5 Further analysis of processed image

The final maps were produced after all these functions had done. For calculating the Land Use land Cover Change (LULC), the final map of all years (2001, 2009, 2019) for two studied area (Moheshkhali and Kutubdia) were used and processed. Recorded LULC grid classified into 8 LULC classes for each studied year. All LULC classes were assessed separately for all maps. For having a change map score, all data was combined by using MS Excel. Statistical analysis with different graphs of different land classes had been done. The LULC class frequencies summarized in terms percent of total area for each mapped LULC class. The assessment results were then used to summarize the changes between the 2001–2019 LULC change maps.

3.8 Data Validation and Field validation

The processed data revalidate with the step by step process and checked for error minimization. For the field validation, Kutubdia was visited for recheck with the satellite data. Ancillary data such as data points obtained by handheld GPS, maps and aerial images and visual analysis were combined with the classification result to improve the precision of land cover mapping.

Ground truth data was obtained using handheld Global Positioning Systems (GPS) in February 2021 (GERMIN e Trex 10). With the coordinate of land classes of LULC map 2019, ground truthing data were matched which justify the significance of the study. Ancillary data such as data points obtained by handheld GPS, maps and visual analysis were combined with the classification result to improve the precision of land cover mapping of those individual composite images.

These have been checked by using GPS points of ground truth obtained by handheld GPS. Land use forms in Google Earth have been digitized and stored as GPX files. All GPX files were converted to shape files after digitization using ArcGIS 10.1 software. All form files were then projected into the projection of the WGS 1984 World Mercator.

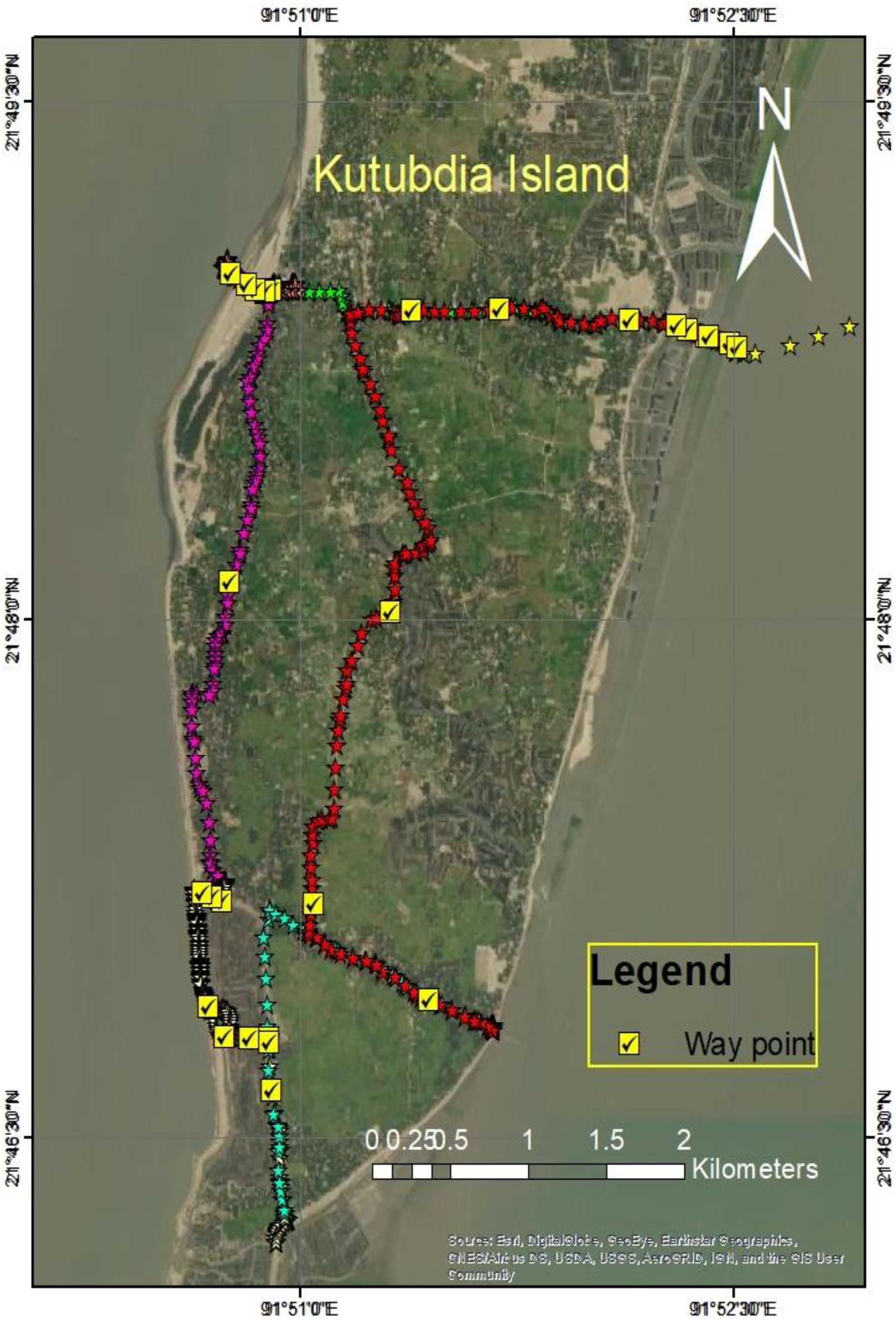

Figure 4 Ground trothing through the Kutubdia Island

CHAPTER FOUR

RESULTS

4.1 Unsupervised classification of Kutubdia and Moheshkhali

4.1.1 LULC change of Kutubdia Island

In all study years (2001, 2009, 2019), seven major land cover categories as waste land, plantations, aquaculture/ salt pan, mangrove forest, bare land, grass land, deciduous forest and permanent wetlands were found in Kutubdia Island. Land use land cover change maps of three years from 2001-2019 were represented in the fig. 5, 6, 7.

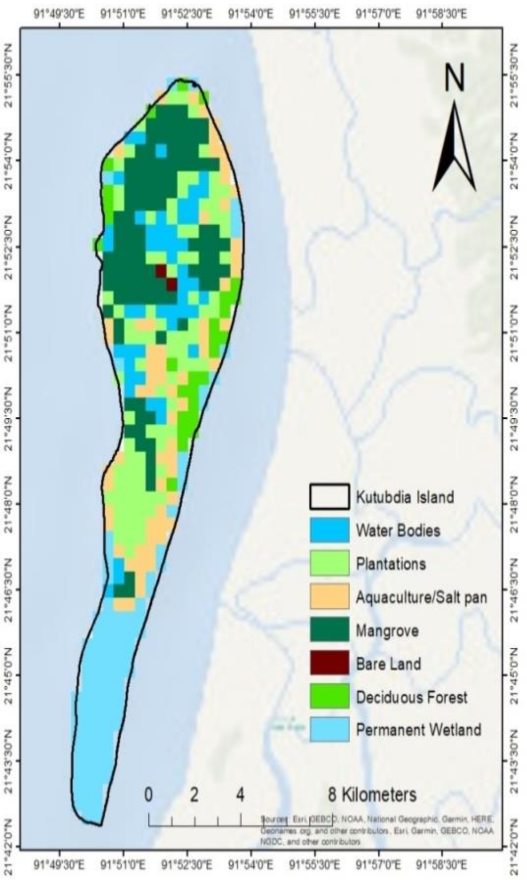

Figure 5 LULC of Kutubdia during 2001

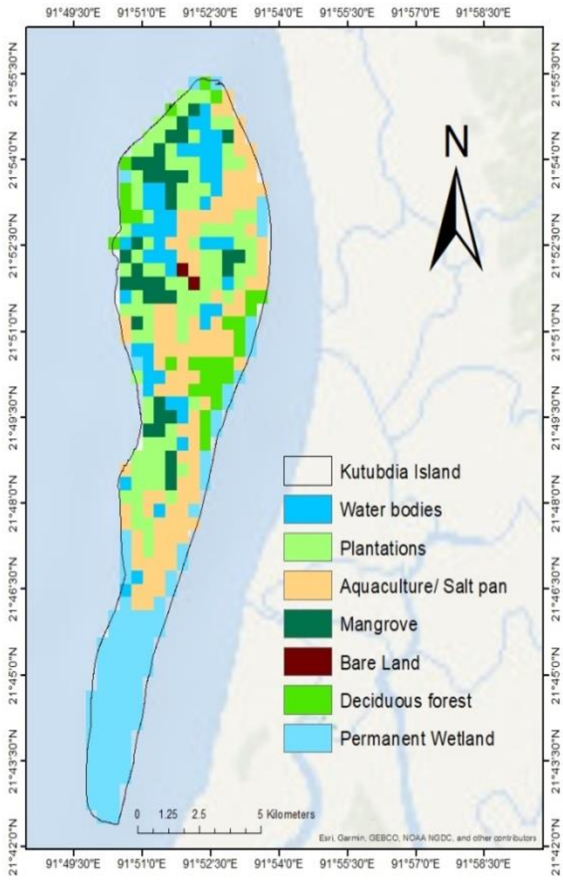

Figure 6 LULC of Kutubdia throughout 2009

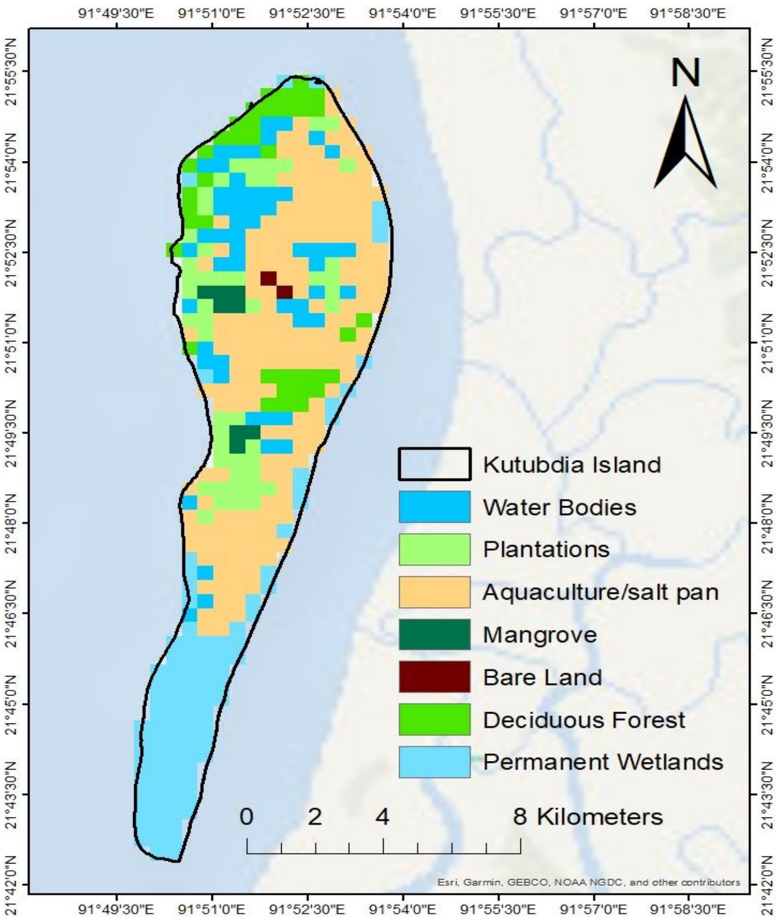

Figure 7 LULC of Kutubdia in 2019

The area of each land use/cover class of the 3 distinct categories are represented by the data reported in table.5 ,years 2001, 2009, 2019 and land classes are waste land, plantations, aquaculture, mangrove forest, salt pan, grass land, deciduous needle-leaf forest are included. Change analysis of whole time period in study area, gives information about changes of three different time periods. Percentages of area change are calculated with land mass without permanent wetland. Plantation area in 2019 is lowest among three years which was 10531511sq.meter (Table 5). Aquaculture has a great improvement through 20 years (Figure 8).

Table 5 Area (sq. meter) and percentage of Land use/ cover classes of different time period

Land Class of Kutubdia	2001		2009		2019	
	Area (sq. meter)	**%**	**Area (sq. meter)**	**%**	**Area (sq. meter)**	**%**
Water Bodies	10899874	**15%**	11771709	**16%**	11493763	**16%**
Plantations	19151422	**26%**	21001054	**29%**	10531511	**14%**
Aquaculture/ Salt pan	13965481	**19%**	25275056	**35%**	41485302	**56%**
Mangrove Forest	23029673	**31%**	7940755	**11%**	1648612	**2%**
Bare land	429318	**1%**	352124	**0%**	361627	**0%**
Deciduous Needle-leaf forest	6475541	**9%**	6571163	**9%**	8349687	**11%**

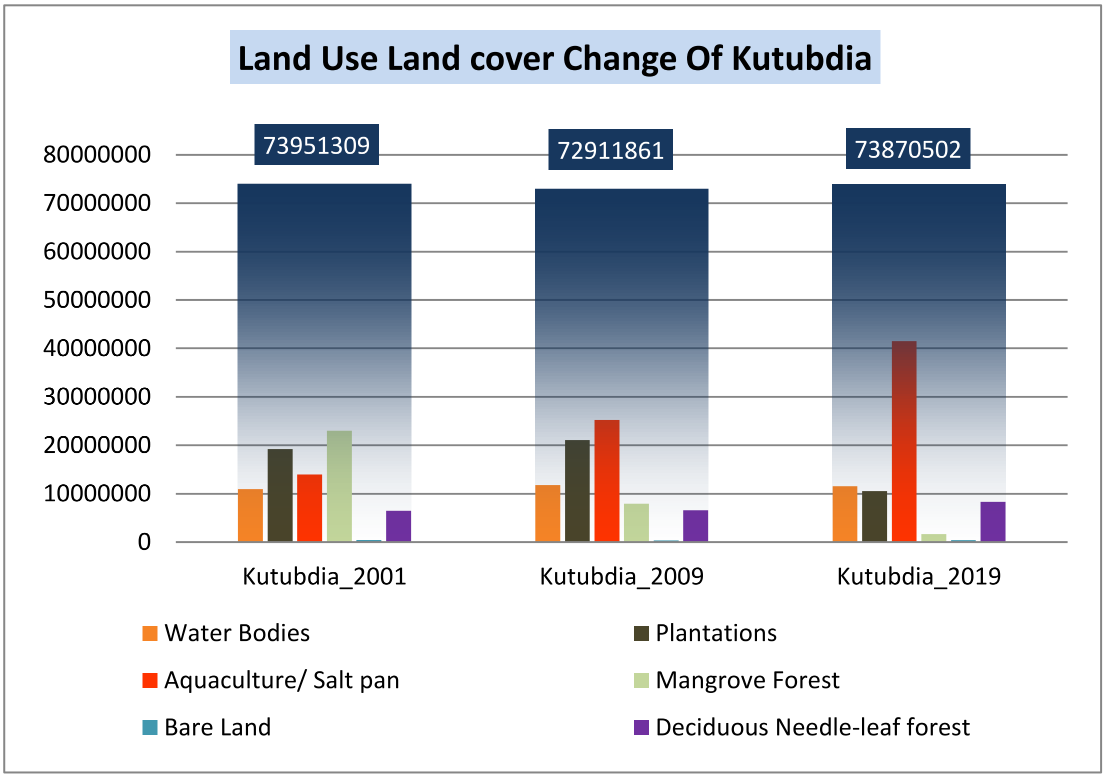

Figure 8 Distribution statuses of LULC classes in area (sq. meter) from 2001 to 2019

The Mosaic or Mekko Charts showed a change in the land class over the years 2001, 2009 and 2019 (Fig 9). Aquaculture percentage improves from 19% to 56% during the 20 years' time span (2001-2019). The land use and land cover change analysis of the whole duration of time in the field of research provides information on developments in three distinct periods of time.

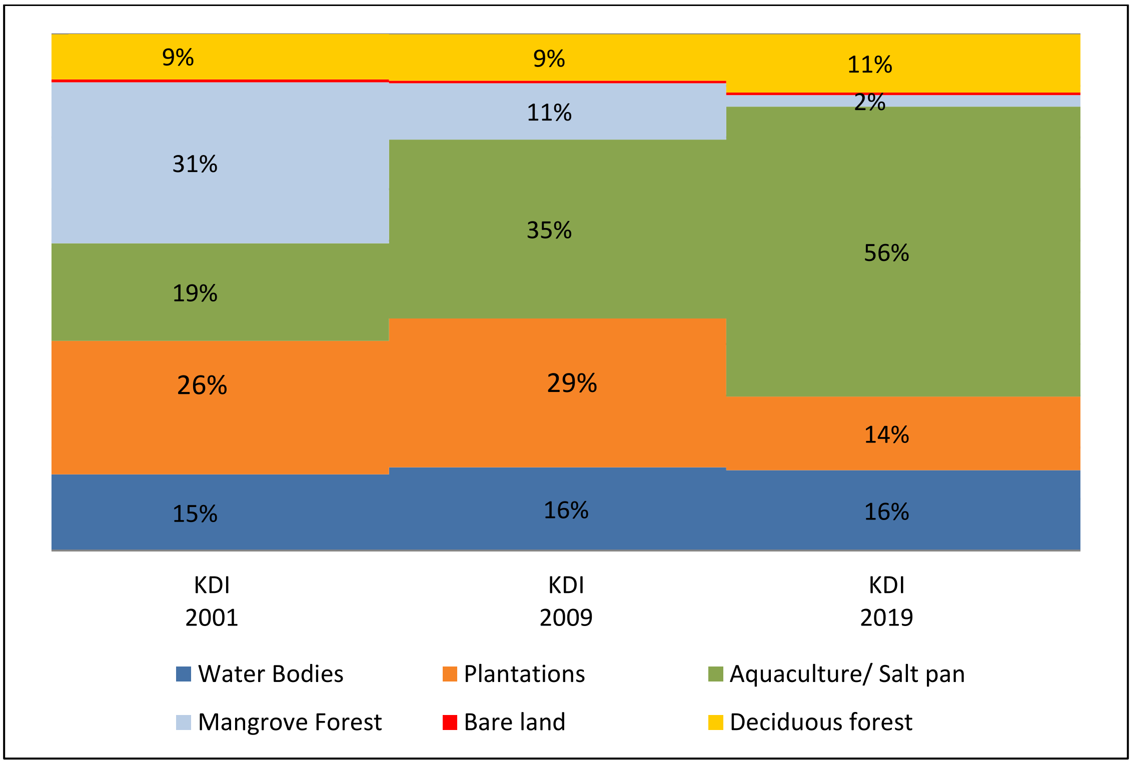

Figure 9 Mosaic or Mekko Charts showed consequence change of land class throughout years 2001, 2009, 2019

Net change analysis of Kutubdia was showed in table 5. 37.27% of aquaculture/salt pan was increase in Kutubdia from 2001 to 2019. Plantation and mangrove have a devastative decreasing trend through those years (figure 10).11.64% of plantation and 28.91% mangrove was decrease in Kutubdia (table 6).

Table 6 Net change analysis of Kutubdia within year 2001-2009, 2009 to 2019 and 2001 to 2019

Land Class in Kutubdia	2001-2009		2009-2019		2001-2019	
	Area (sq. meter)	%	Area (sq. meter)	%	Area (sq. meter)	%
Water Bodies	+871835	+1.41%	-277946	-0.59%	+593889	+0.82%
Plantations	+1849632	+2.91%	-10469543	-14.55%	-8619911	-11.64%
Aquaculture/ Salt pan	+11309575	+15.78%	+16210246	+21.49%	+27519821	+37.27%
Mangrove Forest	-15088918	-20.25%	-6292143	-8.66%	-21381061	-28.91%
Bare land	-77194	-0.10%	+9503	+0.01%	-67691	-0.09%
Deciduous forest	+95622	+0.01%	+1778524	+2.29%	+1874146	+2.30%

Note: (−) sign represents percentage of decreasing rate and (+) sign represents percentage of increasing rate

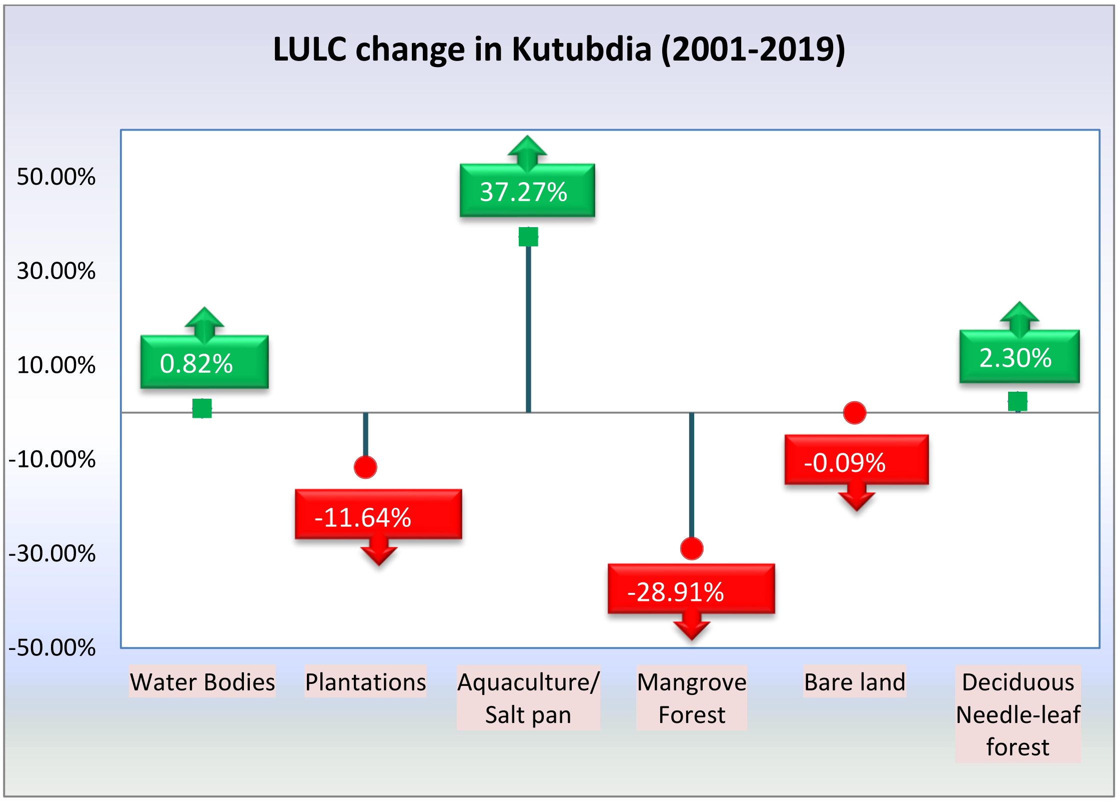

Figure 10 LULC trend of Change (%) with respect to 2001 in Kutubdia Island

The conversion of the land use/cover classes of one type to another and the net change matrix of various time periods, from 2001 to 2019 significant changes were occurred. Approximately 6802153.26 sq. meter area transfer into aquaculture land from mangrove forest area (Table.7). This matrix helps to understand the conversion of area among land classes. Overall 136.95 sq. km area interchange from one land class to another which provide a huge change in Kutubdia Island.

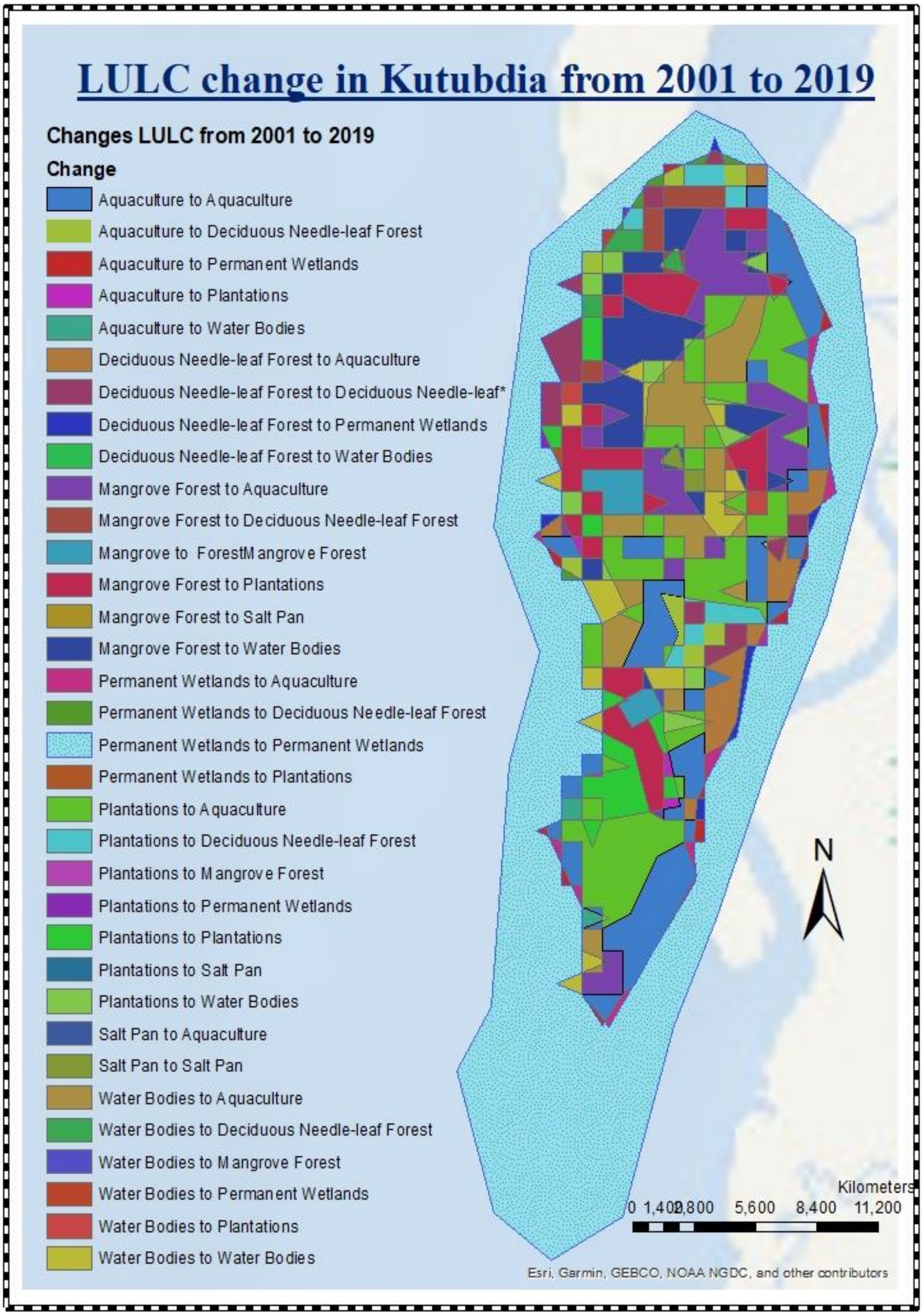

Figure 11 Land use conversion among classes

Table 7 Land use land cover change matrix with area (sq. m) between year 2001 and 2019

Land Class	Land Class 2019								
		Aquaculture/ Salt pan	**Deciduous Forest**	**Mangrove Forest**	**Permanent Wetlands**	**Plantations**	**Bare Land**	**Water Bodies**	**Grand Total**
Land Class 2001	**Aquaculture /Salt pan**	11208466.90	1493434.74	-	686714.70	224736.26	-	352123.55	13965476.16
	Deciduous Forest	3152012.60	2729533.20	-	589135.75	-	-	4858.13	6475539.68
	Mangrove Forest	6802153.26	1368855.65	1584100.13	-	6873135.81	6606.44	6394821.24	23029672.53
	Permanent Wetlands	982105.26	309597.67		61654447.23	53664.67			62999814.83
	Plantations	12643537.65	1744637.84	10847.15	76215.49	2896991.40	6606.44	1772581.49	19151417.45
	Bare land	80903.58	-	-	-	-	348413.77	-	429317.35
	Water Bodies	6616120.87	703626.80	53664.67	74104.29	482982.01	-	2969374.74	10899873.38
	Grand Total	**41485300.11**	**8349685.90**	**1648611.95**	**63080617.46**	**10531510.15**	**361626.66**	**11493759.16**	**136951111.39**

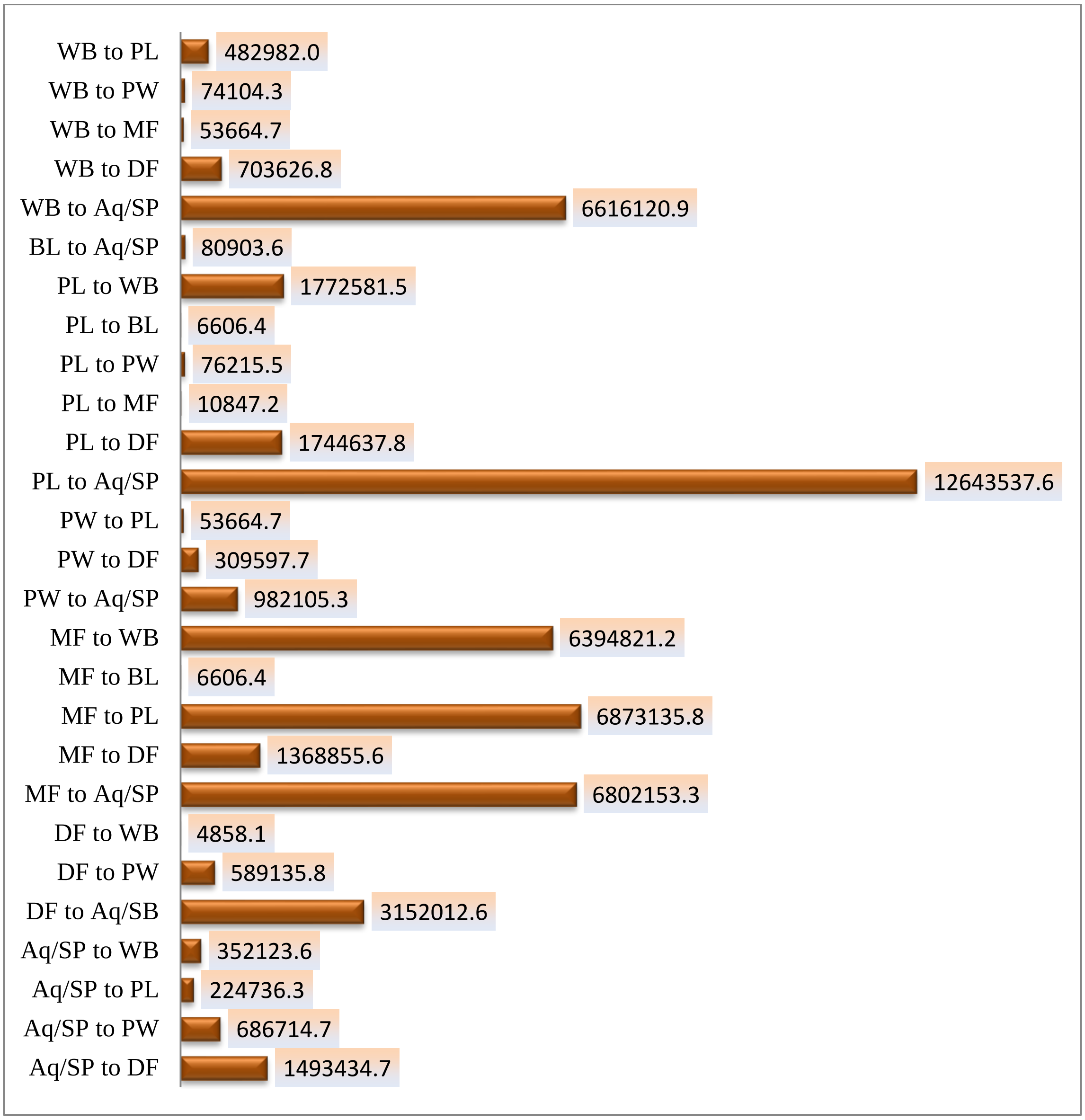

Figure 12 Conversion of area (km^2) from one land class to another from 2001 to 2019 in Kutubdia (Aq = Aquaculture, SP= Salt pan, DF= Deciduous forest, MF= Mangrove Forest, PW= Permanent Wetlands, Pl= Plantation, BL= Bare Land, WB= Water Bodies)

Correlation between Aquaculture and Mangrove Forest

There were two major land classes which contained a huge change through the time period from 2001-2019. Aquaculture increase 37.27% and mangrove forest decrease 28.91% within the last two decades. There had a trend of anti- proportional relation between aquaculture sites and mangrove forest area. Correlation between those land classes was -0.94 (Fig. 13) that means they are negatively correlated.

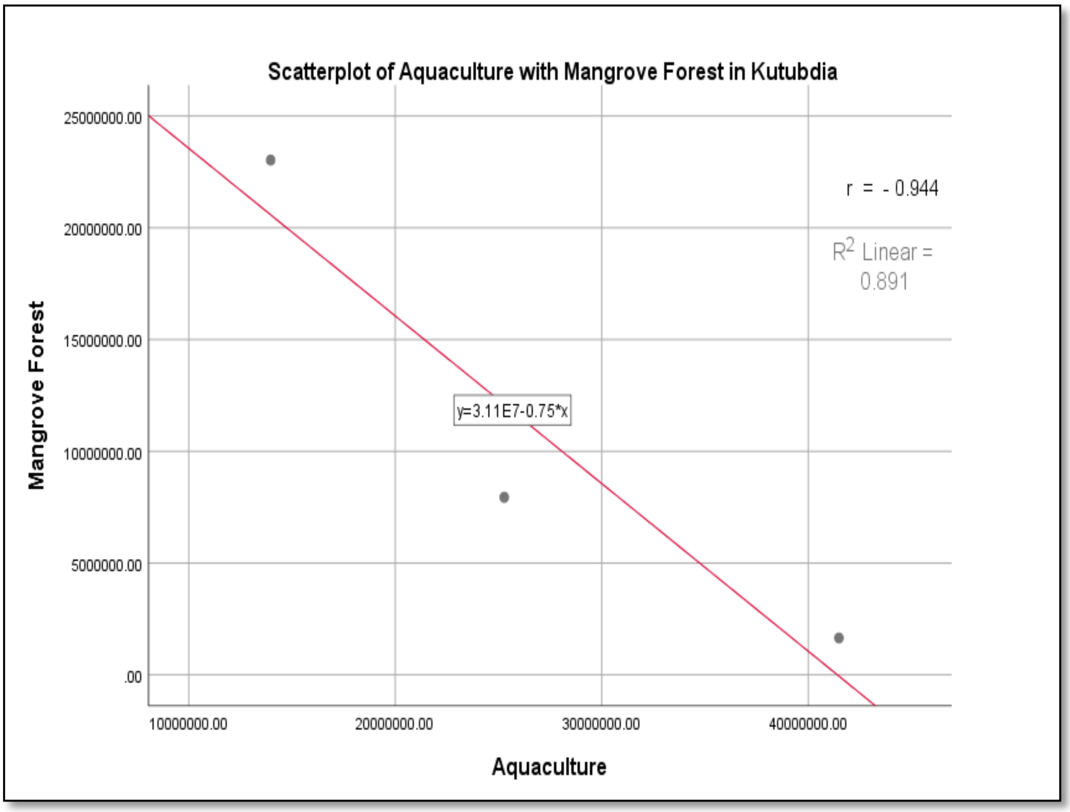

Figure 13 Scatterplot of Aquaculture with mangrove forest in Kutubdia

The result interpreted with the help of Pearson correlation coefficient and p value (Sig. 2- tailed). The significant value (0.214) is more than 0.05 that means null hypothesis is accepted and there is no significant correlation between Aquaculture and Mangrove Forest in Kutubdia.

Table 8 Correlation between mangrove forest and aquaculture in Kutubdia

Aquaculture	Correlations	
Mangrove Forest	r	P Value
	-.944	.214 > 0.05

4.1.2 LULC change of Moheshkhali Island

Eight major categories of land cover were identified in all study years (2001, 2009, and 2019) in Moheshkhali, which were bare land, water bodies, Plantations, aquaculture/salt pan, mangrove forest, grass land, deciduous forest and permanent wetlands. . Figure 14, 15, 16 displayed land use land cover change maps of different years in Moheshkhali.

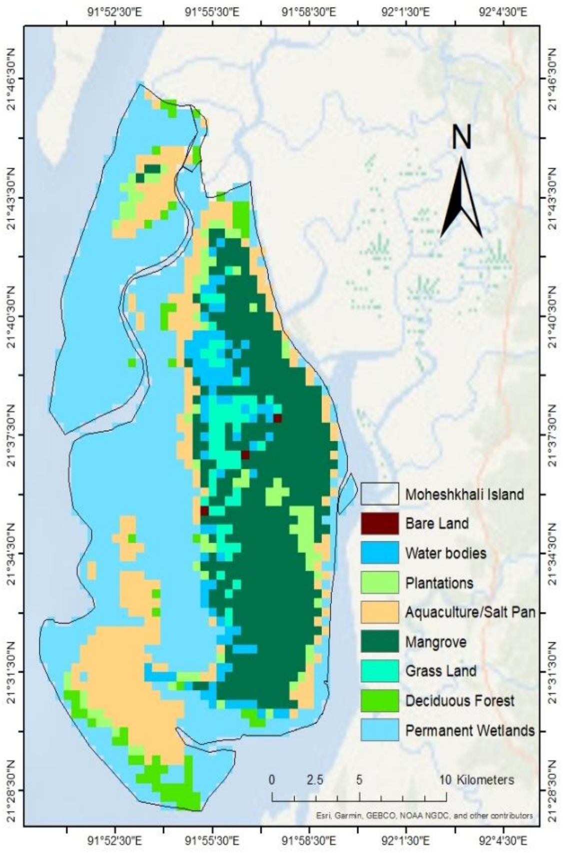

Figure 14 LULC map of Moheshkhali Island (2001)

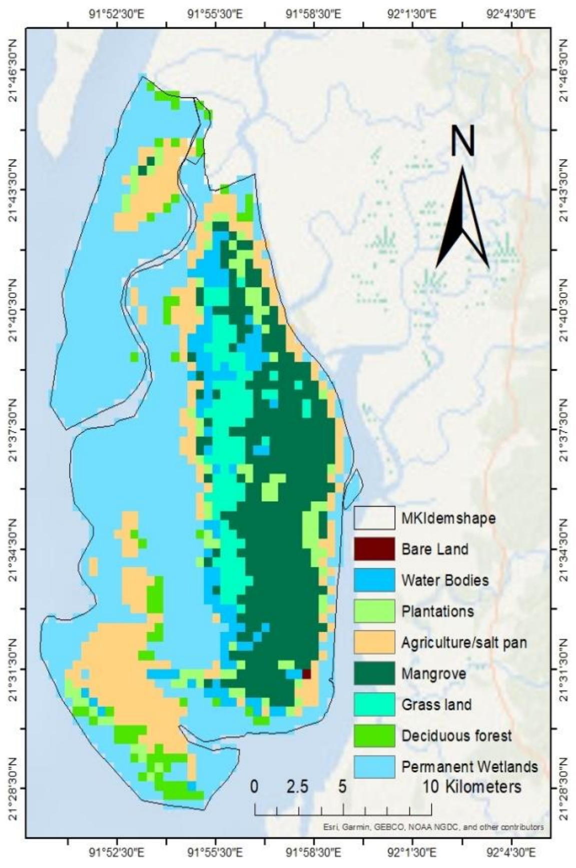

Figure 15 LULC map of Moheshkhali Island (2009)

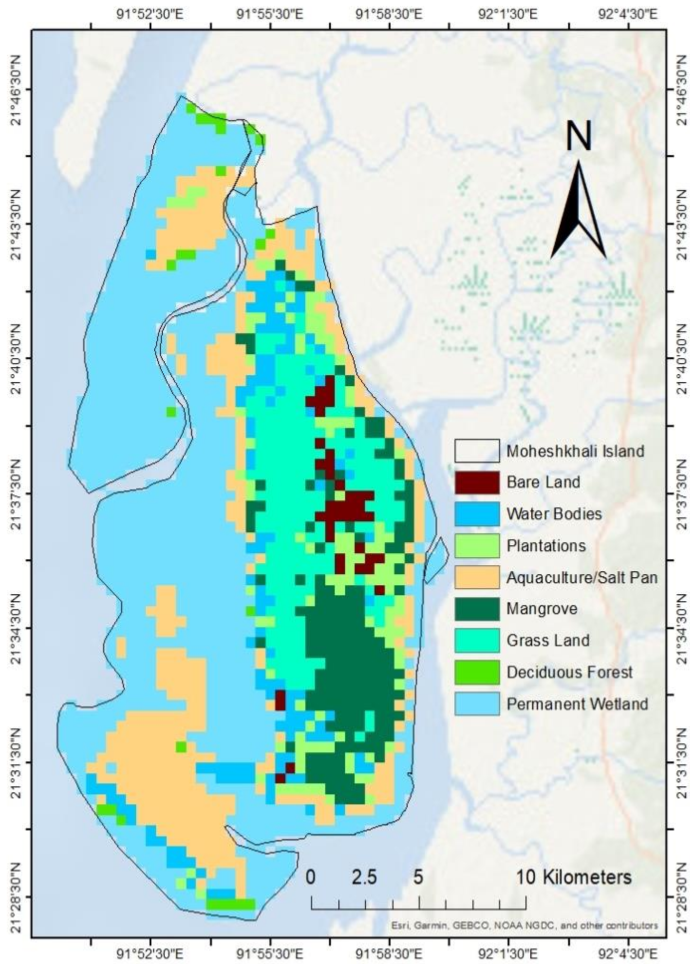

Figure 16 LULC map of Moheshkhali Island (2019)

The findings of Moheshkhali's land use/cover study were given in table 9. Change analysis of the whole time cycle in the field of research provides data on developments in three different time periods. The fig. 17 represents the change of different land class consequently. Land mass and the percentages of area change of this island were measured without permanent wetland. In this analysis. the part of the Bay of Bengal that is not included in the Moheshkhali land area is considered as the permanent wetland area.

Table 9 Area (sq. meter) and percentage of Land use/ cover classes of different time period in Moheshkhali Island

Land Class in Moheshkhali	2001		2009		2019	
	Area (sq. meter)	%	Area (sq. meter)	%	Area (sq. meter)	%
Bare Land	643977	0%	214659	0%	8091677	3%
Water Bodies	18382669	8%	22879095	10%	27359484	12%
Plantations	17766608	8%	20238883	9%	24151994	10%
Aquaculture/ Salt pan	68616205	29%	67070775	29%	77494140	33%
Mangrove Forest	101418583	43%	82866843	36%	39772081	17%
Grass land	23986663	6%	23986663	10%	50106318	22%
Deciduous forest	15571428	6%	15571428	7%	5730556	2%

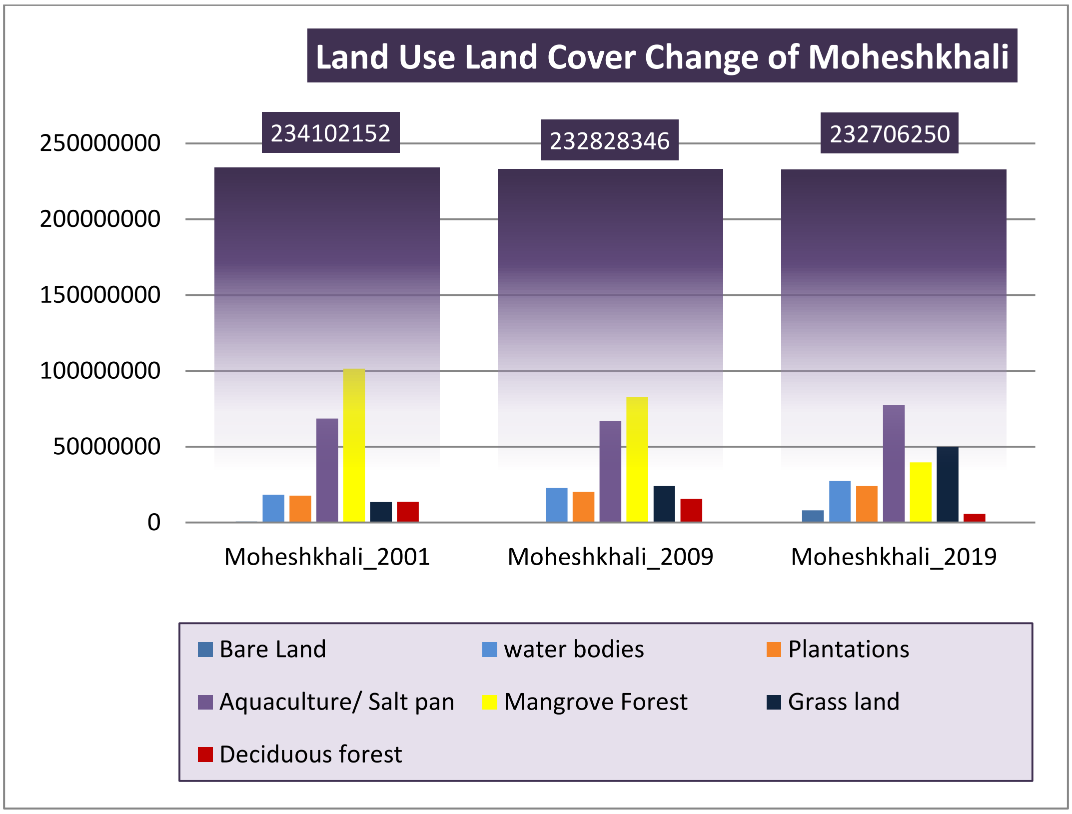

Figure 17 Distribution statuses of LULC classes in area (sq. meter) from 2001 to 2019

A changing trend in the land class over the years 2001, 2009 and 2019 was seen in the Mosaic or Mekko Charts (Fig 18). Water bodies and plantation has no distinct change, but there was a considerable amount of diversion in aquaculture. It has evolved regularly over the last two decades. The percentage of aquaculture would rise from 29% to 35% (Fig. 18). In this research, change analysis of the entire period of time offers information on changes over three distinct periods of time. The area which has been increased or decreased within the land class indicated in the table 10.

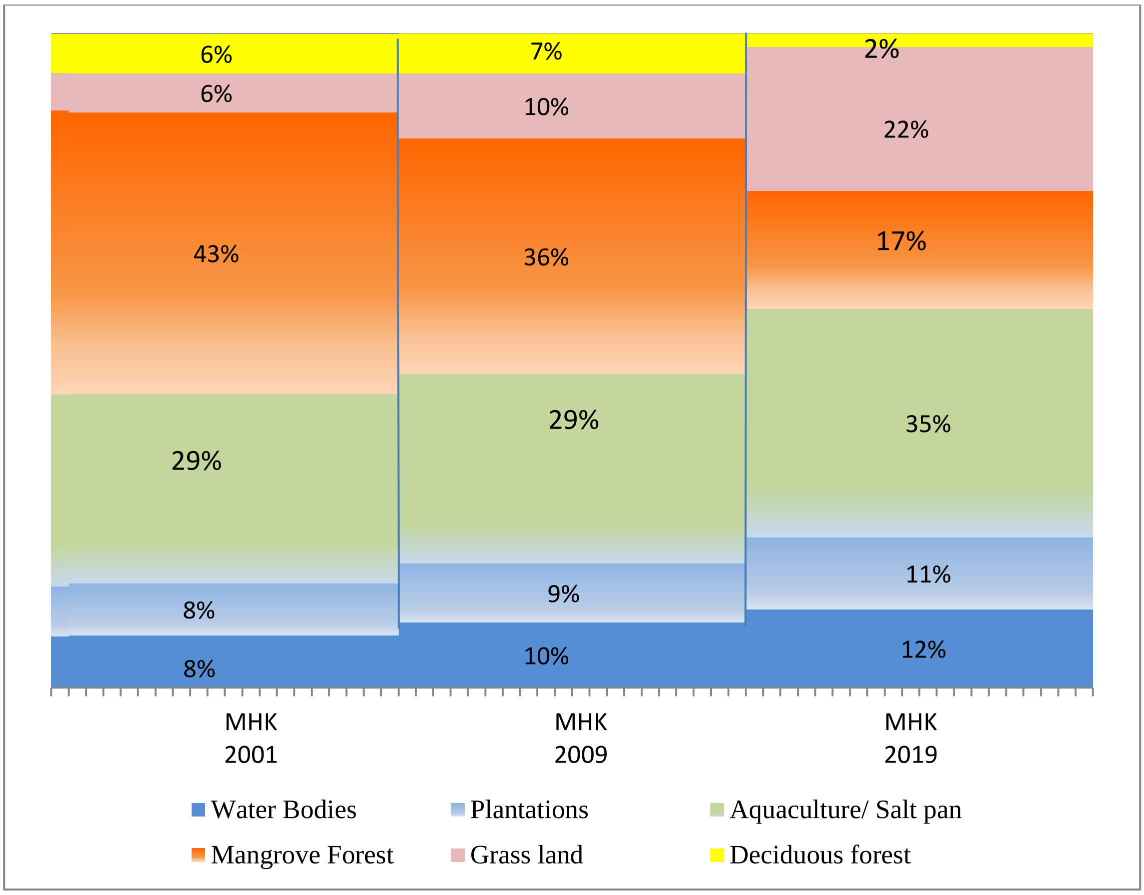

Figure 18 Mosaic or Mekko Charts showed consequence change of land class throughout years 2001, 2009, 2019 in Moheshkhali

Table 10 Net change analysis of Moheshkhali within year 2001-2009, 2009 to 2019 and 2001 to 2019

Land Class in Moheshkhali	**2001-2009**		**2009-2019**		**2001-2019**	
	Area (sq. meter)	**%**	**Area (sq. meter)**	**%**	**Area (sq. meter)**	**%**
Bare Land	-429318	-0.18%	+7877018	+3.39%	+7447700	+3.20%
water bodies	+4496426	+1.97%	+4480389	+1.93%	+8976815	+3.90%
Plantations	+2472275	+1.10%	+3913111	+1.69%	+6385386	+2.79%
Aquaculture/ Salt pan	-1545430	-0.50%	+10423365	+4.49%	+8877935	+3.99%
Mangrove Forest	-18551740	-7.73%	-43094762	-18.50%	-61646502	-26.23%
Grass land	+10530634	+4.55%	+26119655	+11.23%	+36650289	+15.78%
Deciduous Needle-leaf forest	+1753347	+0.79%	-9840872	-4.23%	-8087525	-3.44%

Note: (−) sign represents percentage of decreasing rate and (+) sign represents percentage of increasing rate

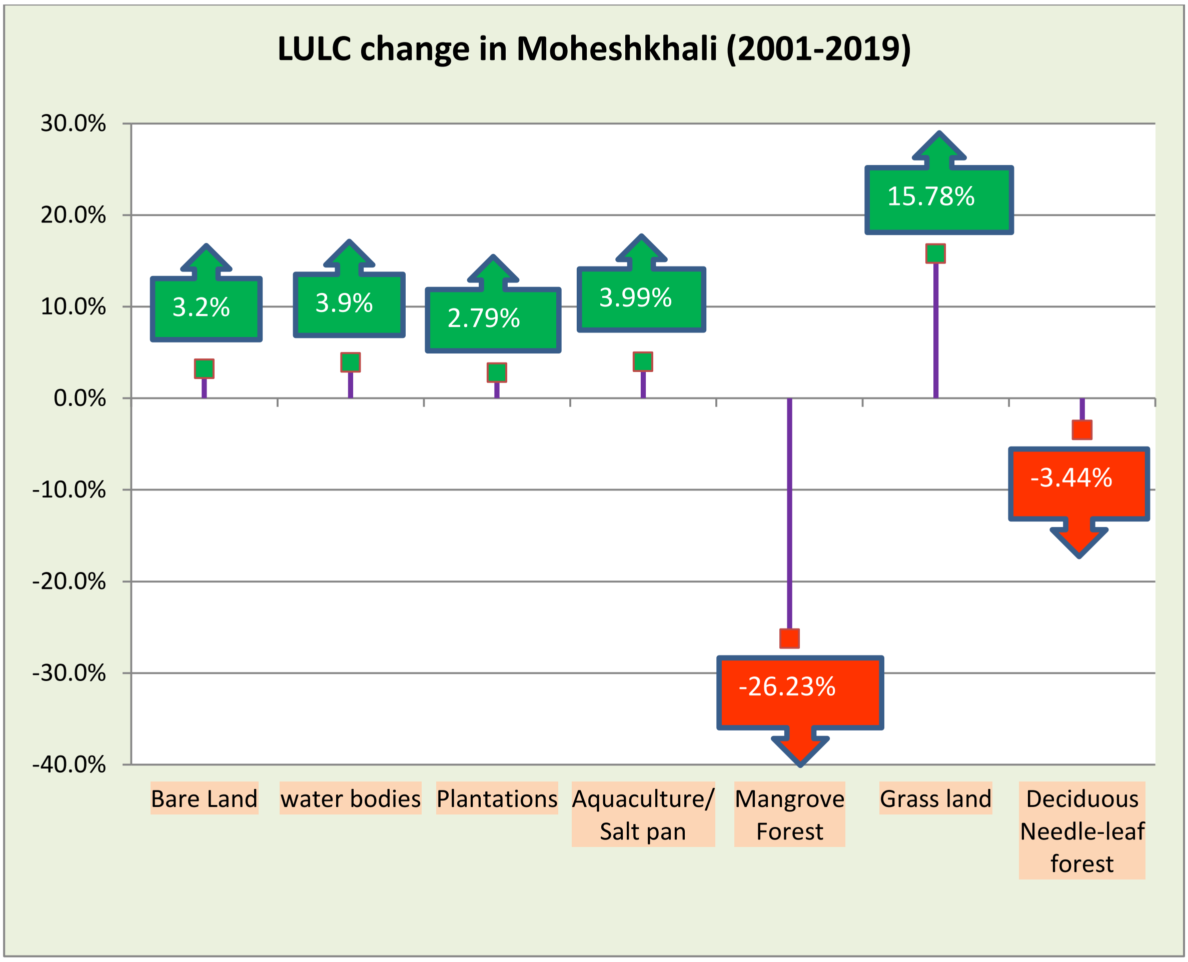

Figure 19 LULC Change (%) with respect to 2001 in Moheshkhali

Table 11 represented the transfer of one type to another of the land use/cover groups and the net change matrix of different time periods. There was a significant amount of transition from 2001 to 2019. Approximately 6802153.26 sq. meter of mangrove transfer into aquaculture/salt pan. The matrix helps to explain the transfer of land between classes of land. 136951111.39 sq. meters in total. Interchange of area from one land class to another, which provides Moheshkhali Island with a significant change.

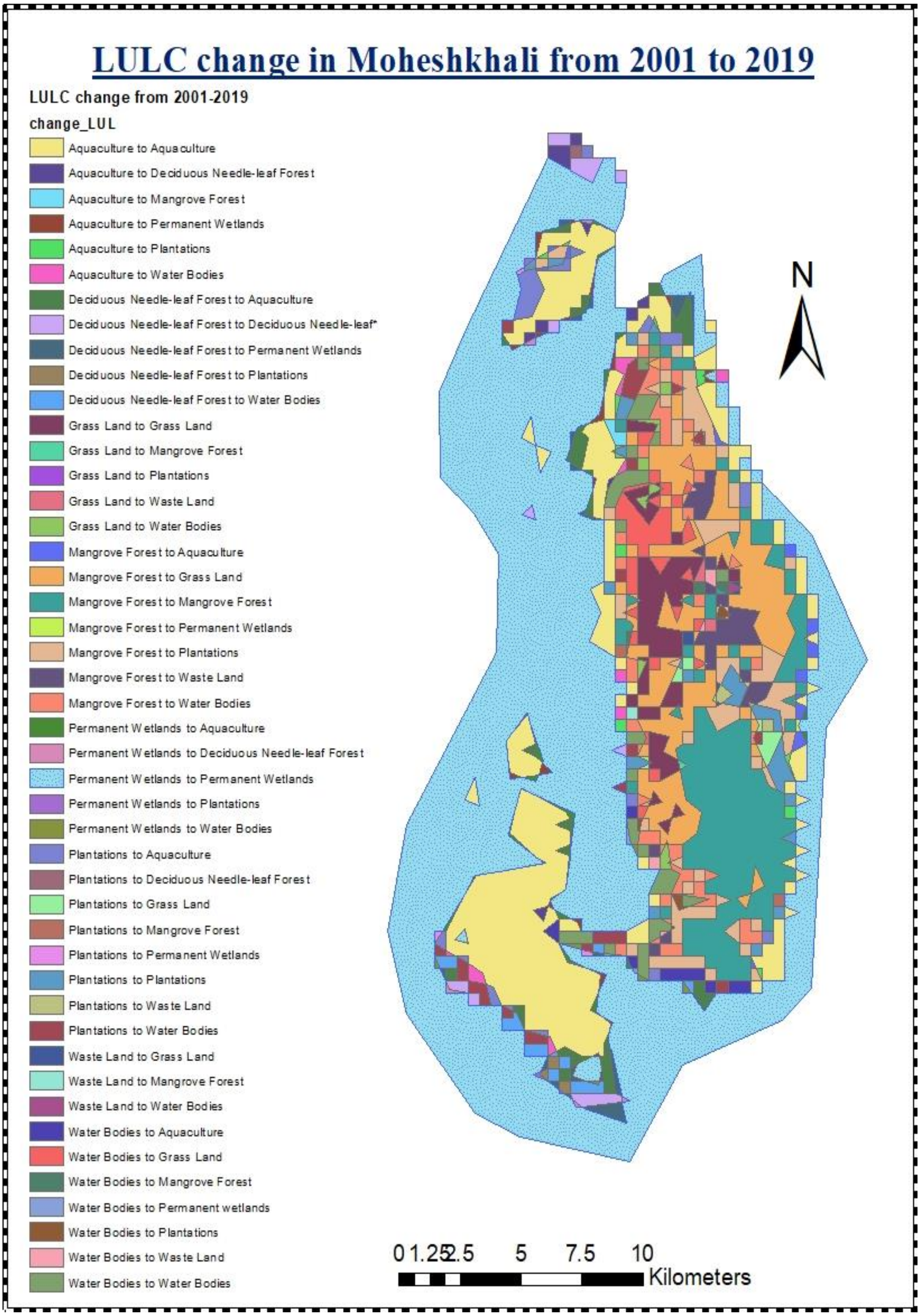

Figure 20 Land use land cover change analysis of Moheshkhali from 2001 to 2019

Table 11 Land use land cover change matrix with area (sq. meter) between year 2001 and 2019 land classes

	Land Class	Land Class-2019								
		Aquaculture/ salt pan	**Forest**	**Grass Land**	**Mangrove Forest**	**Permanent Wetlands**	**Plantations**	**Waste Land**	**Water Bodies**	**Grand Total**
Land Class-2001	**Aquaculture /Salt pan**	61895827.9	1836714.1	-	442530.2	1356487.0	1270341.5	-	1760635.0	68562535.7
	Deciduous Needle-leaf Forest	4930943.6	3344390.7	-	-	2473025.3	500282.1	-	2569437.5	13818079.2
	Grass Land	-	-	11623217.6	72115.0	-	9631.0	429317.3	1321745.2	13456026.2
	Mangrove Forest	1834183.3	-	29794506.4	38158714.9	93487.4	16128874.1	6539547.0	8869268.7	101418581.8
	Permanent Wetlands	2069026.6	281126.3	-	-	22302980.4	147210.7	-	394837.4	22592201.4
	Plantations	4530040.3	214658.7	1370207.7	429317.3	203443.1	5697933.0	494342.9	4826662.7	17766605.7
	Waste Land	-	-	298458.8	214658.7	-	-	-	130858.5	643976.0
	Water	2234	-	7019	4547	1616	3977	628	7486	1838

	Bodies	114.3		927.7	39.7	65.5	15.3	467.9	033.3	2663.7
	Grand Total	**77494136.0**	**5676889.7**	**50106318.2**	**39772075.8**	**227317908.8**	**24151987.8**	**8091675.1**	**27359478.2**	**459970469.6**

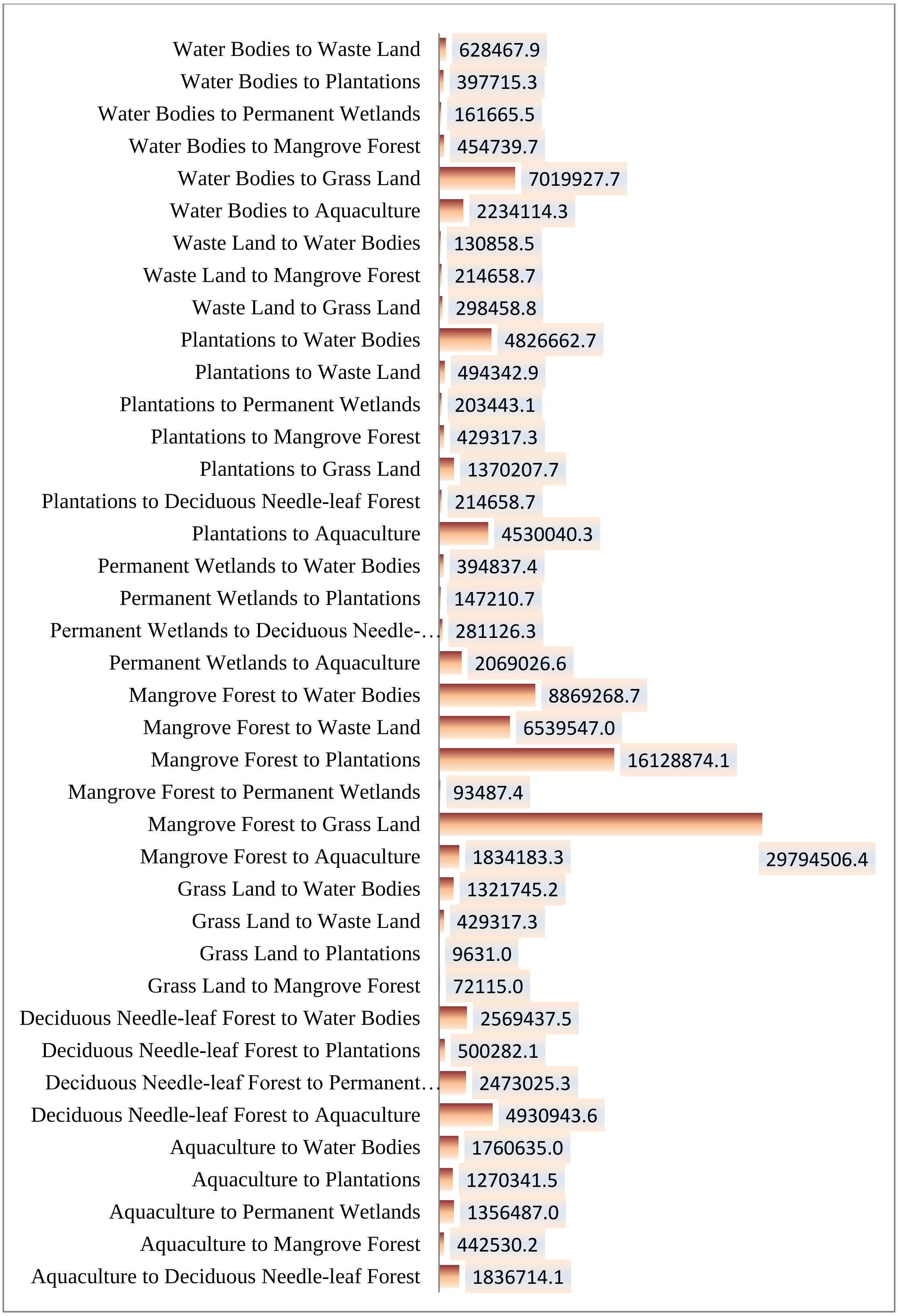

Figure 21 Changed areas (m^2) of LULC among land classes in Moheshkhali

Correlation between Aquaculture and Mangrove Forest

Throughout the time span, there were two main land groups containing a significant change. In the last two decades, aquaculture has increased by 3.99% and mangrove forests have decreased by 26.23% (Fig. 22). The pattern of an anti-proportional relationship between them is present. The correlation value (r) between those types of land was -0.91 (Table 5). This value implies that, they are associated negatively with each other. But at the moment of significance, no relationship of significance was identified between them.

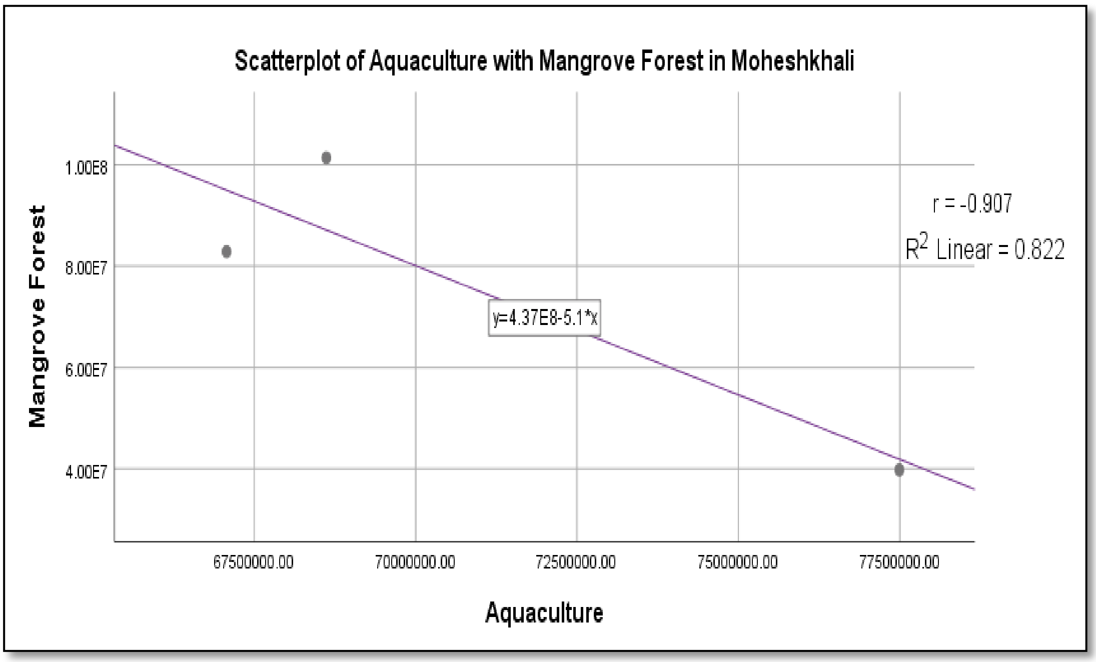

Figure 22 Scatterplot of aquaculture with mangrove forest in Moheshkhali

The result interpreted with the help of Pearson correlation coefficient and p value (Sig. 2- tailed).The significant value (0.277) is more than 0.05 that means null hypothesis is accepted and there is no significant correlation between Aquaculture and Mangrove Forest in Moheshkhali.

Table 12 Correlation between mangrove forest and aquaculture in Moheshkhali

Aquaculture	Correlations	
Mangrove Forest	r	P Value
	-.907	.277 > 0.05

4.1.3 Parallelism among land classes of Kutubdia and Moheshkhali

- **Aquaculture /Salt pan**

A comparative study between Kutubdia and Moheshkhali Island on the basis of increasing aquaculture rate was done during this study. In Kutubdia increasing rate of aquaculture was more frequent than the rate in Moheshkhali. From 19% to 56% promotion provide data about the growth rate of aquaculture in Kutubdia. On the other hand, Moheshkhali contain a good amount of increasing rate of aquaculture but it was lower than the Kutubdia (Fig. 23).

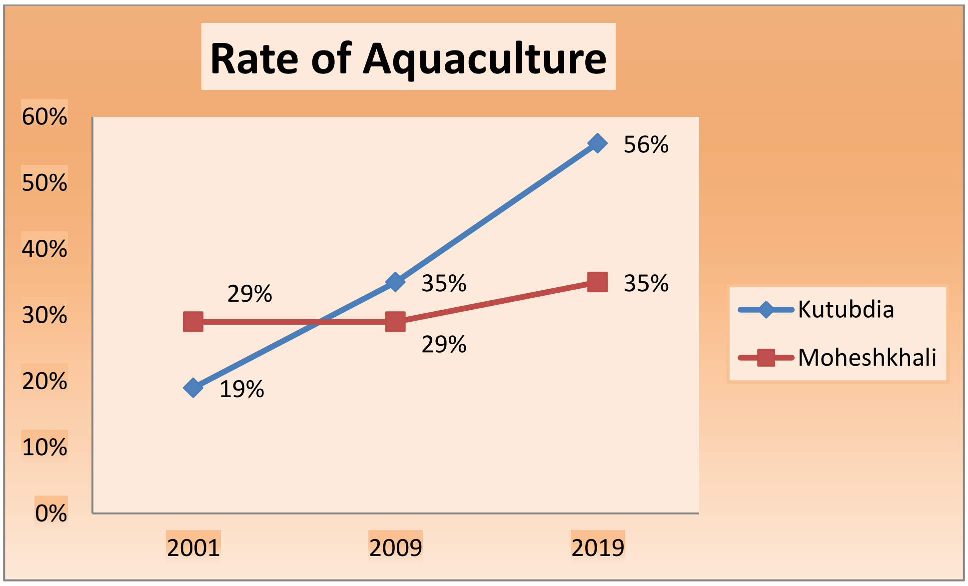

Figure 23 Rate of aquaculture in Moheshkhali and Kutubdia for year 2001, 2009 and 2019

- **Plantations**

Plantation is a major land class for two study areas. Because the changing rate of plantations in Kutubdia had a great significance. In first decade, plantation rate in both study area moreover similar in trends, but in last decade, from 2009 to 2019, a huge change was occurred. The percentage decreased from 29% to 14% in Kutubdia. In contrast, Moheshkhali Island didn't have such kind of changing pattern. Moreover, it had a positive change and increased level of plantation in last decade (Fig. 24).

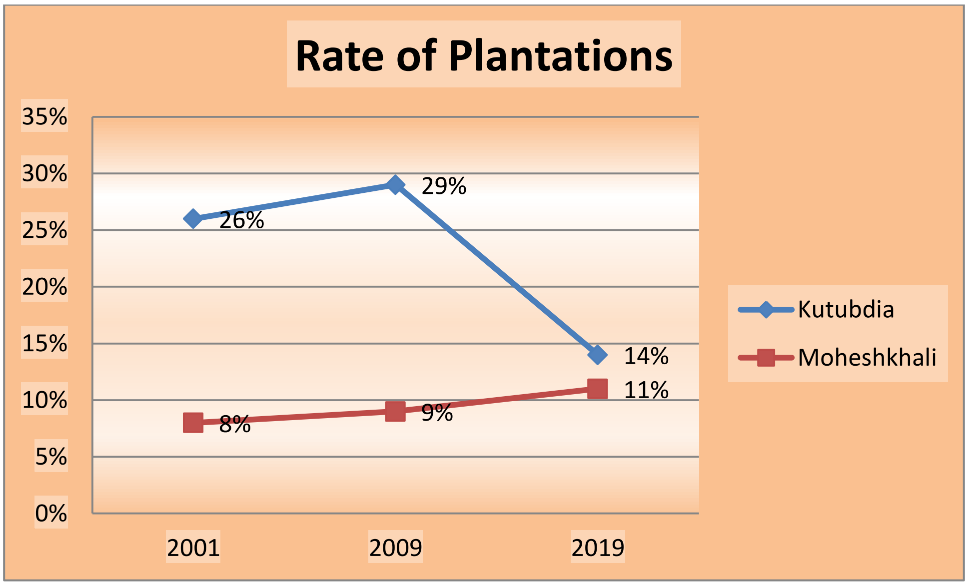

Figure 24 Rate of plantations in Moheshkhali and Kutubdia for year 2001, 2009 and 2019

- **Mangrove Forest**

As a coastal island, mangrove forests have a great significance in Kutubdia and Moheshkhali. But, the rate of mangrove forest in both study areas were in decreasing trends. In Kutubdia, percentage of mangrove forest comparatively lower than the Moheskhali Island. In 2019 this turn into 2% which can be a great threat for ecosystem of this cyclone prone erodible island (Fig. 25).

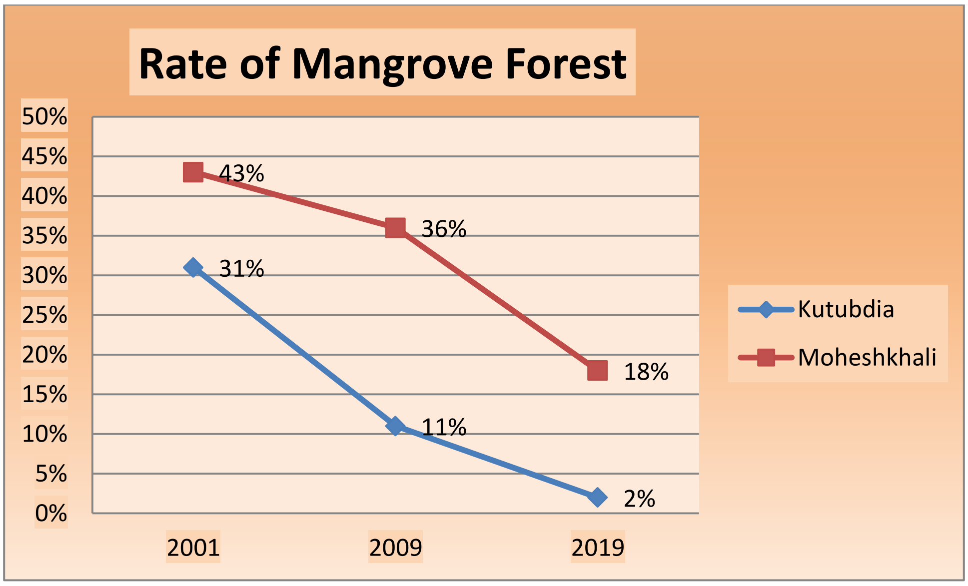

Figure 25 Rate of Mangrove Forest in Moheshkhali and Kutubdia for year 2001, 2009, 2019

4.2 Supervised Classification of Kutubdia and Moheshkhali Island

Different land class was found after ground truthing and GPS data collection of different area.Land classes as salt pan , mangrove,plantation and crop land hed abundant in this area. With supervised classification of those area ,maps of different years showed a distinct change in Kutubdia and Moheshkhali.Salt pan incrase rate was so heavy which dominated in the north-eastern side of Kutubdia and north-wester side of Moheshkhali. Plantation and cropland was decreased for salt production and urbanization in those area.

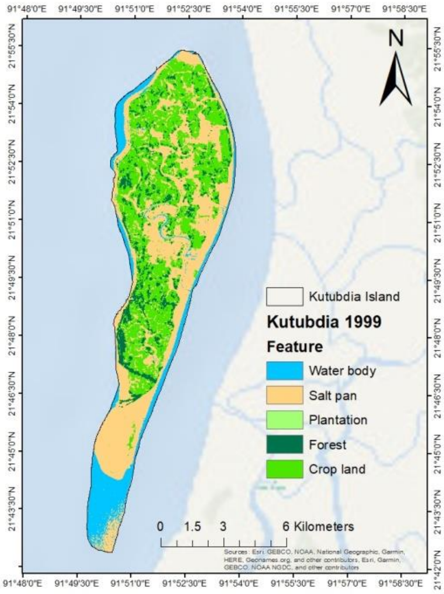

Figure 26 LULC map of Kutubdia (year 1999)

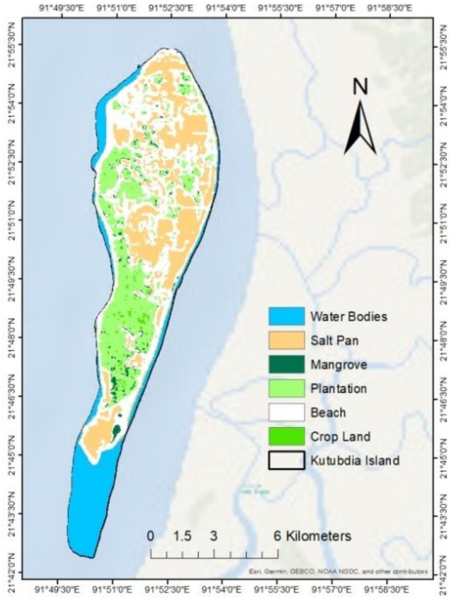

Figure 27 LULC map of Kutubdia (year 2019)

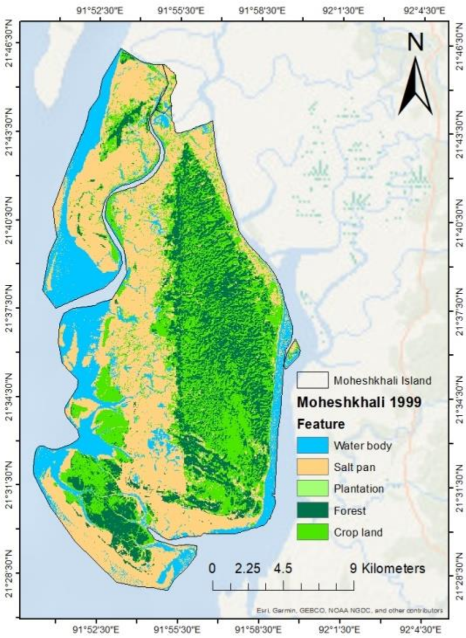

Figure 28 LULC map of Moheshkhali (year 1999)

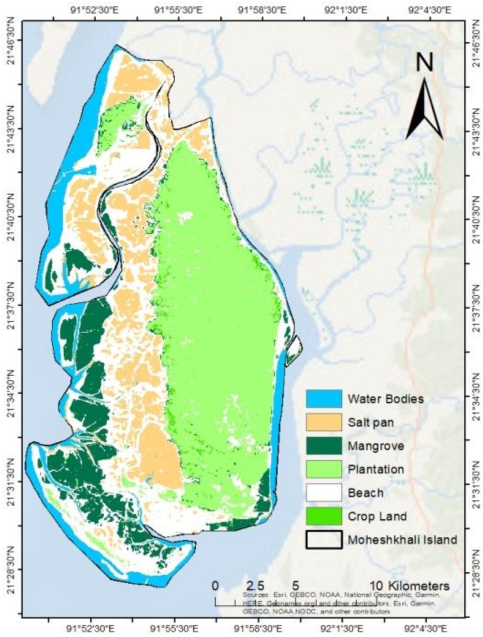

Figure 29 LULC map of Moheshkhali (year 2019)

CHAPTER FIVE

DISCUSSION

Improvements in the use and accessibility of environmental data derived from multi-temporal satellites or other thematic raster data have led to the use of environmental modeling. Remote sensing delivers synoptic information in near real-time on vegetation growth conditions over a wide geographic area. Satellite imagery of the years 2001, 2009 and 2019 are analyzed by using remote sensing analysis together with GIS modeling. Over the 20 years of study period, Kutubdia and Moheshkhali Island are experiencing a major change in land use land cover pattern. This study indicates important changes in mangrove forest and aquaculture /salt pan. These two land features demonstrate an anti-proportional change relationship. In 2012, about 25 km^2 of land was used for salt farming, which is about 37 percent of the Kutubdia Island. From 1972 to 2013, much cultivable land has been converted to salt farms that are used for producing salt (Munshi *et. al*., 2017).

This research described, the conversion pressure was mainly on mangroves between 2001 and 2009 as it shows the maximum loss. However, in the case of 2009-2019, the land cover was shifted to the plantation, as nearly much of the mangrove forest had already been converted to aquaculture/ salt pan. It is estimated that presently about 56%, more than half area of Kutubdia, used for aquaculture/salt pan. 31% of mangrove forest turns into 2% with this high changing pressure within these 19 years. The water bodies, salt pan, deciduous needle leaf forest probably have in the same percentage over those years. Changing trend dominated by mangrove forest, aquaculture and plantation in Kutubdia Island. Aquaculture increase 37.27% in this island and 28.91% decreasing rate was found for mangrove forest. 11.64% plantations keep a significant change trend within those time range. About 41485300.11 sq. meter area are transferred into aquaculture from other land classes through this time.

A large portion of the mangrove forest on Moheshkhali Island was definitely lost and the farming of shrimp dominated those portions (Islam and Murshed, 2011). With this sequence, the conversion pressure was primarily on the mangrove in Moheshkhali from 2001 to 2019, as it shows the highest loss. Mangrove forest were 43% which were about half of the overall area in 2001. But in 2019, 26.23% mangrove forest was decrease in the land cover. On the other hand, grass land and aquaculture rate, plantation, water bodies were improving from 2001 to 2019. About 41485300.11sq meter area contained by aquaculture in 2019, is a great amount for Moheshkhali. But there is not significant relationship between mangrove forest and aquaculture.

There are similarities for both areas in case of aquaculture improving rate. In Kutubdia it increases 19% to 56% and in Moheshkhali 29% to 35%. Increasing rate is relatively high in Kutubdia in this case for aquaculture. On the side of plantations, Moheshkhali have a relatively good view to with improving rate but in Kutubdia have a loss of plantations in last decade. It turns 14% from 29%. There is a worse situation for mangrove forest in both places. For Kutubdia in decrease from 31% to 2% and for Moheshkhali, it became 18% from 43%.

The availability of spatial data is increasingly growing with advances in remote sensing, tracking networks, and geographic information systems (GIS). These geospatial data include not only land use and land cover (LULC) maps and locations, but also several data attributes, such as socio-economic census data. The growth pattern of vegetation is calculated using the Normalized Difference Vegetation Index (NDVI) based on the reflectance of the visible (red) (VIS) and near-infrared (NIR) bands derived from the most commonly used NDVI global data sets.

It has several classification methods. There are different kinds of LULC components, such as salt pan, Mangrove, grass land, plantations, forest land, and many more. There are large applications for LULC maps, such as natural resource management, GIS input baseline mapping, tax and property assessment legal limits, and many more. Without the assistance of other geospatial datasets, LULC mapping is not possible.

To evaluate and manage the proper land planning for the assessment and management of the up-to-date information on different land classes of Kutubdia and Moheshkhali Island, it is important to run very construction research, improvement of local socio-economic problems, evaluation of different environmental and biodiversity impacts. Anthropogenic behaviors and, to a certain degree, few natural phenomena are from 1971 to 2009, the major controlling factors for physical and environmental changes in the different land classes of this region (Islam and Murshed, 2011).

Rapid invasions of the salt field into the mangrove forest area are reducing the environment balance. In the near future, due to the implementation of the deep sea port near Sonadia, the rest of the mangrove forest may also be affected. The government should be responsible for encouraging farming practices for local citizens to conserve the remaining cultivable lands. Local citizens and local authorities should have a crucial role to play in stopping these criminal activities, and proper regulatory legislation and mitigation measures for the conservation of hill forests should be enforced.

CHAPTER SIX

CONCLUSION

Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements of the environment within a specific time period, based on validated empirical and statistical methods of analysis of relevant source materials. The present research, using remote sensing data together with GIS modeling, demonstrated the changes in spatial and temporal land cover over a period of twenty years. The forests, salt fields, grass land and mangrove forests were significant land groups that have evolved over twenty years have changed individually. The research acknowledges the pattern of recent land transformation from 2001-2019. This research is an attempt to understand the dynamics of changes in LULC occurring along the islands of Kutubdia and Moheshkhali. It can be seen through the LULC maps that these regions cover vulnerable mangrove, plantation etc. Therefore, potential environmental deterioration along these coasts may interfere with the normal functioning of the environment. Due to the high percentage of land use change, the outcome is not a good one for those regions. The mangrove forest's decreasing trend can be a significant threat to those areas. Though this study has shown a certain increase in grass land and plantation in Moheshkhali and deciduous needle leaf forest in Kutubdia, the conversion from mangrove forest to aquaculture is still very high. So, there still remain a significant imbalance between the plantation and the area of aquaculture. It is therefore suggested that improved remote sensing (high resolution data) and GIS tools, accompanied by field surveys and numerical modeling, might provide a better understanding of these regions in order to develop a sound strategy for the conservation and restoration of these natural systems. To maintain and restore the natural balance between mangrove forest and the aquaculture, a long-term development plan should be adopted.

RECOMMENDATIONS

The availability of spatial data is increasingly growing with advances in remote sensing, tracking networks, and geographic information systems (GIS). These geospatial data include not only land use and land cover (LULC) maps and locations, but also several data attributes, such as socio-economic census data.

A society's growth depends entirely on its social and economic progress. This is the fundamental explanation why socio-economic surveys are performed. Both spatial and non-spatial databases are part of this type of survey.

On the one hand, this type of knowledge allows a greater understanding of the aspects of land utilization and, on the other, plays an important role in the implementation of the policies and programs needed for development planning. In order to ensure sustainable development, the ongoing land use/land cover pattern process must be monitored over a period of time. This needs the area's present and past land use/land cover data.

LULC maps also allow us to analyze the changes in our ecosystem and climate that are occurring. If we have an inch by inch of the study unit's Land Use/Land Cover information, we can develop policies and launch programs to save our world.

LIMITATIONS

1. Seasonal variation is an important factor in land use in an area. Though there is salt pan in dry season in Kutubdia and Moheshkhali, there is flood land in monsoon.
2. For having such factors as like as cloud, heavy rain, any other error in satellite, satellite image may not be clear.
3. The accuracy of GPS is influenced by a number of factors such as the positions of the satellites in the sky, atmospheric effects, satellite clock errors etc. These factors can’t be controlled by us.

CHAPTER SEVEN

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APPENDIX A

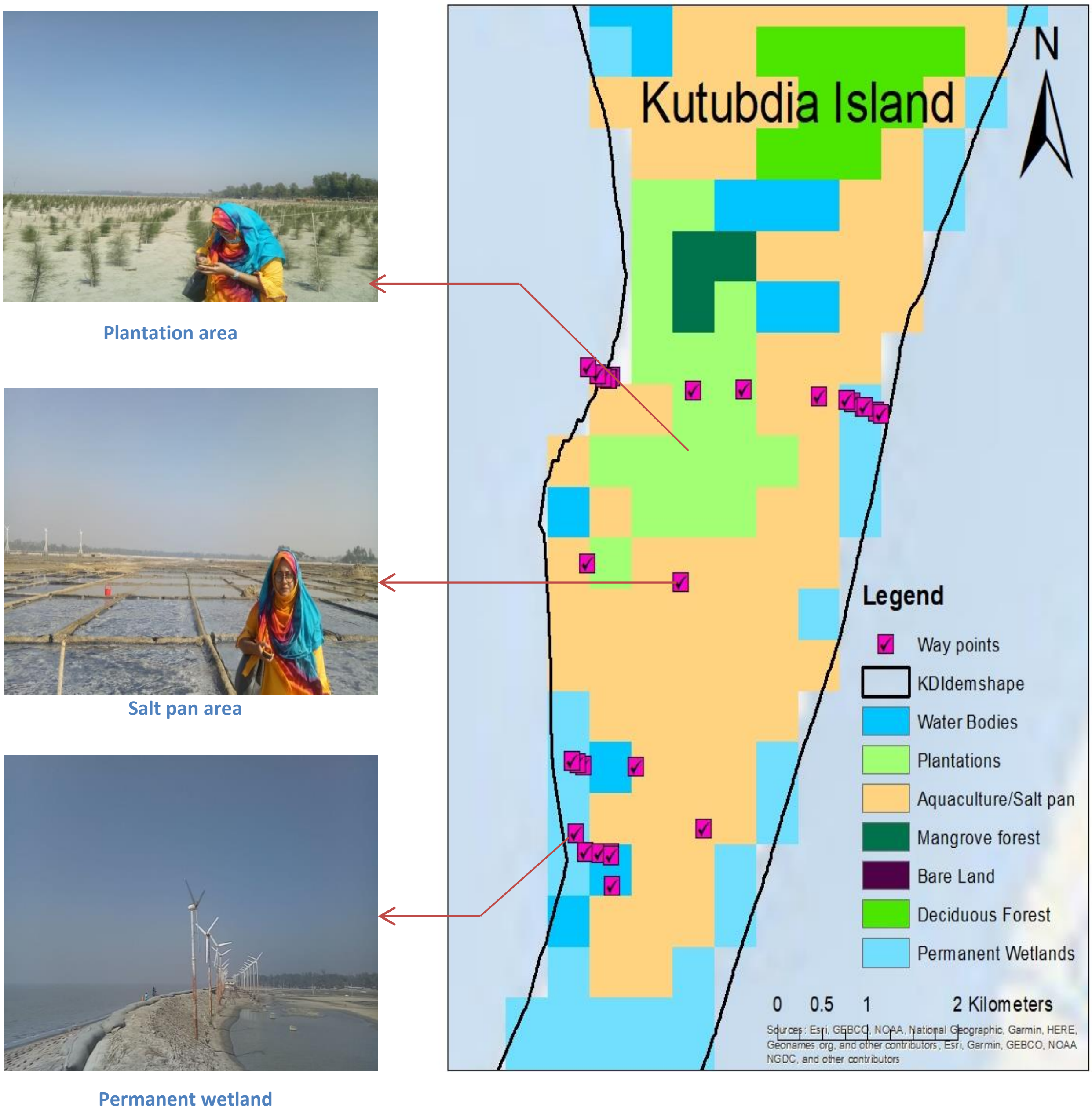

Figure 30 Ground truthing and field data collection from the studied areas

Brief Biography

Sayeda Humaira Ahmed Koly passed the Secondary School Certificate Examination in 2012 and then Higher Secondary Certificate Examination in 2014. Sayeda Humaira Ahmed Koly obtained her B.Sc. (Hons.) in Fisheries in 2018 from Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh. Now, she is a candidate for the degree of MS in Department of Marine Bioresource Science under Faculty of Fisheries (FoF), CVASU. She has immense interest to work in GIS field.