LANDUSE CHANGE MONITORING OF BANSHKHALI COASTAL AREAS USING TOPOSHEET DATA AND SATELLITE IMAGERIES (1988-2010): A GEOINFORMATICS APPROACH

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ABSTRACT

Land use refers to man's activities and the varied uses which are carried on over land. The knowledge of land use changes is very important in understanding natural resources, their utilization, conservation and management uses. Remote sensing satellite data provides a synoptic view of the coastal zones. The modern scientific technologies of remote sensing and digital image processing are extremely useful in periodic assessment of the coastal LULC changes and analyze them to formulate better management. The coastal areas adjacent to Banshkhali in the south of Chittagong, Bangladesh are facing the problem of land use changes due to different types of disaster i.e., cyclone, tidal surge, saline water intrusion, etc. For the detection of land use category in 1988 and in 1999 and 2010, Toposheet from Survey of Bangladesh and Landsat TM satellite imageries are used respectively. Supervised image classification based on maximum likelihood classifier method was applied for the two years 1999 and 2010 and digitization was performed on 1988 toposheet respectively to identify different categories of land use. The Banshkhali coastal zone changes during the past 22 years mainly due to anthropogenic, and different types of disasters. The prepared land use map shows the major changes in the coastal land use because of high powerful destructive cyclonic events in different time period, saline water intrusion, seasonal tidal impact, river bank erosion etc. activities. The present study suggests some remedial measures to protect the Banshkhali coastal environmental changes.

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Proper coastal zone rules should be strictly implemented to protect the embankment and other related activities near to the coast. Proper mitigation plan should be implemented for protecting the coast from erosion.

Keywords: *Land use, Change Monitoring, Banshkhali Coast, Geoinformatics,*

1. Introduction

Coastal areas are highly dynamic and undergoing rapid change. In view of this fact, it is essential to review decisions made and developments undertaken pertaining to the coast from time to time. Land use refers to man's activities and the varied uses which are carried on over land (NRSA, 1989). The knowledge of land use changes is very important in understanding natural resources, their utilization, conservation and Management (Nagamani and Ramachandran, et. al 2003) uses. In order to improve the economic condition of the area without further deteriorating the bio-environment, every bit of the available land has to be used in the most rational way. Remote sensing satellite data provides a synoptic view of the coastal zones. The modern scientific technologies of remote sensing and digital image processing are extremely useful in periodic assessment of the coastal LULC changes and analyze them to formulate better management. Hence the coastal areas are fragile and they are more persistent to land use changes. An attempt has been made in this study to bring out the land use changes in different period of time. Hence the coastal areas are fragile and they are more persistent to land use changes. An attempt has been made in this study to bring out the land use changes in different period time frame.

The coastal region of Bangladesh contributes to about one fifth of the countries landmass and one seventh of the total population. In south eastern part of Bangladesh, land use pattern has significantly changed. Agricultural land has gradually been encroached and undergoes shrimp farming causing increase of salinity. Over 30 million people live in the coastal region relying on agriculture, fishery, forestry and other livelihood activities. But at present, the whole region is at the verge of serious degradation due to human interventions and different natural disasters.

"The term land use relates to the human activities or economic functions associated with a specific piece of land." (Lillesand and Kiefer, 2008). In other words it has to do with series of

operations on land, carried out by humans, with the intension to obtain products and /or benefits through land resources. The land use is simply regarded as the various ways by which man utilizes the land resource at a given time period. It has also been defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it (FAO, 1997a; FAO/UNEP, 1999). Land use refers to how land is used by humans. In other words it refers to the economic use to which land is put. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension. Land use change is the change in the terrestrial surface of the earth. It is also known as land change is a general term by the human beings to the earth's terrestrial surface (EOEARTH, 2010). Human beings are the agents which brings changes in the character of the land more than any other agents. Originally the nature is dominating factor for land use change. But now, humans are leading to nature and modified the earth which is very difficult to bring under its original purpose. The land resources are being damaged at an alarming rate in an unplanned manner.

Land change puts an impact on the environment of the area (Kostrowicki, 1983). Land carries ecosystems; land use is the application of human controls, in a relatively systematic manner, to the key elements within any ecosystem, in order to benefits from it. The conversion of agricultural lands to non agricultural uses is almost inevitable and irreversible. So, comprehensive information on the spatial distribution of agricultural land use and pattern of their change is prerequisite for planning, utilization and management of the land resources.

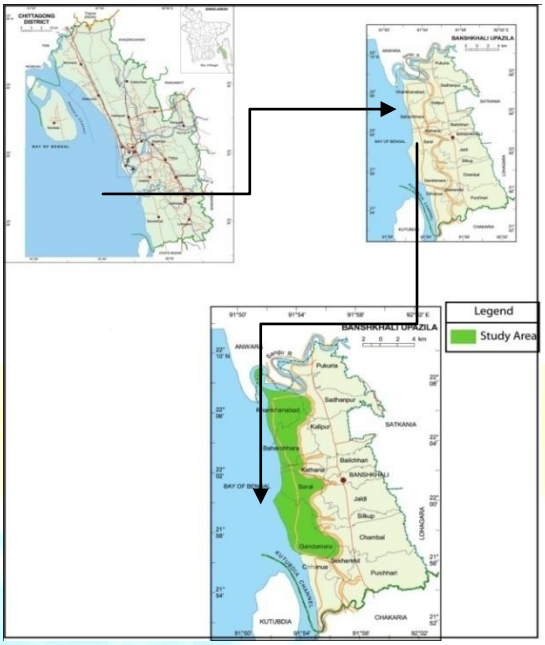
Land change is the primary modifier of the landscape, which leads to an impact on socio-economic, biological, climatic, and hydrologic systems (Sohl and Sohl, 2012). To identify the changes taking place at different times are known as change detection (Singh 1989). Remote sensing data is widely used to provide a cost-effective means to develop land change coverage over large geographic regions (Lunetta et al., 2006). The spatial and temporal distribution of land use is very important in understanding a wide variety of global change phenomenon. Geospatial technology is very much helpful to monitor such changes (Rajan and Shibasaki, 2000). Remote sensing techniques are applied by several researchers for land change detection (Campbell et al., 2003), (Dezso et al., 2005), (Fan et al., 2007), (Panahi et al., 2010), etc. tried to investigate the land change of the adjoining area of the study region and established a link between land change and natural resources. Satellite imageries provide a wide a range of data of an area of different

time periods. Very precisely, it has the ability to quantify temporal changes using multi-temporal data sets (Singh, 1989). For better understanding the land use change we always need to develop a classification scheme for the whole area and divided all the objects into different classes according to our requirement (Anderson et al., 1976). The categorization of land use based on actual field status makes our work more useful and authentic.

2. Study Area

Banshkhali is an Upazila under Chittagong District in the Division of Chittagong. It is bounded by Anwara and Sangu on the north, Chakaria on the south, Lohagara and Satkania on the east, Kutubdia and Bay of Bengal on the west. There is a canal named *Sonaichhari* at Banshkhali which is locally known as *Honaichhari*. Businessmen from Chakaria used to buy bamboos from this area and used Sonaichhari canal to pass these bamboos to another area. At that time, local people observed that Sonaichhari canal filled with bamboos. Banshkhali is named after this historical event.

The whole coastal area is occasionally affected by cyclonic storms, often accompanied by tidal bore in mid April to early June and mid September to early December. Every year the people of this Upazila's can face some natural calamities such as cyclone, tornado, and river bank erosion because of its location in the coastal area. A large amount of crops, fisheries and natural resources are affected by these phenomena. For few years natural calamity has moved in this area just like as octopus. The area named Gondamara, Saral, Baharchhara and Khankhanabad are affected by water logging. Banshkhali upazila is a part of coastal flood plain. The soil is gray to dark grey in color. The soils are mainly acid-sulphate, the pH is mainly below 4.0 and salinity is present in this area's soil. Due to saltiness of soil, shrimp cultivation is increasing and agricultural land is going to decrease day by day. Due to geographical settings study area is situated in the eastern side of the Bay of Bengal, so natural calamities are common phenomena in this area. Overall the climatic condition is good and favorable for human habitat and animal life. The areal extent of the area is from $21^0 56' 31.085'' N$ latitude to $22^0 9' 19.663'' N$ latitude and $91^0 48' 12.847'' E$ longitude to $91^0 56' 18.254'' E$ longitude. The location of the study area of Banshkhali is shown in Figure 1.



Source: Banglapedia, 2003

Figure 1: Location Map of the Study Area

3. Database and Methodology

3.1 Data Acquisition

To detect the land use change satellite imageries of at least two different times are required. So, satellite imageries from Landsat TM 1999 and 2010 are used. Except these two Topo-sheets of 1988 (Sheet No: 79 N/16, 79 O/13 which cover the whole study area are used. Further Ground verification is conducted with the help of Garmin GPS to verify the signatures.

3.2 Data Processing

For data processing visual image interpretation and digital image interpretation techniques are used. Signatures are identified from satellite imageries. ERDAS Imagine 10.0 and ArcGIS 10.0 software's were used for data processing. Supervised image classification based on Maximum Likelihood Classifier method was applied on these Landsat TM satellite imageries.

3.3 Methodology

The NASA-GLCF (Global Land Cover Facility) data provided by University of Maryland for the world from their freely downloadable archive to acquisition of Landsat TM satellite imageries for the years 1999 and 2010 and Survey of Bangladesh (SOB) topographical map sheet no. 79 N/16, 79 O/13 (1988) on 1:50,000 scales were used for Land use mapping coupled with intensive ground truth verifications done during field investigation (September, 2012). The downloaded satellite imageries were geometrically corrected by university of Maryland and Survey of Bangladesh (SOB) topographical maps were geo-referenced with the help of ground control points (4 in numbers in 4 different corners) along with UTM projection and WGS 84 datum using ArcGIS 10 software. Visual image interpretation is still one of the most widely used methods for detecting, identifying and characterizing the spatial features on an image since human brain is a good interpreter of images (Lillesand and Kiefer, 1994). The satellite data were interpreted based on the visual interpretation keys and changes were identified for the land use and for Toposheet maps which are geo-referenced and features are extracted by digitization using ArcGIS 10 software and finally verified with the field check using Garmin GPS e-trex for each category sample identification and change detection analysis was performed through quantitative techniques using ERDAS Imagine 10.

The interpretation key elements prepared for the mapping of land use units in Banshkhali Coastal areas are given in Table 1. Nearly 14 different Land use units have been mapped up to level-II in Banshkhali coastal areas using Landsat TM Satellite imageries for the year 1999 and 2010 and nearly 12 different units have been identified from Toposheet Map of 1988.

Interpretation of remote sensing data for land use change mapping involves analysis of image/digital data. Visual interpretation of image has limitations of human ability to evaluate spatial and spectral variations and require extensive training. The spectral response patterns measured by remote sensing sensors for different features are distinctive but not necessarily unique. However, temporal and spatial effects are other factors that influence spectral responses of a feature. The temporal effects are any factors that change the spectral characteristics of a feature over time.

A thematic map shows the spatial distribution of identifiable earth surface; it provides information description over a given area. Image classification is the process used to produce thematic maps from imagery. The themes can range from categories such as agricultural land,

natural forest, marshy land, muddy land, settlement with vegetation, vacant land, etc. Change monitoring studies can be done more effectively using thematic information derived from multi-date optical sensor data.

4. Results and Discussion

Apart from mapping and monitoring the coastal land use change, the remote sensing data helps in understanding their underlying causes. The coastal areas adjacent to Banshkhali in the south of Chittagong, Bangladesh are facing the problem of land use changes due to different types of disaster i.e., cyclone, tidal surge, saline water intrusion, etc.

For the detection of land use category in 1988 and in 1999 and 2010, Toposheet from Survey of Bangladesh and Landsat TM satellite imageries are used respectively. Supervised image classification based on maximum likelihood classifier method was applied for Land use category identification for the two years 1999 and 2010 using the band combinations of 5,4,3 /R,G,B (Figure 2b and 2c) whereas digitization was performed on two Toposheets for the year 1988, which was scanned and geo-referenced image (Figure 2a). Significant areas are identified under these categories.

The field survey during September, 2012 and analysis of temporal satellite data and toposheet data shows, several changes are found in land use of the study region (Table 1). These changes are found in every land use class and a field investigation result shows that, migrations of population towards coastal zone is occurred only for their livelihood. The Toposheet and Landsat TM imageries derived thematic maps shows the Land use scenarios in this area for 1988, 1999 and 2010 respectively (Figure 2).

4.1 Land use Change Analysis

To understand the recent land use pattern in this area researcher conducted a checklist survey to know the changing scenario. According to respondent's opinion, 55% told that land use is changing in this area. In our study area most of the peoples say that day by day in this area agricultural land become salt land and maximum land are used to building settlement, embankment and local road. The entire study area was changing in between 1988-2010. In 1988 the area was 26663.27 hectare, whereas the area was 22437.10 hectare and 19518.98 hectare in

the year 1999 and 2010 respectively indicates decreasing scenario (Table 1 and Figure 2b and 2c).

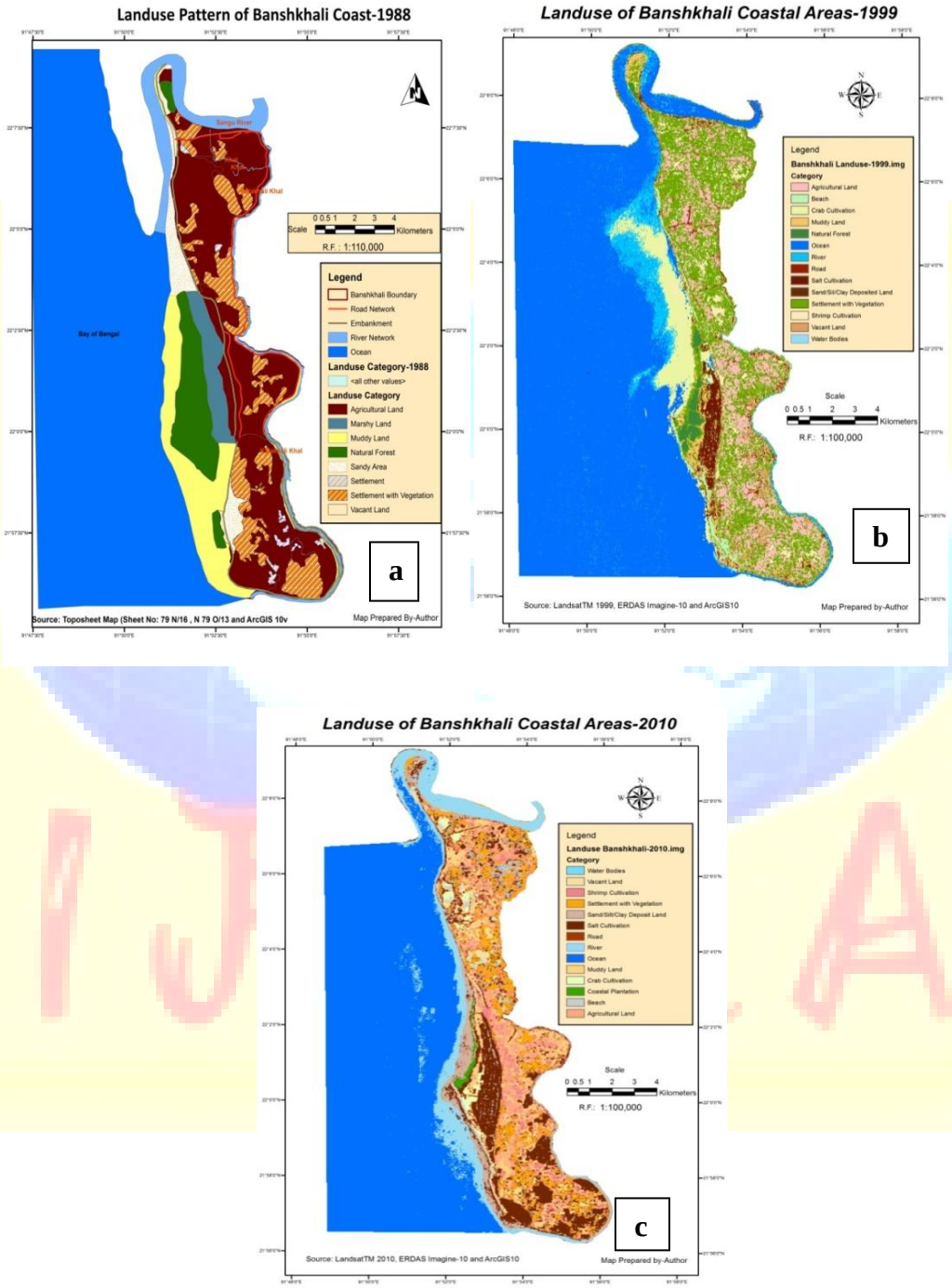


Figure 2: (a,b,c): Landuse scenarios of Banshkhali Coastal Areas from 1988-2010.

The modern scientific technologies of remote sensing and digital image processing are extremely useful in periodic assessment of the coastal land use changes and analyze them to formulate better management. The classification was done under the following heads (Table 1 and Figure 2) as agricultural land, beach, natural forest, crab cultivation, muddy land, marshy land, salt cultivation, sand/silt/clay deposit land, shrimp cultivation, vacant land, water bodies, settlement, settlement with vegetation, coastal plantation and others.

4.1.1 Comparison of Land use Category derived from Toposheet (1988) and Landsat TM imagery (1999)

After classification, the comparison of different land use categories showed either decrease or increase in area. The total area of agricultural land was 4576.3 hectare (17.16%) in 1988 and it was 1532.07 hectare (6.83% of land) in the year 1999 (Table 1). In this time period a decrease in the agricultural land by ~10.33% was observed. The decrease was due to increase of crab cultivation, shrimp cultivation, and the area of settlement. There was a decrease in the sand/silt and clay deposit land and natural forest area due to coastal influence and cyclonic disaster in 1991. Maximum area of the coastal stretches from north to south ward direction had faced severe erosion activities due to aftermath effect of cyclone. The area occupied by beach, crab cultivation and shrimp cultivation showed a increase of around 0.86%, 4.50% and 2.50% respectively.

Table 1: Changes in Land use category of the study area (1988-2010)

Land use Category	Area (hectare) 1988	% of Area	Area (hectare) 1999	% of Area	Area (hectare) 2010	% of Area	% of Change (1988-2010)
Agricultural Land	4576.3	17.16	1532.07	6.83	783.81	4.02	13.14 (-)
Beach	0	0	192.83	0.86	112.77	0.58	0.58 (+)
Natural Forest	1172.29	4.40	167.65	0.75	0	0	4.40 (-)
Crab Cultivation	0	0	1009.14	4.50	180.63	0.93	0.93 (+)
Muddy Land	1668.87	6.26	385.57	1.72	1134.81	5.81	0.45 (-)
Marshy Land	565.28	2.12	0	0	0	0	2.12 (-)
Ocean	14782.38	55.44	13197.92	58.82	10796.49	55.31	0.13 (-)
River	1129.07	4.23	1122.12	5.00	1120.46	5.74	1.51 (+)

Road	323.69	1.21	285.18	1.27	263.34	1.35	0.14 (+)
Salt Cultivation	0	0	258.38	1.15	1813.86	9.30	9.30 (+)
Sand/Silt/Clay Deposit Land	644.66	2.42	97.14	0.43	1134.54	5.81	3.39 (+)
Shrimp Cultivation	0	0	561.02	2.50	696.6	3.57	3.57 (+)
Vacant Land	62.11	0.23	288.84	1.29	217.44	1.11	0.88 (+)
Water Bodies	0	0	36.39	0.16	18.09	0.09	0.09 (+)
Settlement	98.46	0.37	0	0	0	0	0.37 (-)
Settlement with Vegetation	1670.16	6.26	3302.85	14.72	1179.27	6.04	0.22 (-)
Coastal Plantation	0	0	0	0	66.87	0.34	0.34 (+)
Total	**26663.27**	**100.0**	**22437.10**	**100.0**	**19518.98**	**100.0**	

Source: Toposheet (1988) and Landsat TM Satellite Imagery (1999 & 2010) and data computed by Author

4.1.2 Comparison of Land use Category derived from Landsat TM imagery of 1999 and 2010

The area under agricultural land in this case showed negative trend as well, a sharp decrease of 2.81% of the total study area. There was a tremendous increase of shrimp cultivation, sand/silt and clay deposit land, muddy land and coastal plantation in the study area. There was a significant decrease of settlement with vegetation (~7.68%), vacant land (0.18%), water bodies (~0.07%), crab cultivation (~3.57%) and natural forest (~0.75%) in between year 1999 and 2010 respectively.

4.1.3 Conclusion derived from land use change study from 1988-2010

There was a continuous decrease in the area under agricultural land (13.14%), natural forest (4.40%), marshy land (2.12%), muddy land (0.45%) and a significant increase in the area under salt and shrimp cultivation which shares 9.30% and 3.57% respectively (Table 1 and Figure 3). Due to broken coastline and tidal impact, the study area was severely affected by erosion activities and on the contrary tremendous improvement also run in parallel of the coastline which was the deposit of sand/silt/clay land which was increased considerably (3.39%) over the period.

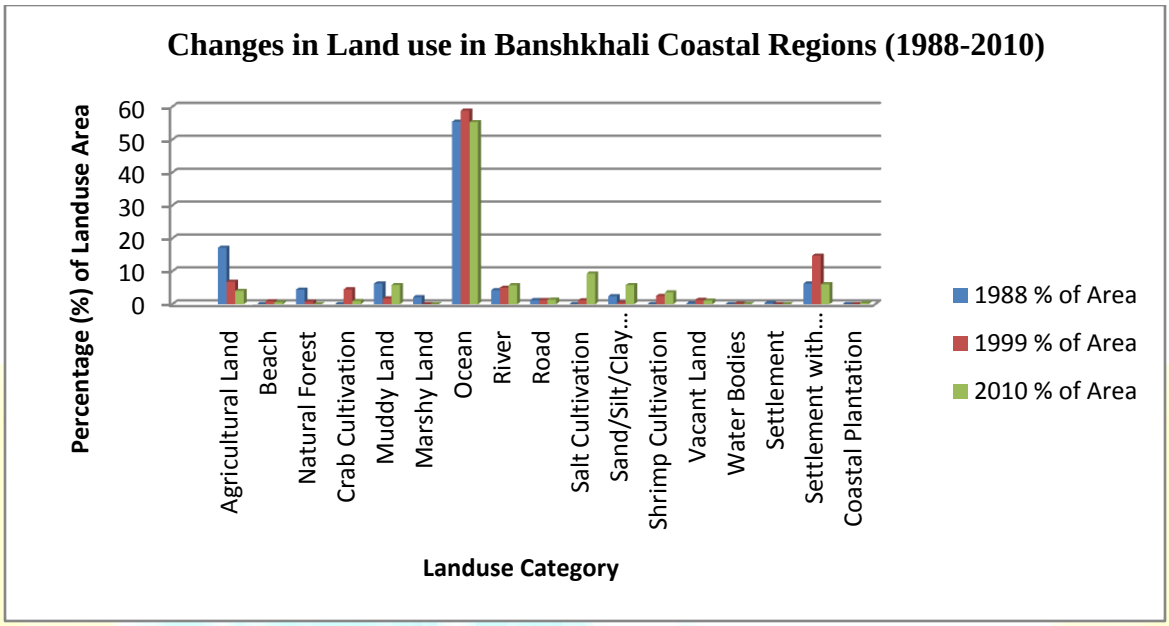


Figure 3: Bar Diagram showing the percentage of Changes in Land use category in Banshkhali Coastal Regions during the year 1988, 1999 and 2010.

5. Outcomes of the Study

Remote sensing data helps to update the information during the last 22 years. Coastal issues and their linkages to Land use could be interpreted/assessed using multi-date optical remote sensing data. Survey of Bangladesh (SOB) 1988s topographical maps is more relevant for baseline information, GIS is more useful for frequently updating, monitoring and preparation of spatial database. The combined use of multi-date optical remote sensing data and GIS database is the only tool for Land use modeling by incorporating all relevant spatial and non-spatial data, and Remote sensing and GIS tools are vital for the preparation of science based management plans.

6. Conclusion

Satellite remote sensing and GIS is a powerful integrated approach for mapping and evaluating the land use/land cover changes in coastal environment. The Banshkhali coastal zone changes during the past 22 years mainly due to anthropogenic, and different types of disasters. The map shows the major changes in the coastal landforms i.e. Field observation also proves that drastic change in the Banshkhali coastal zone because of high powerful destructive cyclonic events in different time period, saline water intrusion, seasonal tidal impact, river bank erosion etc.

activities. The extracted data from Toposheet and Landsat TM satellite imageries represent useful information for resource managers to support their efforts to conserve and manage the natural resources and to advice the local community on the changing status. The present study suggests some remedial measures to protect the Banshkhali coastal environmental changes. Proper coastal zone rules should be strictly implemented to protect the embankment and other related activities near to the coast. Proper mitigation plan should be implemented for protecting the coast from erosion. More awareness should be developed about the importance of the coastal ecology to visiting tourist and also for the local people. Hence, the synergies of Remote sensing and GIS integrated techniques is very useful tool for future planning and management of coastal regions.

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