Journal of Bangladesh Institute of Planners ISSN 2075-9363
Vol. 9, 2016 (Printed in April 2018), pp. 1-16, © Bangladesh Institute of Planners

Investigating the Coastal Livelihood in Relation to Land Use - Land Cover Change Modeling: A Case Study of Sharankhola, Bagerhat

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Abstract

Land-use change is a common phenomenon in coastal countries. The consequences of this phenomenon affect the coastal livelihood. Sharankhola Upazila is one of the Upazilas of coastal region of Bangladesh and has same characteristics, like other parts of the region. Land use of Sharankhola is changing day by day, like agricultural lands have been transformed into rural settlement, water body, vegetation etc. The major objectives of this study are to detect and predict the Land- use Land- cover Change (LULCC) and investigate the coastal livelihood in relation to LULCC Modeling. It is found that 22% rural settlement is increased and 20% agricultural land is decreased between 1989 and 2010 and in the year of 2025, maximum portion of the agricultural will be lost. This paper found that the rate of landless households increased alarmingly due to frequent disasters (e.g. SIDR, AILA) and it also compelled the farmers to sell their rest of the land consistently. In this study, ArcGIS, Remote Sensing software and Land Change Modeler (LCM) of IDRISI Selva is used and SPSS and Microsoft Excel are used to investigate the impact on coastal livelihood. This study can help policy makers, planners, and researchers to plan coastal region.

Introduction

People living in the coastal region of Bangladesh experience the consequences of the effect of land use change. Land-use Land-cover Change (LULCC) has the impact on livelihood of coastal people. Coastal people are one-fourth of the country's total population and 75% coastal people live in poor livelihood condition due to some specific reasons in the coastal zone (Chowdhury, 2012). Land use and land cover change has been recognized as an important driver of environmental change on all spatial and temporal scales (Adepoju, et al., 2006). It is widely accepted that LULCC has an important effect on both the functioning of the Earth's systems as a whole. Land-use Land-cover Changes (from agricultural land to rural settlement, vacant land, fallow land, etc.) jeopardize the livelihood of coastal people. Land cover change is one of the sole reasons of forest ecosystem change (Uddin, et al., 2015).

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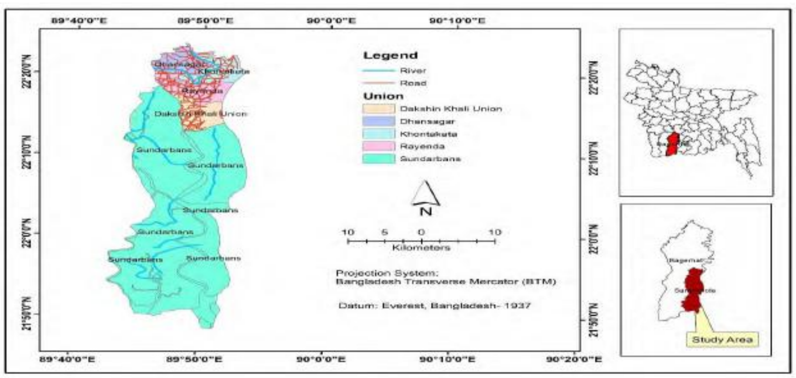
In Bangladesh, agricultural land directly benefits majority of coastal people who directly make important contribution to the national economy. The natural process of erosion and accretion causes the land-use change of coastal zone. Cultivable land of coastal zone is decreasing with an alarming rate, which is conspicuously affecting the coastal livelihood.

For this study, analysis is performed by a remote sensing based Land Change Modeler (LCM) method based on past trend (1989-2010) for land use changes and future prediction map of Sharankhola for 2025 has been generated. To investigate the livelihood in relation to LCM, questionnaire survey has been conducted and analyzed the impact on livelihood of coastal people.

Objectives and Methodology

The main objective of this research is to detect the Land Use and Land Cover Changes (LULCC) using GIS and Remote sensing techniques and investigate the coastal livelihood in relation to land use changes.



Source: Prepared by Authors, 2016

Figure 1: Location Map of the Study Area

Sharankhola is situated in the southern part of coastal region. It lies between 22°33′ and 21°49′ north latitudes and between 89°32′ and 89°44′ longitudes with an area of 756.60 sq. km and it is spread like of 154.25 sq. km of land area, 594.58 sq. km of forest area and 7.78 of riverine area. Sharankhola Upazila consists of 4 unions, 18 mauzas and 51 villages. The unions are Dhansagor, Khontakata, Rayenda and Dakshin Khali respectively. Major rivers of it are the Bhola and the Boleshawar running inside the Upazila. It is highly disaster prone area among other Upazilas of Bagerhat district.

The study is based on primary and secondary data. Sharankhola Upazila which experience land-use and land-cover change frequently is selected as study area purposively for the convenience of primary data collection and here severity of climate change impact is more visible.

Satellite images of the study area were collected for analysis and interpretation. Landsat images of 1989, 1999 and 2010 have been collected from the official website of US geological survey (USGS). Those images have been radio metrically corrected and ground truthing has also been done. Interactive supervised classification was used for classifying land-cover types into six categories such as rural settlements, water, agricultural land, Sundarbans, vacant land and vegetation. The images are projected to WGS 1984 and UTM Zone-45N Coordinate system and land-cover map of 1989, 1999 and 2010 are prepared. Information of Landsat satellite images which are collected are shown in Table 1.

Table 1: Collected satellite images.

Satellite sensor name	**Acquired date**	**Row and path**		**Cloud cover**
Landsat 5 TM	1989/11/04	45	137	.03
Landsat 7 ETM	1999/03/05	45	137	0
Landsat 7 ETM+	2010/02/03	45	137	.07

Source: Authors, 2016

Landsat Path 137 Row 45 covers the whole study area. Map Projection of the collected satellite images is Universal Transverse Mercator (UTM) within Zone 45 N– Datum World Geodetic System (WGS) 84 and the pixel size is 30 meters. Data set attribute of these images are given in Table 2.

Table 2: Data set attribute of the satellite images

<table>
<tr><td colspan="2">Image Properties</td><td>Description</td></tr>
<tr><td colspan="2">File format</td><td>Raster</td></tr>
<tr><td colspan="2">File type</td><td>Binary</td></tr>
<tr><td colspan="2">Data type</td><td>Byte</td></tr>
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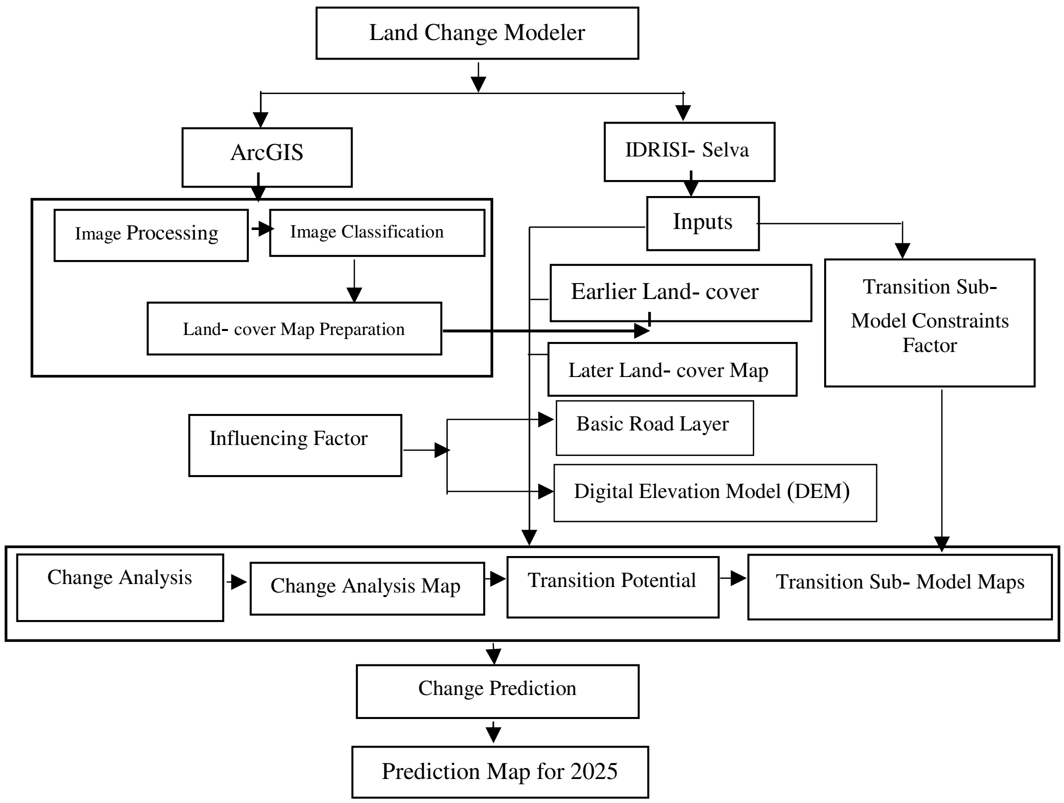
<tr><td colspan="2">Rows</td><td>2187</td></tr>
<tr><td colspan="2">Spatial Reference</td><td>WGS 1984 UTM-Zone 45N</td></tr>
<tr><td colspan="2">Reference Unit</td><td>Meters</td></tr>
<tr><td colspan="2">Datum</td><td>WGS 1984</td></tr>
<tr><td rowspan="4">Extent</td><td>Top</td><td>2480355</td></tr>
<tr><td>Left</td><td>160275</td></tr>
<tr><td>Right</td><td>180195</td></tr>
<tr><td>Bottom</td><td>2414745</td></tr>
<tr><td colspan="2">X Resolution</td><td>30</td></tr>
<tr><td colspan="2">Y Resolution</td><td>30</td></tr>
</table>

Source: Authors, 2016

Land Change Modeler: Land Change Modeler for ecological sustainability is integrated software developed by IDRISI Selva for analyzing the land cover changes. Digital Elevation Model for basic road layer of the study area is the influencing factor of this research. Land Change Modeler is performed to measure change detection from 1989 to

2010 and make prediction for 2025 (Figure 2). Creating maps for gains and losses, net contribution of land-cover types were obtained from the model.



Source: Authors, 2016

Figure 2: Flow Chart of Land Change Modeler (LCM)

Accuracy Assessment: There is always vagueness in accepting the results, particularly in predicting results. But in GIS and Remote Sensing techniques, there is scope for cross checking of the results. The prediction has been performed in Multi-Layer Perception (MLP Markov Chain) Neural Network built in IDRISI Selva. If accuracy rate is more than 80%, it can be considered as the satisfied accuracy (citation). The accuracy was obtained as the 84.82% for all conversion types (Table 3).

Table 3: Running Statistics for MLP Markov Chain

Iterations	**10000**	**Accuracy Rate**
Learning Rate	0.0010	84.82%
Training RMS	0.2429	
Testing RMS	0.2266	

Source: Authors, 2016.

Accuracy rate is based on the sampling specifications for the training and testing RMS error per category. The acceptable error rate is evaluated based on the Root Mean Square (RMS) Error:

RMS=∑ (ei)2/N = ∑(ti-ai)2/N

Where, N = the number of elements, i = the index for elements, ei = the error of the ith element, ti = the target value (measured) for ith element, ai = the calculated value for the ith element.

Questionnaire Survey: To investigate the coastal livelihood, necessary primary data are collected through the questionnaire survey. Sample size has been determined for applying stratified random sampling method. 200 samples have been collected from all unions such as Dhansagor, Khontakata, Rayenda and Southkhali of Sharankhola Upazila. A questionnaire containing both close-ended and open-ended questions was prepared to collect data. The questionnaire was pre-tested before final data collection. Data were obtained from general households, who were selected from each union. The survey format were designed to understand the past and present of income profile of the people, occupation profile and the condition of existing land use pattern, settlement and displacement pattern. The land-use which will be changed in 2025 was found from LCM cross checked by Global Possessing System (GPS). The survey has been conducted during January to May, 2016. Collected data were processed for subsequent analysis using software, such as SPSS and Microsoft Excel.

Analysis and Results

Change Analysis: From the three classified images of 1989, 1999 and 2010, the area of each land- cover types were measured and compared statistically. Table 4 illustrates the differences of area among the land-cover types.

Table 4: Land-cover Classification Statistics

Land- cover Types	1989		1999		2010		Change in Area (%) [1989- 2010]
	Area (km2)	(%)	Area (km2)	(%)	Area (km2)	(%)	
Rural Settlements	25.63	3.37	57.95	7.63	68.99	9.09	5.72
Water	126.42	16.66	128.16	16.89	128.68	16.89	0.23
Sundarbans	460.77	60.77	475.56	62.68	475.56	62.68	1.89
Agricultural Land	77.30	10.18	39.07	5.14	14.22	1.87	-8.31
Vegetation	68.47	9.02	18.61	2.45	19.13	2.52	-6.5
Vacant Land	0.08	0.01	39.32	5.18	52.60	6.93	6.92
Total	758.68	100	758.68	100	758.68	100	0

Source: All the information given in the tables are collected based on satellite data classification and analysis.

From Table 4, it is significantly clear that area of agricultural land and vegetation is decreasing day by day, whereas area of rural settlements and vacant land is increasing continuously. Land-cover types of agricultural land and vegetation are converted into area of rural settlements and vacant land. Land-cover types of agricultural land and vegetation are demolished for the faster growth of population for their accommodation. Vacant land is increasing, because this land will be used in future for mixed agricultural uses (e.g. shrimp farming) and rural settlement.

From the land- cover map of study area in the year of 1989, 1999 and 2010 the differences are seen conspicuously (Figure 3, 4 and 5).

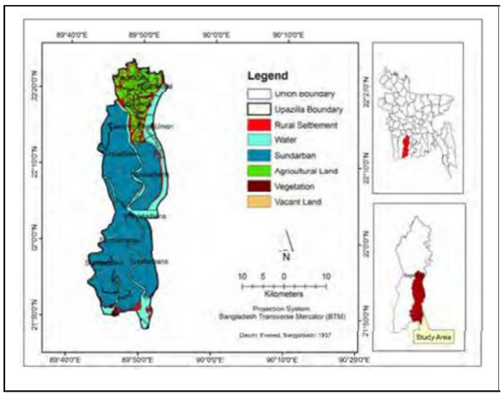


Figure 3: Land- cover Map for 1989

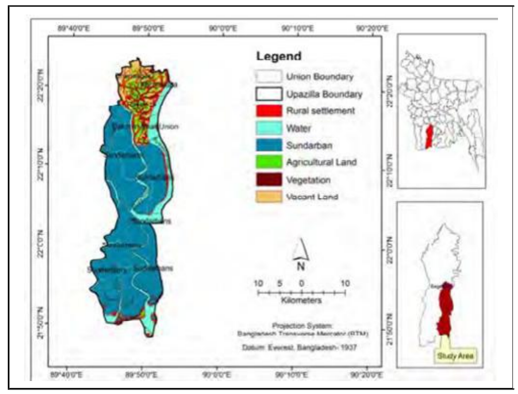
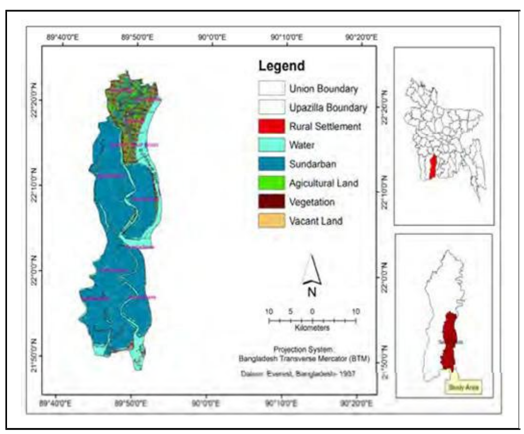


Figure 4: Land- cover Map for 1999



Source: Prepared by Authors, 2016

Figure 5: Land- cover Map for 2010

Figure 6 and 7 illustrate that agricultural land has been changing day by day. All six categories are transitioned into each of them. It is transparently clear that agricultural land is transitioned into rest of them but there is a little few paradigms where agricultural lands are increased. With the recurrences of this proceeding it will put an impact on farmers, who live on this land in future. To lessen the originated sufferings, new technologies have to be discovered but what will happen in future who knows?

Land Change Modeler was used to analyze the Land-cover changes from 1989 to 2010. Evaluating this trend of changes future land- cover change is predicted. The Land-cover changes were evaluated by gain and losses by different categories. Figure 8 illustrates this gain and loss.

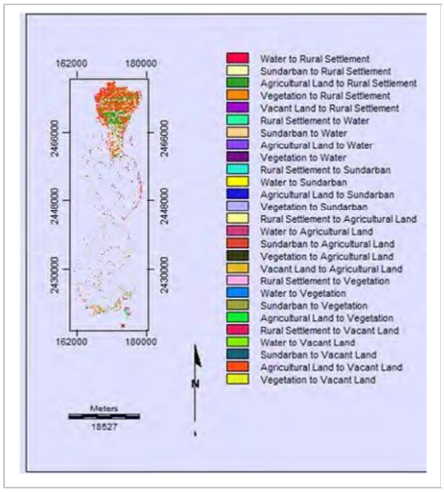


Figure 6: Agricultural Land Change from Land- cover 1989 to Land- cover 2010

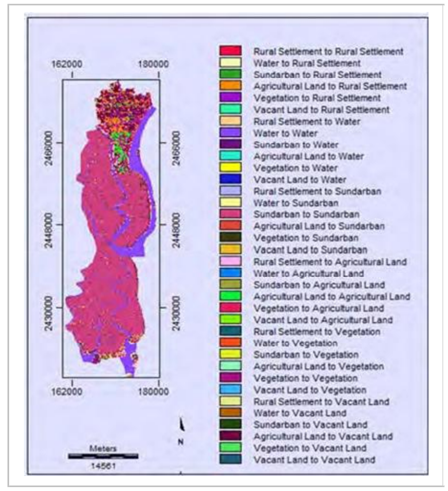
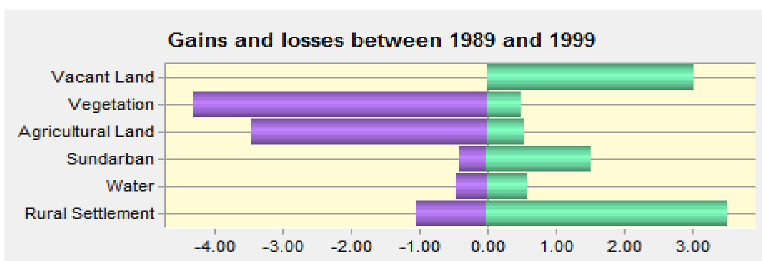


Figure 7: All Land- cover Change from Land- cover 1989 to Land- cover 2010



Source: Prepared by Authors, 2016.

Figure 8: Gain and Losses of Land- cover by each Category (Unit: % of Area)

Transition Potential: Markov Chain determines the amount of using the earlier and later land cover maps along with the date specified. The procedure determines exactly how much land would be expected to transition from the later date to the predicted date based on a projection of the transition potentials into the future and creates a transition probabilities file.

The matrix of transition probabilities (Table 5) shows the probability that each land cover category will change to other categories in 2025. Transition potential value means the transition area where has higher degree of membership of change will occur in future.

Prediction: Prediction for 2025 is done based on the change detection throughout 1989 to 2010. With the proper accuracy assessment prediction result has been executed. Projected land- cover statistics of study area for 2025 is given below in Table 6.

Table 5: Markov Prediction of 2025 based on Land- use Land- cover Change (LULCC) of 1989 and 2010 (given Probability of Changes to the values)

	Rural Settlement	Water	Sundarban	Agricultural Land	Vegetation	Vacant Land
Rural Settlement	0.5190	0.0376	0.013	0.1343	0.0440	0.2539
Water	0.0305	0.9656	0.0004	0.0000	0.0030	0.0005
Sundarban	0.0006	0.0001	0.9912	0.0000	0.0081	0.0000
Agricultural Land	0.1752	0.0007	0.0028	0.1448	0.0106	0.6660
Vegetation	0.4015	0.0678	0.2250	0.0000	0.3057	0.0000
Vacant Land	0.5518	0.0000	0.0000	0.0839	0.0000	0.3643

Source: Derived from Multi-Layer Perception (MLP) Neural Network

Table 6: Land-cover Statistics of Study Area for 2025

Land- cover Types	Rural Settlements	Water	Sundarbans	Agricultural Land	Vegetation	Vacant Land/ Mixed Agricultural Land
Area (Sq. Km)	71.08	128.16	475.56	2.25	24.03	58.1
Area (in %)	9.36	16.88	62.64	0.30	3.16	7.65

Source: All the information given in the table are collected based on satellite data classification and analysis.

Table 6 illustrates that agricultural land in 2025 is a few that will create sufferings to farmers. Mixed agricultural land will be increased in 2025. If crop field will be transmitted into other types of land-use, crop production will also be reduced. So the concerned authority will be bound to seek favor from abroad. The whole nation will face a great threat for this consequence. As most of the people in the coastal region live below the poverty line, coastal livelihood will be hampered with a large extent because of this consequence. Projected land-cover map in Figure 9 shows the land use changes in 2025.

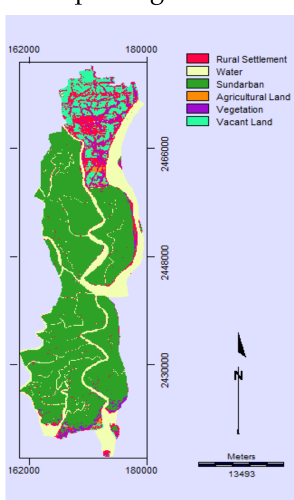
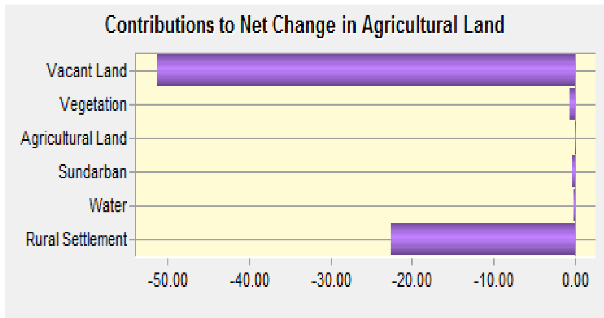


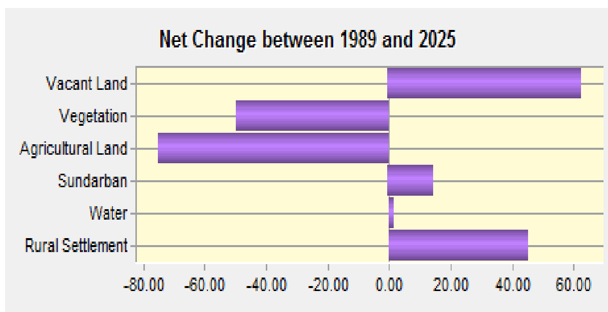
Figure 9: Projected Land- cover map of Study Area for 2025

Figure 10-12 illustrate that the land- cover types which will contribute to change the agricultural land- cover types. It is easily seen that the decreasing rate of agricultural land is abrupt and major land- cover type which are responsible to contribute to change are rural settlement, vegetation, water and vacant land.



Source: Derived from Land Change Modeler (LCM), 2016

Figure 10: Net Contribution Change experienced by agricultural land (Unit: Square Km)



Source: Authors, 2016

Figure 11 shows the change in area of study area from 1989 to 2025.

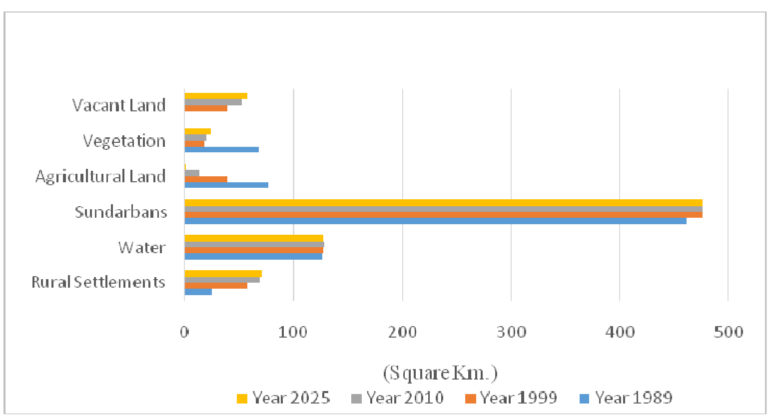


Figure 12: Area statistics of different land- cover types among 1989, 1999, 2010 and 2025.

Coastal Livelihood

Existing Land Use Scenario: Among the stratified uses of land, agriculture and water body occupied the dominating feature. A large area of land was predominantly used for agricultural purpose and some areas were used seasonally for shrimp cultivation and crab fattening.

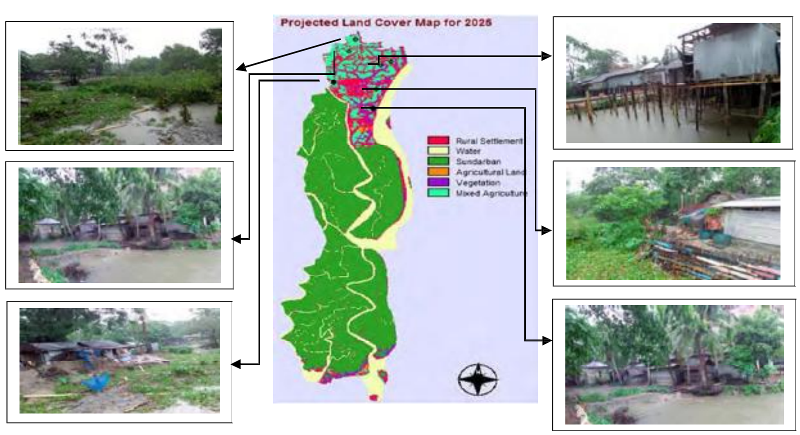
Table 7: Existing land use pattern of the Study Area

Land use	Total Area (Acre)	Percentage
Rural Settlement	913	27
Waterbody	588	17
Agriculture	1357	39
Commercial	137	4
Institution	203	6
Roads	105	3
Others	130	4
Total	3433	100

Source: BBS 2010 and Field Survey, January to May, 2016

Table 7 summarizes that, agriculture, rural settlement cover (39 percent) and (27 percent) of land whereas 17 percent was used for the purpose of permanent gher, pond, ditches and river. Although a negligible amount (3 percent) of land was used for road networks.

Cross-Checking the Land-Use Scenarios: Figure 13 reveals the existing scenarios of this study area by comparing projected land-use Land-cover scenarios in 2025. As from the prediction, most of the agricultural land will be lost in 2025 which will be covered major portion of the area. Losses of agricultural land have already been started because of river erosion, coastal flooding, cyclonic storm, and salinity intrusion. Some pictures in Figure 13 present the existing land-use scenario based on projected land-use land-cover scenario for the sake of achieving objectives.



Source: Prepared by Authors, 2016; Image Courtesy: Authors, 2016

Figure 13: Checking existing Scenarios based on Predicted land-use land-cover map of 2025

Disaster Effects and Land Use Changes: Table 8 explains Land-use Change from 1985 to 2010. The average land for homestead with a standard deviation is declined gradually from 1985 to 2010. When seasonal flooding and water logging affects homesteads, the waterlogged land is used for shrimp cultivation purpose and for that reason larger homestead is squeezing day by day. The standard deviation of land for homestead is decreasing which states that the gap between high and low land is decreasing.

Table 8: Land-use Change from 1985 to 2010

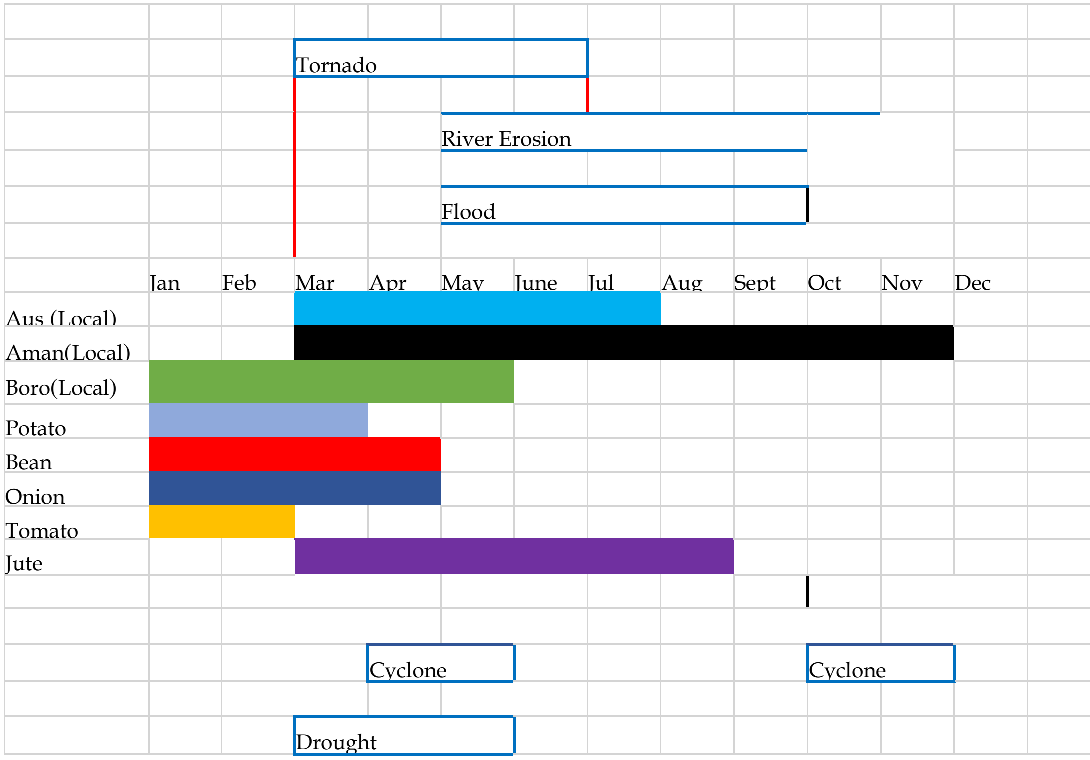
Land-use	Change in Land Area over the decades (in Katha)					
	1985		1995		2010	
	Mean	SD	Mean	SD	Mean	SD
Homestead	7.49	4.60	7.18	4.44	6.87	3.62
Agricultural Land	37	66.19	28	54.53	22	27.76
Shrimp farming land	0	0	19	31.13	46	56.77
Others (Fellow land, etc.)	26	65.84	17	42.71	8	29.59

Source: Upazila Land Office, Sharankhola

Average amount of agricultural land was decreasing from 1985 to 2010 meant much of the low lying land is flooded by river water and lower parts of the land also submerged by rainwater under monsoon season. The land area became water logged because of this flooding which is responsible for disrupting normal cropping pattern. For this reason, rice cultivable land is decreasing and shrimp cultivable land is increasing in the waterlogged areas. The amount of average shrimp cultivable area was 19 Katha in 1995 but it raised to 46 Katha in 2010. Practising shrimp farming over the years is gradually increasing. Comparison between the standard deviation of shrimp cultivable land is increasing which indicates that there is a variation among the land size. For instance, no land was used for shrimp cultivation in 1985, and so the standard deviation of land size used for cultivation was zero. But after the passage of time it increased to 31.13 in 1995 and to 56.77 in 2010. This increasing standard deviation reveals that land size variation used for shrimp farming is widening over the years. The Fellow lands are used for shrimp farming purpose in recent years. Amount of average fellow land is decreasing because of this.

Figure 14 illustrates the normal cropping pattern of the respondent throughout the year. Here the study reveals that most of the land produces three crops in a year. These are Boro, Aus and Aman respectively. Cyclone occurs in the pre monsoon season that affects Boro and Aus as well as Aman. Jute is also mostly affected crop due to drought and cyclone. Besides, in the pre-monsoon season this region normally becomes flooded from the river water, and the flow of river water causes seasonal flood frequently, sometimes several times in a year. Seasonal flood generally occurs most between April and May. It affects most when the Boro rice crop is grown. It generally causes most of the damages of the crop. In most of the cases farmers face double loss for their agriculture production. This further leads to long term abstention from crop cultivation. Moreover, flood and tornado is another sole reason behind this dilemma. Furthermore, river erosion causes

Seasonal Cropping Patterns in Relation with Natural Disaster



Source: Field Survey, January to May, 2016

Figure 14: Seasonal Cropping Patterns throughout the year and their association with Natural Disaster

major loss of the agricultural land. So finding no other ways, they are changing their cropping pattern and many of them are now interested in shrimp farming because as we know it is 12 times profiteer than rice cultivation. They also experienced the same form local farmers those involved in shrimp farming.

Occupation Changes with comparison to Income Attribute: It is found from Table 9 that the income of most of the farmers is increased due to change in their occupation from agriculture to shrimp farming.

Table 9 reveals that income of the most of the farmers is increased due to change in their occupation from agriculture to shrimp farming. Cropping activities are reduced and shrimp farming replaced agriculture due to frequent disasters that result land use change. As vegetables cannot grow due to saline water, the local women are hardly related with shrimp farming as traditionally women cannot contribute in earnings which ultimately reduced the economic activity of women and affect adversely in their livelihoods.

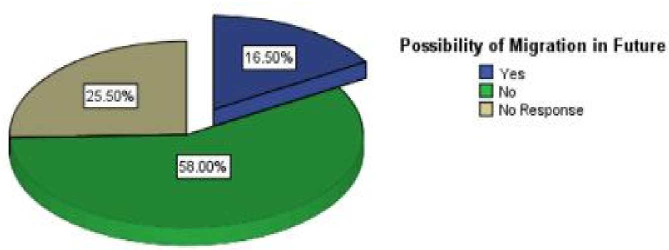
Many people have changed their occupation due to psychological reasons as they found out shrimp farming is more profitable than agriculture. Other primary reasons like river erosion, flooding, salinity intrusion is responsible likewise for changing their major occupation. Occupation is changed alarmingly along with Land Use Land-Cover changes.

Table 9: Occupation Conversion with comparison to Income Attribute

Previous Profession		Savings (T.K)	Frequency	Percent	Changes Profession from Farmer		Savings (T.K)	Frequency	Percent
N=59	Farmer	No Savings	8	13.5	N=23	Shrimp Farming	No Savings	2	9
		0-5000	22	37			0-5000	11	48
		5001-10000	18	30.5			5001-10000	5	22
		10001-15000	8	14			10001-15000	1	4.5
		15001-20000	2	3.5			15001-20000	3	12
		Above 20000	1	2			Above 20000	1	4.5

Source: Field Survey, January to May, 2016

Migration Pattern: Figure 14 illustrates the percentage of tendency of migration according to field survey. It is because of land use change caused by river erosion, salinity intrusion, coastal flooding, and cyclonic storms and so on. Many people lost their only homestead because of this. Some people intentionally change their land use because of more profit so that they can change their living condition by improving it.



Source: Field Survey, January to May, 2016

Figure 14: Percentage of Migration Possibility based on Field Survey (N=200)

Figure 14 explains the percentage of migration probability among respondents as revealed from the field survey. Most of the people living in the study area responded to migrate in future, because of the adverse effects of weather of coastal region and to seek better life standard.

Major Findings

In this research, land-use and land-cover change is predicted to show the land-use change for 2025. Coastal livelihood has been investigated with comparison to LULCC modeling. The major findings are as follows:

- Land-Use Land-Cover scenario of the study area has been detected throughout 21 years (1989-2010). As much as 22% rural settlement is increased and 20% agricultural land is decreased between 1989 and 2010
- Maximum portion of agricultural land will be lost in 2025 that will give pressure on national economy. Farmers will be bound to change their occupation into shrimp farming, small business, fisheries, etc. and Arable land is being used to make homestead and shrimp farming purpose as those land can't be used as crop cultivable land due to insufficient fertility
- The land which will be changed in 2025 have been investigated and present scenario is also cross checked through Global Possessing System (GPS). Those areas have already started to experience that changes which is predicted in the study. Agricultural land is started to turn into shrimp farming
- Coastal Livelihood is affected with a large extent because of land- use changes. Contributing reasons like flood, cyclone, drought, and high temperature significantly reduced the income from agricultural land over the years that will give pressure on national economy.

Conclusions

Land use land cover changes of various categories of Sharankhola, Bagerhat has revealed through this study. Land Change Modeler (LCM) of IDRISI Selva helps to execute this. This model has also used to predict future land use and land cover maps of year 2025.It clearly shows the gain and losses, net changes in agricultural land, rural settlement, fellow land while other land cover categories are fluctuating. Perfect results could be executed through high quality satellite images. This study will be very helpful for local government bodies while making decision for this coastal district. Besides, it is also known that, coastal zone is enriched with enormous resources like agricultural land, livestock, fisheries, forestry, waterways, salt production, seaport facilities etc. Sometimes these resources were seriously damaged by river erosion, food, cyclone etc. which have a serious effect on land use change and finally do affect the coastal livelihood pattern. The surveyed data demonstrate that frequent disaster in every year compelled the farmers to sell their land consistently because these displaced lands became unusable due to its excessive salinity and longtime water logging. Consequently, life, livelihood and occupation of these vulnerable people were widely affected and force them to outward migration especially towards urban areas.

Acknowledgment: *This research was supported in part by US geological survey for Landsat satellite images for free. We like to thank the people of Sharankhola for their valuable support during field survey.*

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