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RESEARCH PAPER

Cyclone Induced Land Transformation in the Bagerhat Coast of Bangladesh

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ABSTRACT

Land transformation is the change in land use and land cover, and the change may involve either a shift to a different use or an intensification of an existing one. Cyclone is one of the agents of land transformation. The aim of the study was to document the impacts of cyclone Sidr on land transformation of Sarankhola Upazila of Bagerhat District, Bangladesh. The research was encompassed by mainly secondary data and information collected from published sources and documents from the Upazila government offices as well as disaster management oriented public offices in Bangladesh. In addition, primary data were collected through field observation and key informant interviews with different stakeholders of the study area. This study revealed that cyclone Sidr acted as one of the agents of transforming land either from one use to another or no use in the study area. It was found that about 43 ha agricultural land was converted into culture and small scale commercial carp fish land, approximately 72 percent of agricultural land was temporary uncovered by storm water, some of the recovery main houses built on agriculture land. In addition, crop type and land cover changed by the farmers destroying about 60 percent homestead and social forest due to cyclonic wind and storm surges created by cyclone Sidr. This study suggested for taking afforestation project in order to restore the forest zone in the study area. Moreover, concerned authority of the government should be strengthened for monitoring and controlling any sorts of construction activities on the agriculture land.

Key words: Afforestation, coastal area, land cover, land use change

Introduction

Bangladesh is the largest delta of the world and contains most of the vast delta of the Ganges, Brahmaputra and Meghna river systems (Rashid 2005, Rashid 2008). The area of this delta region is almost equal to the total area of Belgium and the Netherlands (WARPO 2006). The coastal zone (CZ) covers 19 districts with 147 Upazilas facing or having proximity to the Bay of Bengal and the exclusive economic zone (BBS 2003, WARPO 2006).

The coastal region contains more than 30 percent net cultivable area of Bangladesh which is under great threat of climate risk factors such as cyclone and storm surges, saline water intrusion, sea level rise, flood etc. (Miah 2010). Natural hazards in the recent decades became more recurrent and intense compared with last fifty years (Biswas 2011). Particularly, the coastal zone of Bangladesh is highly vulnerable to cyclones, storm surges, floods, saline water intrusion (Haque 1997, WARPO 2006). Typically every three years at least one severe cyclone hits Bangladesh coast (GoB 2008, Dasgupta *et al*. 2010, Moniruzzaman *et al.* 2013).

Land transformation (LT) is a process where changes in land use and land cover are observed at different time periods. It is the outcome of interrelationship of social conflict, inheritance related issues, selling, culturally morality, war, political conflict, natural hazards etc. Land is extremely transforming in the coastal areas due to cyclone, storm surge, sea level rise, saltwater etc. (Kaliraj *et al.* 2017).

Cyclone Sidr hit the coastal areas of Bangladesh on 15 November 2007 and was a Category- 4 storm, with a diameter of nearly 1,000 km and wind speed up to 240 km/hour. Storm surge analysis indicates that maximum 5.5 m to 6 m surge level observed at the outfall of Balaeshwar River (SDMC 2008, Siddik *et al.* 2014) and significant and visible damages and losses mainly occurred around this River due to close proximity of the landfall (Siddik and Moniruzzaman 2013). Sarankhola sub-district (also called as Upazila), the study area, is situated in the western bank of the Balaeshwar River (Figure 1) and cyclone Sidr acted as the land transforming agent there. This study aimed to document

the impacts of cyclone Sidr on land transformation in Sarankhola Upazila of Bagerhat, Bangladesh.

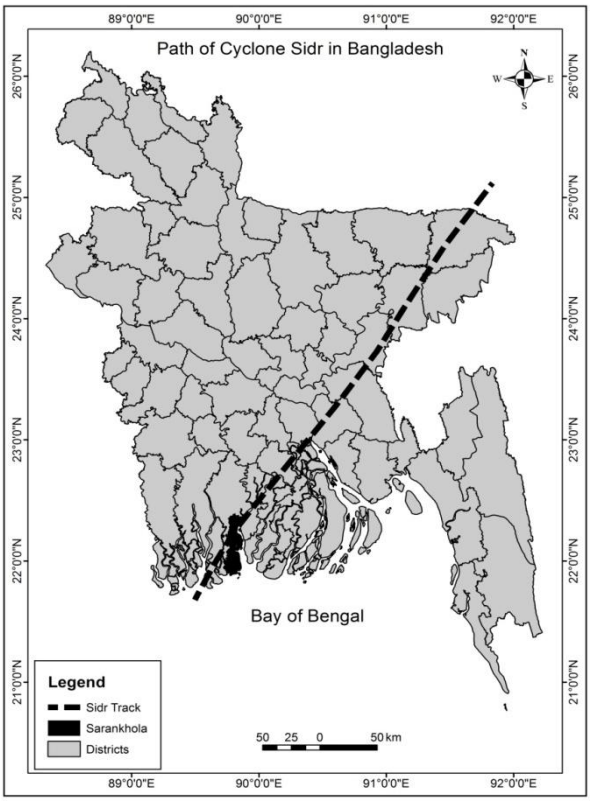

Figure 1: Cyclone Sidr crossed the study area
(Source: after GoB 2008**)**

Materials and Methods

Sarankhola is one of most cyclone affected coastal Upazila under Bagerhat district, Bangladesh (Figure 2). The Upazila was selected as the study area purposively. The Upazila is located in *bio-ecological zone*: 7a Sundarbans (Ganges Tidal Floodplain) comprising part of the Sundarbans, the world's largest stretch of mangrove ecosystem. The area is vulnerable to natural calamities like cyclones, storm surges, river erosion, salinity, siltation and water logging etc. that cause enormous sufferings to the lives and livelihood conditions of people (MoL 2011). The Upazila is lays between $22^0.13'$ and $22^0.24'$ north latitudes and between $89^0.46'$ and $89^0.54'$ East longitudes and bounded on the north by Morrelganj Upazila of Bagerhat District, on the east by Mathbaria Upazila of Pirozpur District and Patharghata Upazila of Barguna District, on the south by the Bay of Bengal and on the west by Mongla Upazila of Khulna District. The study area occupied a total area of 746.13 sq.km including 594.84 sq.km forest areas (Sarankhola Forest Range). The Upazila was included 4 Unions (Dhansagor, Khontakata, Raenda and Southkhali), 11 mauzas and 45 villages (BBS 2011, MoL 2011).

The research was encompassed by mainly secondary data and information collected from published sources and documents from the Upazila government offices as well as disaster management oriented public offices in Bangladesh such as office of Comprehensive Disaster Management Program, Disaster Management Bureau etc. In addition, secondary data and information, and primary data were collected through field observation and ten key informant interviews (KIIs) including five community people and five Upazila Officers i.e. Upazila Agriculture Officer, Upazila Statistical Officer, Officer of Upazila Project Implementation Office (PIO), Upazila Forestry Officer and Upazila Fishery Officer. Global Positioning System (GPS) was used to point out the actual location of the recovery houses in the study area. ArcGIS software was used to prepare the maps.

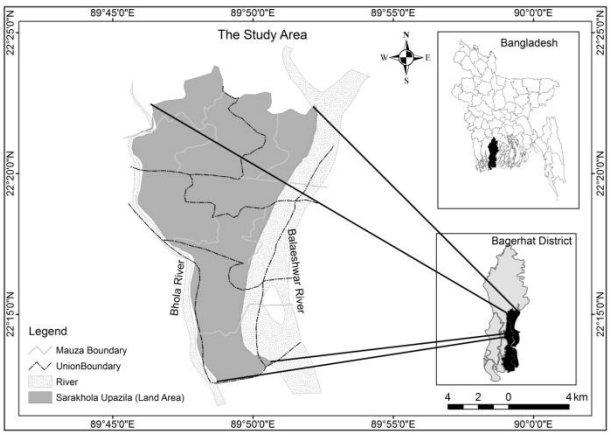

Figure 2: The study area- Sarankhola Upazila
(Source: Author's compilation, 2011)

Results and Discussion

Salient Features of the Coast

The coastal region comprises a territory of 47,201 sq km, which is about 32 percent of the total area of Bangladesh (Table 1). The total length of the coast is 710 km. Out of 19 districts and 147 Upazilas, 12 Districts and 48 Upazilas are directly exposed to sea coast. These exposed Districts and Upazilas together make 23,935 sq.km or 50.7 percent of the coastal area. The other 7 Districts and 99 Upazilas are interior of the coast but contain the same physical and environmental feature. But they are also prone to tidal surge and other form of natural calamities with varying intensities. Moreover, coastal zone offers immense potential for economic growth. Renewable and non-renewable energy, marine resources, beach minerals tourism are some of the less explored areas (WARPO 2006, BBS 2003).

Table 1: Salient features of the Bangladesh coast

Items	Coastal Zone	Data year and sources
Land area	47,201 km^2	2001 (BBS 2003)
Sea area (boundary)	200 nautical miles	Territorial Waters & Maritime Zones Act, # 26; April 1974
Districts	19 nos.	2001 (BBS 2003)
Upazila/Sub -district	147nos.	2001 (BBS 2003)
Total Population	36.8 million	2001 (BBS 2003)
Male	18.8 million	2001 (BBS 2003)
Female	18.0 million	2001 (BBS 2003)
Urban	8.5 million	2001 (BBS 2003)
Rural	28.3 million	2001 (BBS 2003)

Conversion of Crop Land into Fish Cultivable Land

There are four Unions in the study area having a total area of 15,129 ha and Sarankhola forest range covers an area of 59,484 ha. Total cultivable land of this Upazila is about 9,951 ha or about 66 percent of total area (Figure 3) except Sarankhola forest range. On the other hand, total wetland area of this Upazila is about 3,258 ha of which major portions are used as agriculture land in dry season (BBS 2011, MoL 2011).

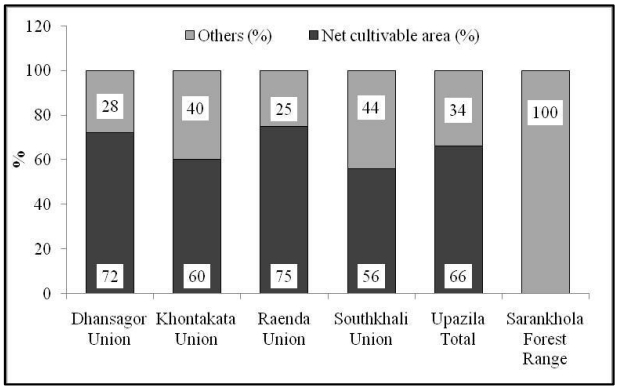

Figure 3: Net cultivable area of the study area

There were two types of wetland in this Upazila such as open water fisheries consist of river, canal and flood plain with water area and aquaculture comprises of homestead fish culture, commercial fish culture and shrimp culture. Homestead ponds were small, medium, large types. All types of culture were found in this Upazila. Major native species were: rui (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhina mrigala*) and exotic fishes tilapia (*T. nilotica*), grass carp (*Ctenopharyn godon idella*), silver carp (*Hypopthalmichthys militia*), big head (*Hypopthalmicthys nobilis*) etc. (MoL 2011).

It was observed that crop land gradually converted into the culture fish grounds. In pre-disaster condition (2007), 2,034 homestead ponds and ditches were cultured carp fish (Table 2). In some cases, small scale commercial water bodies were used for carp fish production. Total area of four Unions under homestead and commercial fish culture was 222 ha. Dhansagor Union was found as the top based on the number of ponds and maximum area of fish culture and followed by Raenda, Khontakata, and Southkhali Union. Total numbers of fish culture ponds and ditches as well as total area were increased after cyclone Sidr. A total of 2,063 homestead ponds and ditches were found in 2011 and total area was 265 ha. It was found from field observation (community KIIs), KII survey results of Upazila Agriculture Officer and Upazila Fishery Officer show that additional 43 ha culture and small scale commercial carp fish land was converted from agricultural land. People of the study area converted their land because cyclone Sidr decreased soil fertility as well as increased soil salinity of agricultural land.

Table 2: Union wise status of culture fish

Unions	Number of Ponds		Area of Ponds (ha)		Number Gher		Area of Gher (ha)	
	BS[+]	AS[++]	BS	AS	BS	AS	BS	AS
Dhansagor	610	615	75	80	515	520	250	255
Khontakata	530	535	31	66	310	315	155	160
Raenda	545	555	70	72	150	265	130	135
Southkhali	349	358	46	47	145	150	70	72
Upazila Total	2,034	2,063	222	265	1,120	1,250	605	622

Source: Compiled by the Authors based on Upazila database, 2011

[+] Before Sidr; [++] After Sidr

Temporary Change of Land Cover

Total 9,434 ha agricultural land was affected by cyclone Sidr in Sarankhola. Amongst the total agricultural land, crops of 6,764 ha land were washed away while 2,670 ha were partially damaged due to cyclone Sidr and its associated storm surges (Upazila Agriculture Officer during KII 2011). That means about 72% of agricultural land was temporarily uncovered (in terms of crop) by storm water.

Conversion of Crop Land into Homestead Land

There were 21,960 households in the study area. Amongst them 21,023 houses (main house) were damaged due to cyclonic effects of Sidr. According to the distribution of houses by damage type, there were 13,267 houses fully and 7,756 houses partially damaged. Most affected Union by the number of fully damaged main houses was Southkhali. A total of 4,584 main houses were fully damaged there. On the other hand, relatively less affected Union by the number of fully damaged main houses was Dhansagor where were total 1,948 main houses fully damaged there. Table 3 shows the detail information about Union wise fully and partially damaged main houses.

Table3: Union wise distribution of damaged main house

Union	Fully damaged	Partially damaged	Total damaged
Dhansagor	1948	1819	3767
Khontakata	3081	2808	5889
Raenda	3654	2112	5766
Southkhali	4584	1017	5601
Upazila total	13267	7756	21023

Source: Upazila PIO Office, 2011

A total of 18 agencies along with Bangladesh Government i.e., MoFDM, Muslim Aid, Caritas, Islamic Relief, Indian Government, Friendship etc. were

involved in post-disaster recovery in housing sector at Sarankhola Upazila. It was found from the study that some of the recovery main houses were built on agriculture land during post-Sidr recovery program of different agencies (Figure 4).

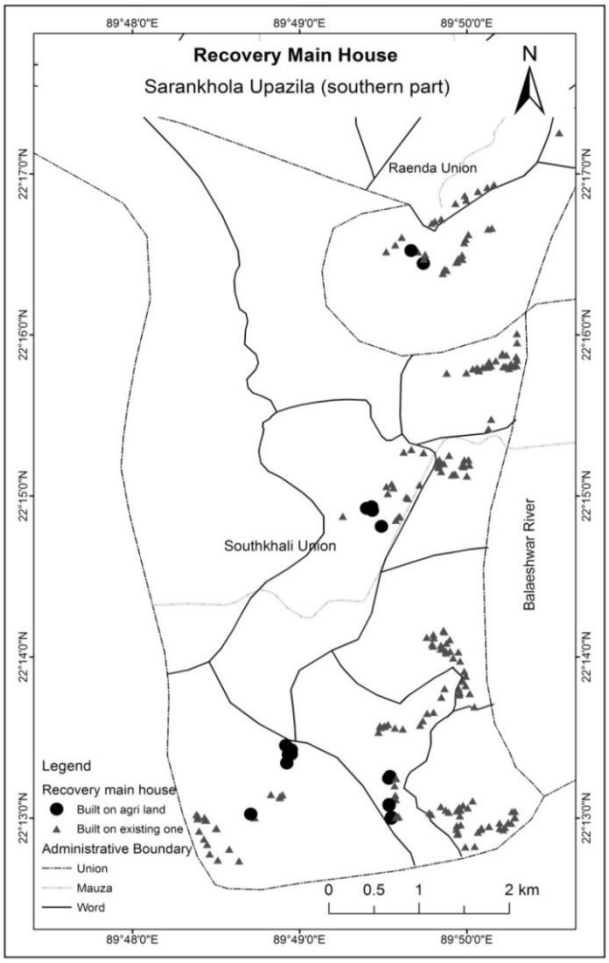

Figure 4: Settlement (sampled house) occupied agricultural land after Sidr

Land Use Modification

Modification is one of two categories of land cover and land use change. It represents a change within one land use or land cover category due to changes in its physical or functional attributes (Sambou *et al.* 2015). It was found from the key informant interviews, documents from Upazila Agricultural Office as well as field observation that after cyclone Sidr some farmers had modified their existing crop culture. Farmers of the study area strongly believed that saline water intrusion in soil due to cyclone Sidr became main challenge in farming. Therefore, they modified their existing crop culture such as they had started to cultivate sunflower instead of other crops. Sunflower (*Helianthus annuus* L.) was classified as moderately tolerant to salt though some wild species were more tolerant (Ashraf and Tufail 1995) thus sunflower was cultivated in many regions of the world and was a popular crop in countries that had salt affected soils like India and China (Masor 2011). Sunflower as new variety was cultivated in approximately150 ha land since 2011 in the study area. Non-government organization BRAC had provided technical and monetary help to the farmers (Upazila Agriculture Office database 2012).

Conversion of Homestead Forest Land

Homestead forest is a forest for the people and by the people, grown on marginal and fallow lands of homestead area, roadside, railway, embankment, river, canals (*khals)* and on fallow high lands characterized by a combination of annual and perennial forest species (MoL 2011). Table 4 showed there were 3608.04 ha forest area out of 15129 ha total area in the study area before cyclone Sidr. Of the total forest area homestead forest accounts for 3,451.59 ha which is about 22.81 percent of the total area.

Table 4: Union wise distribution of forest area before Sidr

Type	Union Name	Union area (ha)	Forest area (ha)	(%)
Homestead	Dhansagor	3,500	754.32	21.55
	Khontakata	3,861	1,075.96	28.87
	Raenda	4,030	877.33	21.77
	Southkhali	3,738	743.98	19.90
	Upazila Total	15,129	3,451.59	22.81
All	Sarankhola range	-	156.81	1.76
	Upazila total	15,129	3,608.04	23.85

Source: Compiled by the Authors based on Upazila database, 2011

Sidr struck the south-eastern part of the Sarankhola Upazila and caused severe destruction of forestry. The severe ecosystem disruption included uprooted, broken and twisted plants, and burnt foliage. According to the Upazila Forestry Office database (2011), about 60 percent homestead and social forest were destroyed during high wind and storm surges of cyclone Sidr. Among them, 98 percent of the trees along the embankment of the eastern part of the study area were almost destroyed whereas 60 percent trees were destroyed in the western part and 20 percent homestead forest were fallen due to cyclone Sidr. Therefore, it was understood that cyclone Sidr played crucial role in transforming homestead forest into deforestation by changing land cover and later by other use such as building new shelter etc.

Conclusion and Recommendations

Land transformation is the change in land use and land cover and the change may involve either a shift to a different use or an intensification of an existing one. Cyclone is one of the agents of land transformation in Bangladesh and all over the world. Cyclone Sidr hit the Bangladesh coast on 15 November 2007 and directly or indirectly changed the land use and land cover. It acted as an agent to shift crop cultivation land into culture and small scale commercial fish land, land cover to

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temporary uncovered land, crop land to homestead land as well as modified land use through introducing new crop variety and transformed the homestead forest in the study area. Based on the above discussion following recommendations can be made:

i) No doubt that cyclone is a devastating event and it may damage our crops and crop land more or less. Shifting nature of crop culture as well as crop type or introducing new crop may be accepted but shrinking the agriculture land through shifting of crop cultivable land into other use is going to be a great threat to our country considering food security. Thus, Government, particularly Agriculture Department should take proper initiatives to protect conversion of cultivable land into other use.

ii) About 60 percent homestead and social forest were uprooted and destroyed during cyclonic wind and storm surges created by cyclone Sidr. Thus, government should take afforestation project in order to restore the forest zone in the study area.

iii) Recovery program must be encouraged after any devastating event but the concerned authority of the government should also monitor and control the construction of houses, cyclone shelters and other structures on the agriculture land.

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