REMOTE SENSING AND GIS APPLICATION FOR ASSESSING COASTAL GEOMORPHOLOGICAL CHANGES: A RIVER BASIN APPROACH

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The purpose of this study is to understand the nature and state of geomorphic environment changes occurred in a southwestern coastal river basin of Bangladesh over a period of three decades (1967-2003). The study concentrates on the Kholpetua river basin, which receive fresh water flow from Betna in the upstream and tidal flow in the middle from Morichapa and finally drains to the Bay of Bengal through Kapotakshi River. The whole Kholpetua basin may be divided into three distinct parts: fresh water upstream, brackish water middle part and saline lower part.

Large-scale population increase, both in the up and middle stream section; infrastructure development, in the form of road network and introduction of HYV rice in the floodplain of Betna and shrimp farming on the brackish water have lead to the loss of both quality and extent of wetland resources in the basin area, endangering the geomorphological systematic balance in terms of input and output between upstream and downstream. A large section of Betna has dried-up, and most of the tributaries and distributaries of the Morichapa have been silted up, partly because of extensive poldering effect of the sub-basin. As a result, energy exchange (through tide) between basin plains and channels ways has lost vitally.

Multi-spectral remote sensing data, in conjunction with topographical maps and ancillary data analysis reveals that throughout the basin, a wide range of anthropogenic interference have physically altered the characteristic ecosystem of the basin. Such physical alteration has been initiated with the poldering of middle brackish water part of the basin and later with the introduction of extensive shrimp cultivation. Attempt has been made to explore the linkage of upstream landuse activities and drainage alteration to the hydrological and geomorphological behavior of the downstream basin areas, so that ecological sensitivity of the basin may be understood.

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1. Purpose:

The aims of this paper is to describe and explain the nature of environmental transformation that took place in the Kholpetua river basin since early '70's. The specific objectives are:

a. To identify & zoning the characteristics geomorphological, environmental setting of the coastal river basin;
b. To identify & inventorying the land use and land cover change occurred in the basin area over a period of 3 decades (1967-2001).
c. To understand the manner in which they are influenced by human interactions.

2. Background:

Bangladesh's coastal environment is changing under the influence of human activities. This is happening in the last few hundred years; human kind has deliberately changed the surrounding environment to serve both immediate and long-term needs. The extent to which this has occurred in ours coastal areas; however varies from coast to coast. There have been many unwanted side effects as a result of human activities; some were predictable, others are yet to be known. This initiative is a part of long-term project to document the changes and effects of human activities on the coast to provide a comprehensive picture of the state in a river basin approach. Unlike administrative units, a river basin is a form of hydrological unit, which provides a natural framework for a comprehensive evaluation of input-output relationship (Cooke & DoornKemp 1974).

3. Study Area: The Kholpetua river basin

Physical setting

The river basin developed from the combination of two important channels; the Betna and the Morichapa at the upper and middle part respectively. It covers the Upazila of Kolaroa, Satkhira upper part and part of Debhata, Asasuni in the middle part and Shyamnagar in the lower middle and lower estuarine part (Figure 1). Topographically, ridge and valleys are two common features of the flood and tidal plain. Elevation declines from 5m at the upper Betna to 0.6m at the lower kholpetua (Figure 2a). Agro-ecologically, the basin covers five characteristic zonation (Figure 2b): Lower Ganges flood plain, saline calcarious, salaine mixed, saline acid sulphate and mangrove areas (Table 1).

Table 1: The characterictics of the Kholpetua basin area

Basin Segment	Drainage condition	Drainage pattern	Tidal effect	Soil	Landuse/ landcover
Upper	Level low, well to moderate	Meandering	Free	Silty clay loam	Irrigated agriculture (ground water base)
Middle to lower middle	Moderate to low	Modified, under polder project	Tidal	Brakish & mixed, calcarious & non-calcarious, acid sulphate soil	Mainly shrimp faring, very limited agriculture
Lower part	Well, under natural condition	Anastomizing, well-interconnected through multiple branching of the tidal creeks	Strongly tidal	Saline, Silty clay & clay	Mangrove

Anthropogenic Activities with in the Basin:

Large-scale population increase, expansion of human settlements and intensive agricultural practices in the Kholpetua basin area has created the ground for major environmental transformation. The upper part of the Kholpetua basin area (Kolaroa) witnessed intense human pressure in the form of agriculture.

The middle and lower mid basin area covering lower Satkhira, Debhata, Kaligonj and Shyamnagar area under polder/ coastal embankments, since early seventies. Being protected against regular tidal effects through polder/embankment, the land witnessed a transformation from paddy cum grazing agriculture to protected agriculture up till the middle of 80's, when shrimp farming was introduced. Originally, the whole area was under mangrove forest even in the late 18^{th} centuries (Rennells 1779). Fierce competition between low yielding rice cum grazing and shrimp within the semi-saline belt came into surface (DDP 1985). The local traditional agriculture practices are more of local demand driven; the shrimp farming, however, is more of international market demand based.

4. Data:

The study used mainly primary data, were includes remote sensing and hydrological data. Besides, some secondary data where gathered, like population, land use, infrastructure related information's. Historical maps, like Renells map of 1779 and Thuilier's Map of 1872 were analyzed to record the extent of changes occurred in the mangrove forest. Digital images were processed and analyzed to identify and classify the basin area into different land use and land cover units. BWDB data on tidal records and embankment alignments were analyzed for documenting the nature and form of the changes occurred in basin landscapes.

5. Environmental Changes in the Kholapetua Basin:

Environmental changes of a landscape may be understood through a comparative analysis of land, water, atmosphere and its biotic condition of a period with a base period. In the present study, environmental changes related to land and water were analyzed only. According to B.B.S. (2001) the local population of the basin area has increased about 58 percent between 1981 to 2001. This extra population growth has impacted pressure on local resources, particularly on land use and land cover

Changes in land use /land cover of Kholpetua basin area between 1967 to 2001

The spatial and temporal changes occurred through 1967 t0 2001 area recorded in figure 3 (land use and land cover 1967, 1988 and 2001) and the statistics of land cover are given in Table 2. It appears that over a period of 3 decades there has been a net gain in settlement areas at the cost of agricultural lands. Besides, a phenomenal increase in shrimp farming took place and on the other hand seasonal grazing land has declined. The northern extent of mangrove forest was about 20 km interiors as recorded in the Rennells map and Thuilier's 1872 map (Figure 4). The Debhata, Kaligonj, Asssasuni were at the edge of the Sundarbans. The present Shyamnagar upazila was well inside the mangrove forest. Unlike, other parts of Bangladesh, net water bodies have increased due to the expansion of shrimp farming.

Table 2: Main land use of the Kholpetua basin area

Type of Land use (hectare)	1967	1988	2001
Settlement	32,318	49,925	56,789
Agricultural land	79,395	52,637	53,328
Shrimp farm	-	76,839	98,595
Fallow/ seasonal grazing	79,395	68,205	61,589
Mangrove forest	-	200,708	200,708
Closed waterbodies	6,325	2,806	1,611
River/Canal	-	108,131	107,630

Changes in hydrological conditions

The upper Betna has almost dried up above Kolaroa, drains only rainwater during rainy season. The middle part below Kolaroa is partly tidal but poldering at the down stream has induced rapid siltation of the channel. This has deteriorated the local drainage condition of the flood plains (Hossain 1998). Similar poldering effects are also evident in the immediate south of the Satkhira town where a vast embankment area become silted up, rendering the channels unfit for navigation and created serious water logging in the interior tidal plain (Figure 5). The water logged areas are in an around Jhaudanga, Raghunathpur, Kamarbaisa, Labsha, Dattadanga, Daulatpur, Korivila, Nevakhali, Bejudanga, Dhakakula. It was observed from the field that from Jhaudanga down to Gopinathpur, vast pockets of area, varying in size, remains water logged mainly due to the construction of the water control structure at the downstream. The local inhabitants also reported that Rajnagar, Bultipara, Kheterdanga, Khajurdanga, Kaikhali, Shibnagar and Taltala remains water logged from middle of June to October. So these new water logged areas are the out come of deteriorating river condition of the area.

The embankment, although given protection against saline water intrusion, but it has deprived the interior plains effectively from two important benefits:

a. In the tidal exchange between sea and tidal plain at the interior, huge finer silts are added to the valley bottom and thereby, low-lying area gains height. This process of valley infilling goes on until land raise up. In the present context, as tidal water cannot get in to the tidal plains, thus silt laden tidal water deposits silts on the channel bed instead of tidal plain, thereby, drainage behind the channel remains a problem, and the hydraulic behavior become more erratic, particularly bank erosion expedites.
b. Again, in the form of tidal exchange, the sea actually transports oxygenated water to the tidal wetlands wherein biotic life requires oxygen for respiration and local organic substances and detritus are decomposed through this water.In exchange, nitrate and phosphate rich wetland water are transported back to the estuaries which are essential to the near-shore marine life (Slaymaker 1996).

6. Discussion and Conclusion:

a) The Kholpetua river basin has three distrinct physical setting – Fresh water, semi-saline/brackish and saline zone. Extensive shrimp farming practices in semi-saline zone are gradually pushing both laterally and upwards causing alteration of the characteristic fresh water habitats and the semi-saline characteristics as well.

b) Poldering of the tidal rivers have affected the drainage efficiency at lower order, causing serious drainage congestion in the tidal wetlands and enhance siltation in the tidal channels.

c) From estuarine ecological point, poldering also affects nutrient exchange between tidal wetlands and estuaries and Bay.

d) In the last 3 hundred years the mangrove forest has been cleared southward very rapidly. From 1779 to 1872 a strip of about 10 km wide mangrove forest has been disappeared and up till now another strip of similar extent has gone.

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