



## CHANGES IN PHYSICAL ENVIRONMENT OF THE SOUTHWESTERN COASTAL BANGLADESH: A RIVER BASIN APPROACH

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**Abstract:** This study deals with the nature and state of geomorphic environmental changes of a coastal river basin at southwestern Bangladesh over a period of three decades (1973-2009). 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 upper and middle basin; 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 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 *polders* of the sub-basin. As a result, energy exchange (through tide) between basin plains and channels ways has lost vitality.

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. The agricultural land is about 79,395 ha. in 1973, which is reduced at about 53,328 ha in 2009. With 1779 to 2001, a strip of about 20 km wide mangrove forest has been disappeared. 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, extrapolate ecological sensitivity of the basin.

**Keywords:** South-western Bangladesh, River basin Environment, Hydro-geomorphology, Coastal embankment (*Polder*), Land use and Land cover, Remote Sensing and GIS

### Introduction

The physical environment of coastal Bangladesh is changing because of human activities particularly during the last few hundred years. However, the extent varies from coast to coast. There have been many unwanted side effects as a result of human activities; some are predictable, others are yet to be known. This study is part of a long-term project to document the changes and effects of human activities on the coast in order to have a comprehensive picture of the state of art of the river basin. River basin is a form of hydrological unit, which provides a natural framework for a comprehensive evaluation of input-output relationship (Cooke and DoornKemp, 1974). It is expected that a basin approach would enable us in understanding the state of hydro-geomorphological, agro-ecological condition and their interconnectivity with human activities within a time span of 30 years. The aims of this research is to describe and explain the nature of environmental transformation in the *Kholpetua* river basin during (1973-2009) with the particular reference to its geomorphological, environmental setting, land use and land cover changes and human interventions.

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### Material and Methods

**Study area:** *Kholpetua* basin has developed from the combination of two important channels; the *Betna* and the *Morichapa* at the upper and middle part respectively. The upper part of the basin covers upazila *Kaloroa* and part of *Sathkira*, the middle basin covers part of *Assasuni* and *Shyamnagar* covers the lower part of the basin. It covers the Upazila of *Shyamnagar* in the lower middle and lower estuarine part (Fig. 1).

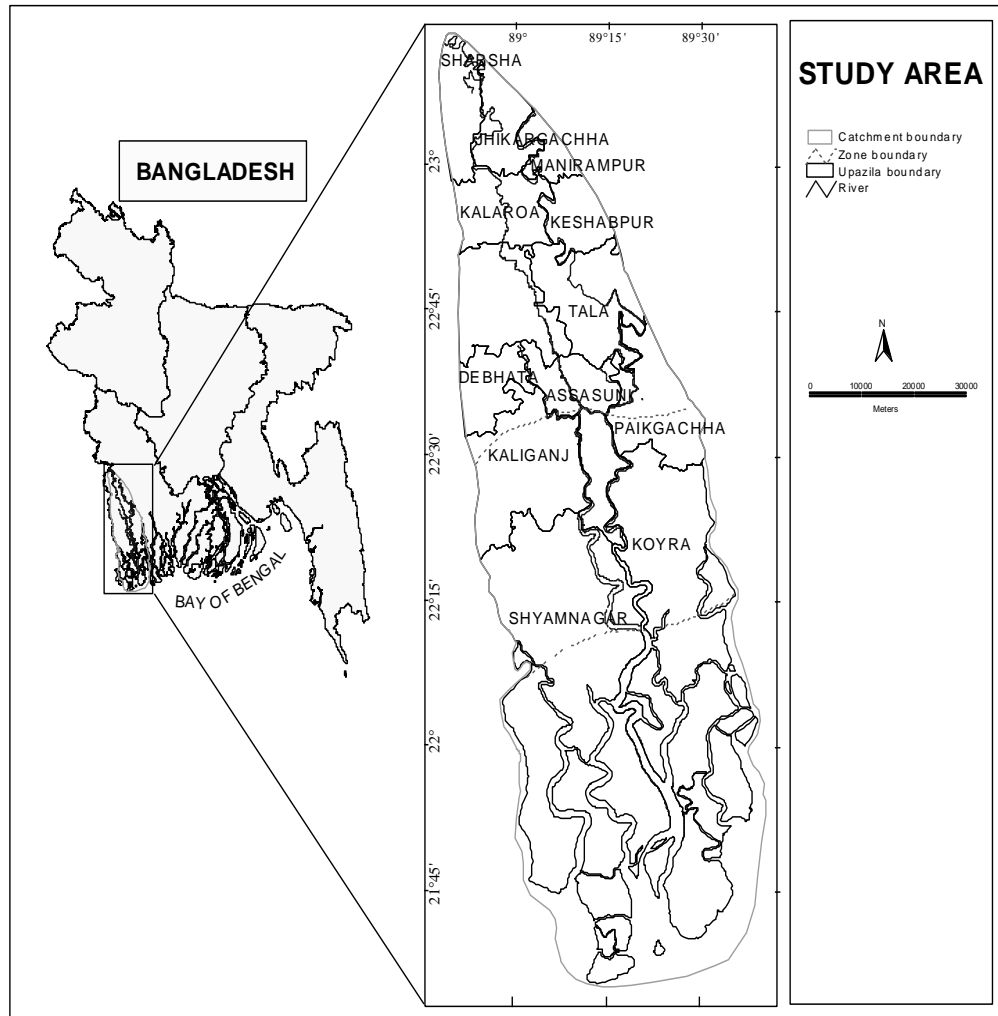


Fig. 1. Location of the *Kholpetua* river basin

Topographically, ridge and valleys are two common features of the flood and tidal plain. Slope declines from 5m at the upper *Betna* to 0.6m at the lower *Kholpetua* (Fig. 2a). High tide reaches approximately up to 4 meters which means more than 90 percent of the basin area are under regular tidal influence. Agro-ecologically, the basin covers five characteristic zones (Fig. 2b) such as Lower Ganges flood plain, saline calcareous, saline mixed, saline acid sulphate and mangrove areas (Table 1).

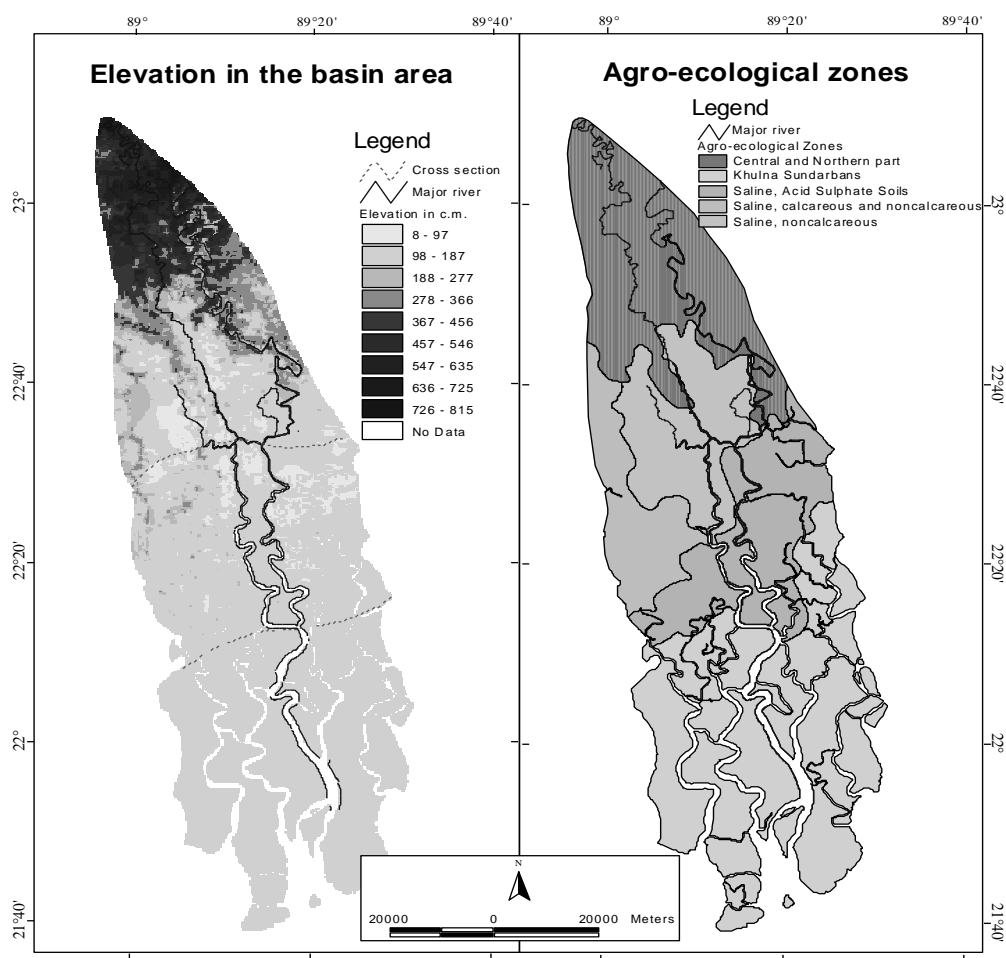


Fig. 2. Elevation and Agro-ecological of the basin area

Table 1. The characteristics 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

The broad agro-ecological zonation clearly reflects the local tidal soil and agro meteorological condition. Among the zones only lower Ganges floodplain are under intense agricultural practice. The other zones are limited to rice cultivation in the wet season. The major part is under mangrove forest with very dense river network.

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 *Satkira*, *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<sup>th</sup> centuries (Rennells, 1779) as reflected in the Fig. 3. 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.

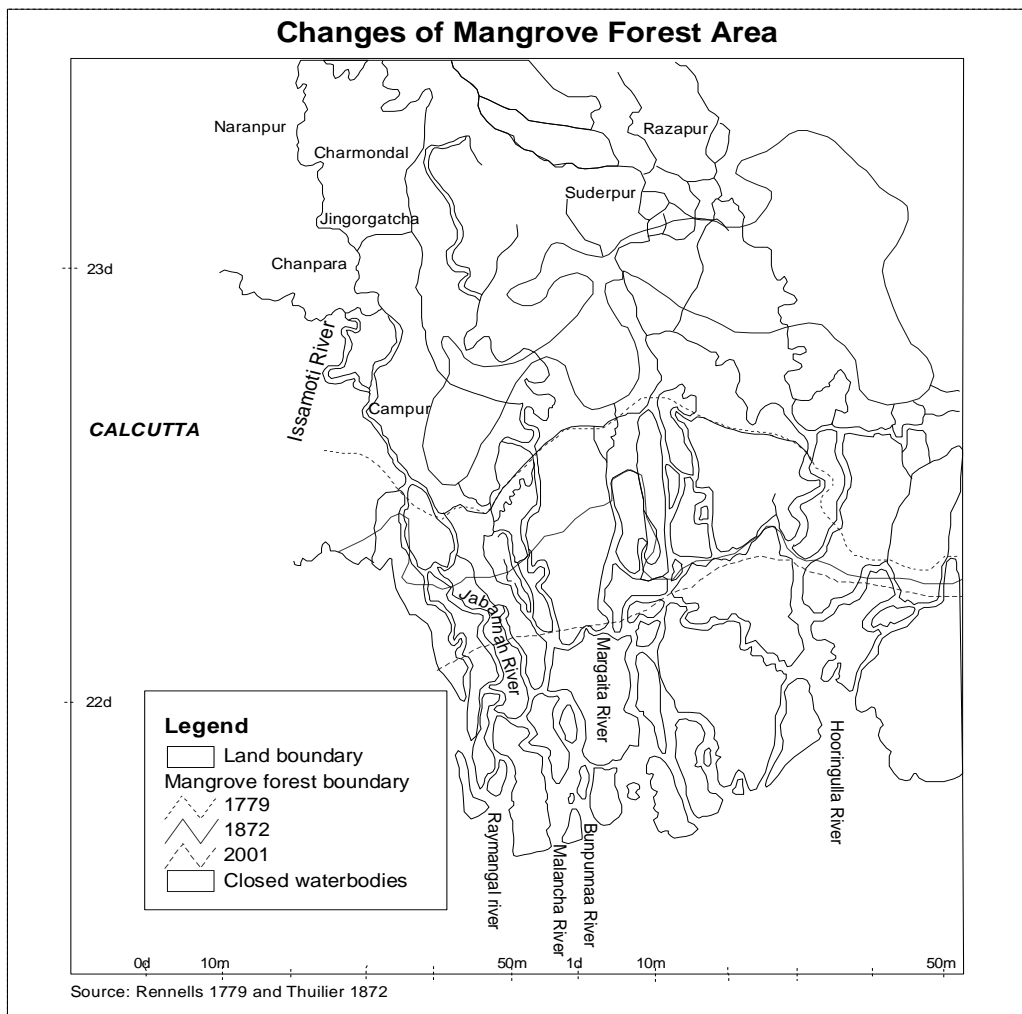


Fig. 3. Changes of Mangrove forest area

Traditional agricultural practices are on retreat more rapidly mid basin to upper basin. Therefore, diversified demand agriculture has also declined in the area. The shrimp farming practice support very limited population, reduced in surplus agricultural labor. Moreover, net cultivable agricultural land has declined quite dramatically, putting tremendous pressure on the marginal farmers and landless people.

**Methods:** Optical satellite remote sensing and hydrological data were used primarily in this study. Secondary data such as agro-ecological, hydro-geomorphological, elevation, population census and land use, and infrastructure related information's were also used. Renells map of 1779 and Thuilier's Map of 1872 were analyzed to record the extent of changes occurred in the mangrove forest. Digital image processing software was used to process the images (Table 2) and analyzed to identify and classify the basin area into different land use and land cover units. Bangladesh Water Development Board's data on tidal records and embankment alignments were analyzed in Microsoft excel and access environment and for documenting the nature and form of the changes occurred in basin landscapes.

Table 2. Optical sensor satellite data used in the study

Satellite Sensor	Acquisition Year	Spatial Resolution (Meter)	Spectral Resolution (No of Bands)
Landsat MSS	1973	80	3
Landsat-5 TM	1988	30	4
IRS P6 LISS-III	2009	24	4

**Results**

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 Bangladesh Bureau Statistics (2001) the local population of the basin area has increased about 58 percent between 1974 and 2009 (Fig. 4). This extra population growth has impact on local resources, particularly on land use and land cover.

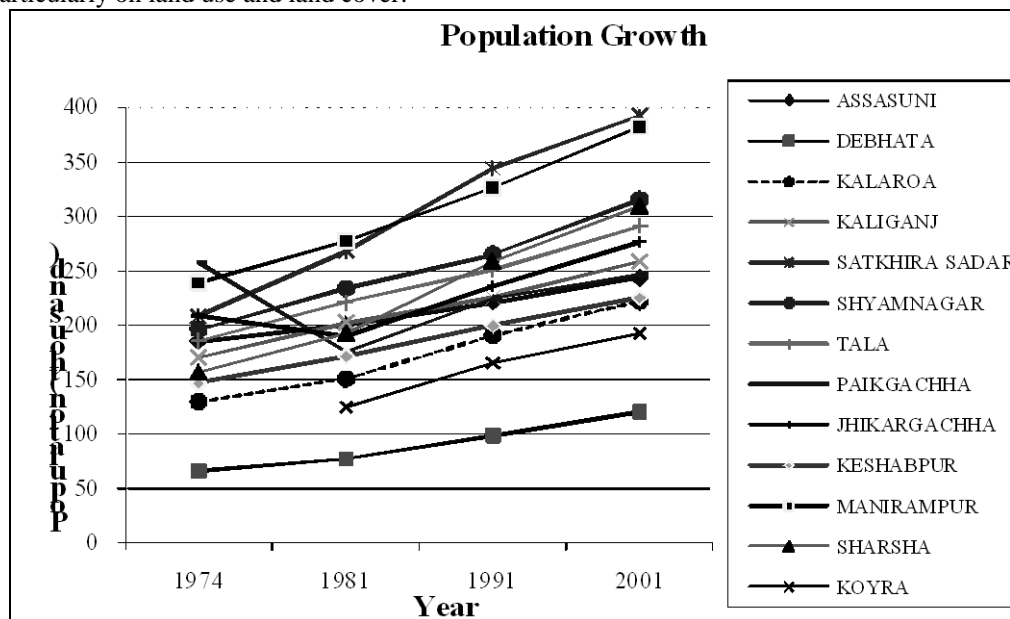


Fig. 4. Population growth in the basin area (1974-2001)

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**Changes in land use /land cover of Kholpetua basin area between 1973 and 2009:** The spatial and temporal changes in land use and land cover occurred between 1973 and 2009 are recorded and is presented in Table 3. Over a period of three decades net gain by settlement and agrarian activities in settlement areas at the cost of agricultural lands has been observed. An increase in shrimp farming has caused drastic decline in seasonal grazing opportunities. The northern extent of mangrove forest was about 20 km interiors as recorded in the Rennells's 1779 and Thuilier's 1872 map (Fig. 3). The *Debhata, Kaligonj, Assasuni* 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 3. Main land use of the *Kholpetua* basin area

Type of Land use (in hectare)	Year		
	1973	1988	2009
Settlement	32,318	49,925	61,269
Agricultural land	79,395	52,637	49,128
Shrimp farm	NI	76,839	102,978
Fallow/ seasonal grazing	79,395	68,205	57,896
Mangrove forest	NI	200,708	199,527
Closed waterbodies	6,325	2,806	1,327
River/Canal	NI	108,131	106,116

*Nb.* NI- Not identified in the image due to coarser resolution; Open waterbodies are not considered and value remained constant.

**Changes in hydro-geomorphic 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 *polders* at the down stream have induced rapid siltation of the channel. This has deteriorated the local drainage condition of the flood plains (Hossain, 1998). Similar impacts 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. The water logged areas are in and 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 flows of the area.

The embankment, although given protection against saline water intrusion, deprives the interior plains effectively from two important benefits: *a.* In the tidal exchange between sea and tidal plain at the interior, huge amount of silts are added to the valley bottom and thereby, low-lying areas gain height. This process of valley infilling goes on until land raise up. In the present context, as tidal water cannot get into the tidal plains, thus silt laden tidal water deposit silts on the channel bed instead of tidal plain. In a short time, drainage behind the channel became restricted 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 for near-shore marine life (Slaymaker, 1996). In the study river basin, tidal exchange between offshore and interior of the basin occurs twice daily thus opportunity for energy exchange remains open up to the upper tidal limit of basin.

However, with increasing control in the tidal river through *polders* and shrimp farming possibilities such energy exchanges through tidal pressure are waning.

### **Discussion**

The *Kholpetua* river basin has three distinct physical setting – fresh water, semi-saline/brackish and saline zone. Extensive shrimp farming practices pushing the semi-saline zone gradually upward is causing alteration of the transition zone lying between semi-saline and the fresh water zone and the characteristic fresh water habitats. *Polders* of the tidal rivers have affected the drainage efficiency, causing serious drainage congestion in the tidal wetlands and enhanced siltation in the tidal channels. *Polders* also affect nutrient exchange between tidal wetlands and estuaries and Bay. In the last three hundred years the mangrove forest has been deforested southward very rapidly. From 1779 to 1872 a strip of about 20 km wide mangrove forest has been disappeared and up till now another strip of similar extent is in the process of disappearing (Fig. 3).

### **Conclusion**

The present study is only indicative of the types and direction of environmental changes occurred in a coastal river basin arising out of present human activities. 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. Similar transformation of the river basin are widely taking place elsewhere of the coast. Further research is needed to generate the hydro geomorphological and bio-geomorphological aspects in a basin approach, so that measures and related to the environmental quality of the basin may be maintained in a sustainable manner.

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