



RECENT GEOMORPHOLOGICAL CHANGES OF *MAYUR* RIVER, KHULNA, BANGLADESH

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Background

The *Mayur River* is situated at the back swamp of the *Bhairab-Rupsha River*. Khulna City Corporation (KCC) is situated on the bank of this river basin and the *Mayur River* borders the westbound of the city. On the northbound of KCC there is a vast water body called *Beel Pabla* from which the *Mayur River* is originated. It is locally known as the *Khuder Khal* at the point of origin. From *Rayer Mahal or Hamidnagar* sluice gate it is known as *Mayur*. It has run through *Chalk Mathurabad* and *Choto Boyra* and has met the *Rupsha River* at *Alutola*. The river is about 11.69 km long and varies by width widely at different chains. A branch of the *Mayur* near *Alutola* is also called *Hatia River* which is now almost dead. Bangladesh Water Development Board (BWDB) constructed an embankment along the *Mayur River* during 1982-1983 as a protection embankment for KCC to protect saline water intrusion in the region. Since then this river has been experiencing intervention or tidal water flow from downstream (*Alutola*) to upstream (*Hamidnagar*) during dry season. Besides, most of the part of KCC belongs to the *Mayur* sub-basin which has gone through an obvious modification of landscape due to urbanization in this area in recent time.

Geomorphological changes of landscape of *Mayur* sub-basin can be attributed to changes in the river-scape of *Mayur*. This tiny river drains out about 75% of the KCC effluents of 242,028 L per day and to be regarded as a very important component of the city drainage system. Excessive waste dumping and infrastructural modification along the river bank enhances mass deposition thereby lowering the river depth. As a result, almost no tidal action is observed during the dry season. It is now dominated by downstream flow (tidal water) and rainfall-runoff and is subjected to continuous exposure of industrial

effluents and waste disposals from riverside establishments and city wastewater lines. Consequently, the water quality is assumed to be deteriorated, even though this water is still used in irrigation for its cost effectiveness and lack of alternatives. In this context of *Mayur*, if the anthropogenic stresses surpass the ability of the biophysical processes to undoing the alteration, it can widely rearrange the geomorphology of the ecosystem.

In this context, this study examines and interprets the recent geomorphological changes of *Mayur* River bordering the north-western limit of Khulna City Corporation (KCC) situated in the south-western coastal Bangladesh, to identify the hydrodynamics of the river-scape.

Materials and methods

The methodology of this study is embedded in identifying the changes in the landform of the *Mayur* sub-basin due to anthropogenic stresses. Anthropogenic actions can be considered as formative events since those are responsible for shaping landforms that persist over longer period of time irrespective of morphological changes generated by frequent events (Brunsden 1990; Urban and Rhodes 2003). In this study, contribution of anthropogenic actions in changing the geomorphology of *Mayur* river sub-basin has been analyzed by using satellite images to classify the land use change over a time period of 32 years (1977 - 2009) and to analyze change in channel plan-form and channel geometry within this time.

All the analysis has been done within the drainage basin of *Mayur* (Figure 1) that has been derived by a DEM based automatic watershed delineation technique of the ArcSWAT

2009.10.1 software, the GIS version of SWAT (The Soil and Water Assessment Tool) model (<http://swat.tamu.edu/>). The DEM of SRTM GTOPO30 data set (available at <http://earthexplorer.usgs.gov/>) was used for the watershed delineation.

The land use classification for this analysis has been done by supervised classification technique using Landsat Images that were obtained from the website of USGS (<http://earthexplorer.usgs.gov/>) for the years 1977, 1989, 1999, 2006 and 2009 and all of them were dry season images. All the images are of 30 meter resolution except the image of 1977 which had a resolution of 60 meter. However, the classified maps were not possible to verify since no reference land use map is available for this area in the respective interval of available satellite images.

Changes in channel plan-form have been derived from a Geographic Information System (GIS) based analysis of the stream locations according to the available satellite images. The stream locations in the respective satellite images were digitized along the centreline of the stream-channel of *Mayur*. The digitized lines are then buffered with an equal distance of 30m and superimposed to compare the lateral change of the stream centreline (Urban 2003). A 30m buffer distance has been chosen to avoid maximum possible digitizing error since the satellite images are of 30 m resolution. Therefore, the comparisons of the buffers are expected to reflect actual changes in the position of centrelines. When buffer area of the centrelines for two years didn't overlap, they shall form a polygon which actually represents channel displacement during the time interval of the images.

The changes in channel width of the river have been measured at 12 stations of the river from the satellite images. In fact, the mean width of the channel in 100 meter up and down stream of the respective station has been determined to better represent the channel width along the river.

Geological Setup of the *Mayur* Basin

The drainage basin of *Mayur* is bounded between 22°51'15" N and 22°45'01" N latitude and 89°29'31" E and 89°34'25" E longitude (Figure 1) which covers an area of 39.89 km² and the elevation varies between 1.5 to 5 m above mean sea level. The current state of the *Mayur* drainage basin and the *Mayur* valley is the result of changing land use and land cover through urbanization and construction of infrastructure for water diversion.

Geologically the *Mayur* sub-basin is relatively recent formation. It is a part of the lower region of the moribund delta. It represents a smaller component of one of the three subsystems e.g., *Shibsha-Passur-Marjata* of the complex network of rivers in the southwestern Bangladesh where freshwater from upstream is ceased to flow much earlier. The geology of *Mayur* sub-basin is characterized by neo-tectonics and is an area of active tectonic subsidence (Adhikari et al., 2006). Structurally the drainage basin represents the southern edge of the Faridpur trough and stratigraphically composed of dark grey to black silt and clay deposited in the active tidal zone dominated by organic rich swamps. Geomorphologically the *Mayur* drainage basin represents functional attributes of fluvial forms and processes along with recent human interventions and modifications in the form of inter-basin diversions and flow regulations (Rashid 1991).

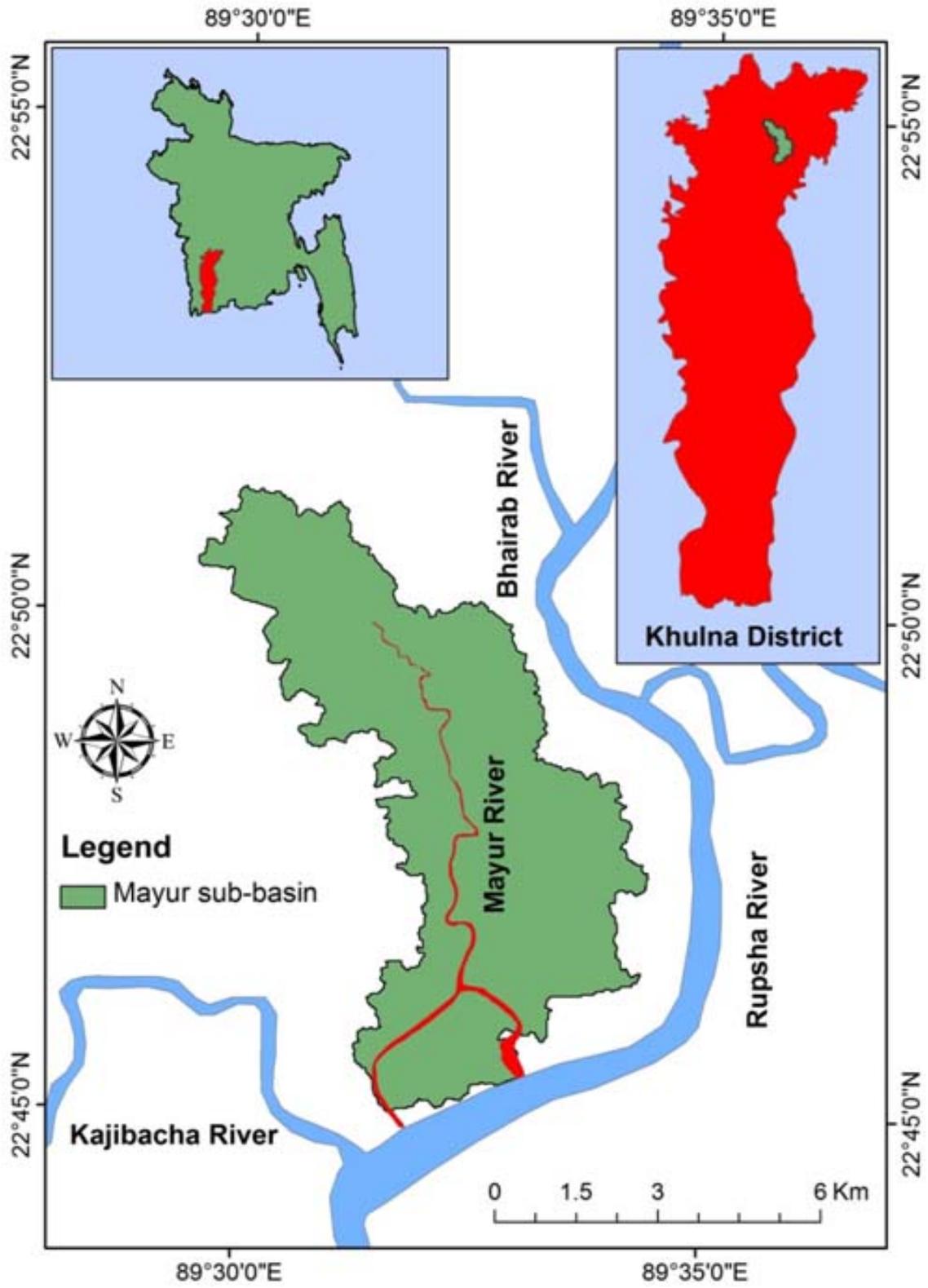


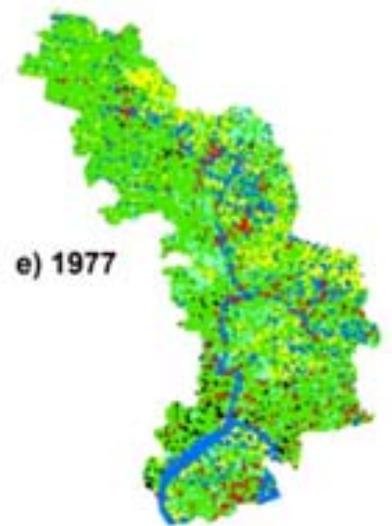
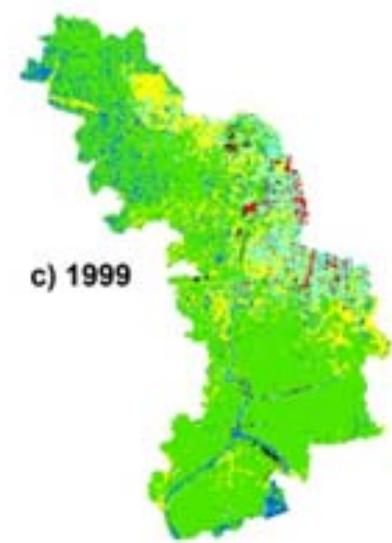
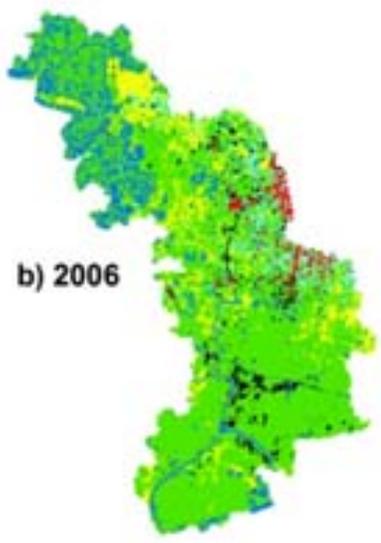
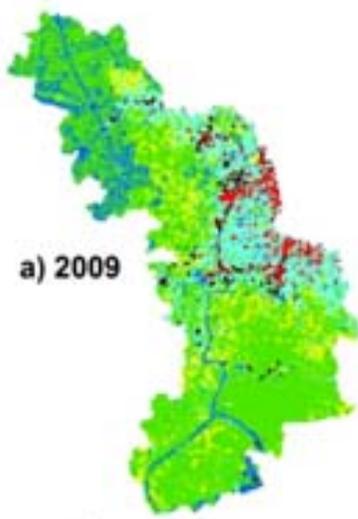
Figure 1: Map of *Mayur* sub-basin.

Morphological changes of Mayur Basin

About 30 years ago *Mayur* was a very forceful and mighty river. The water was fresh and people use to swim. Even Trawlers and gigantic country boats use to pass through this river (Kamal et al. 2007; Das 2011; Karim, 2011; Rifat 2011). A City protection dam was constructed in 1982-1983 by BWDB to protect encroachment of saline water in the region. This blocked the natural flow of upstream water of the river and since then the *Mayur* started to die. The *Mayur* River is the main drainage channel for the eastern part of Polder 28/2, via a single 10 vent-sluice at Alutola (BWDB, 1992). Anthropogenic stresses like waste dumping from domestic and industrial sources and unplanned extraction of water for irrigation threatens the water quality of the river.

Land use change

The *Mayur* sub-basin experienced significant change of land use in last three decades. The land use and land cover change from 1977 to 2009 was identified through the satellite image based supervised land use classification. Land use classification was done by the images masked by the *Mayur* sub-basin area. For the convenience of this study, we classified land use of *Mayur* sub-basin in to five classes: agriculture, low settlements (having about 30 paved area or less), high settlements (about 70% paved area or more), medium settlements (about 50% paved area), wetlands (all types of water body), others (unclassified area). Land use map of the *Mayur* sub-basin for the above mentioned year is presented in Figure 2 and the Area under different land use classes are illustrated in Figure 3.



Legend

-  Agriculture
-  Low settlements
-  Medium settlements
-  High settlements
-  Waterbody
-  Others



Figure 2: Land use map of Mayur sub-basin from 1977-2009.

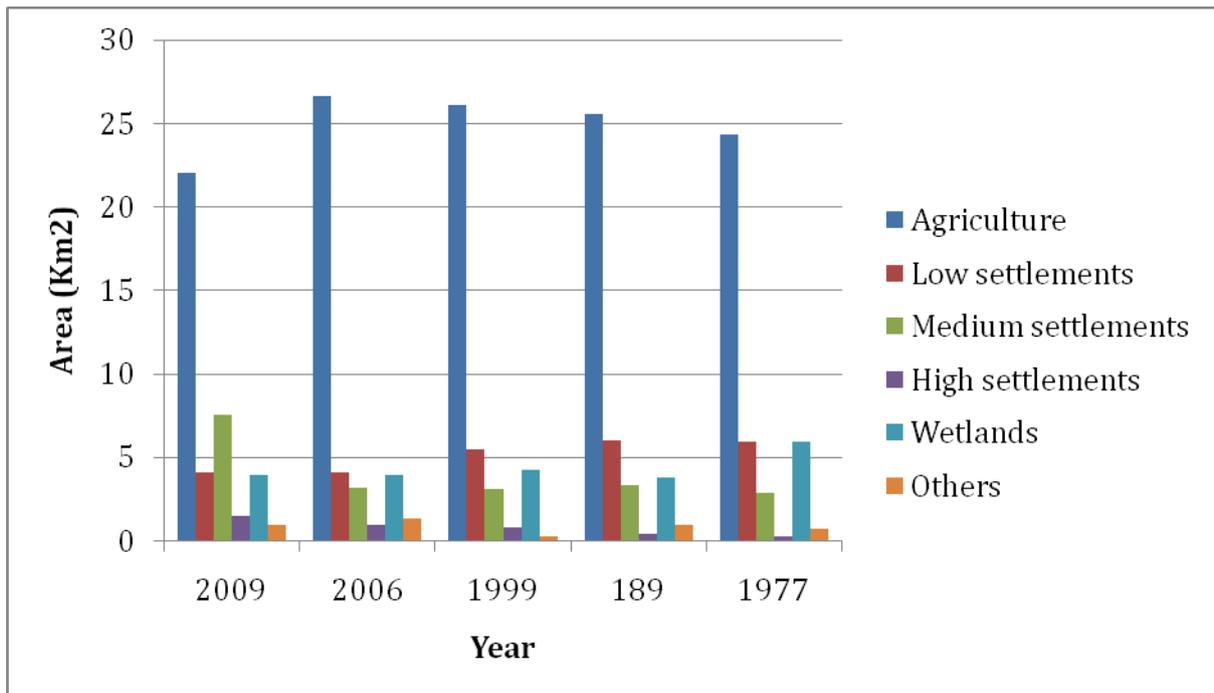


Figure 3: Land use classes of *Mayur* sub-basin between years 2009-1977.

Agriculture is the main land use of *Mayur* sub-basin and has a declining trend. It declined from about 61% to 55% from 1977 to 2009 respectively. Settlements is the second major land use and area under this category increased from about 22.5% to 33% from 1997 to 2009 respectively. Although in 1977, low settlements were the major type of settlements (about 65.5% of total area under settlements) and high settlements were the lowest (about 3% of total area under settlements). Whereas, in the year 2009, medium settlements became dominant among the types of settlements (about 58% of total area under settlements) and high settlements still remains lowest (about 4.5% of total area under settlements). Between 1977-1989, growth rate of medium settlements were highest in comparison to other settlements categories and it still remains highest between 1999-2009, but the rate for low settlements had declined sharply from +0.02% to -0.35% per year. Area under wetland declined gradually from about 15% to 4% between 1997 to 2009.

Channel plan-form and channel geometry

A GIS based analysis of the changes in the stream location was done to identify the changes in channel planform. The same satellite images were used to digitize the centreline of the stream-channel of *Mayur*. The digitized lines are then buffered with an equal distance of 30 m and superimposed to compare the lateral change of the stream centreline. A 30 m buffer distance has been chosen to avoid maximum possible digitizing error since the satellite images are of 30 m resolution. Therefore, the buffers are expected to reflect actual changes in the position of centrelines. When buffer area of the centrelines for two years didn't overlap, they shall form a polygon which actually represents channel displacement during the time interval of the images. A simple visual comparison using this technique has been presented in Figure 4.

The figure shows minor migration of the *Mayur* River at six stations between the year 1977 and 2009. It exhibits almost no detectable change in position at the six stations between time intervals indicating the stability of the river. In recent time (between 1999 and 2009), for most of the part, the channel is very stable. High degree of immobility of this river can be attributed to low stream power per unit bed area (ω). Stream power can be an approximate index of dynamics of a channel as it has a relationship with sediment transport and bank stability of the channel, and it is more likely for meandering stream (Bagnold 1966, 1977; Hickin and Nanson 1984; Nanson and Hickin 1986). Development of settlements and heavy construction in the bank area of the river can be an approximate cause of this channel stability. From the land use map it is obvious that the gradual growth of medium settlements along the river which is actually transformed from low settlements in recent past.

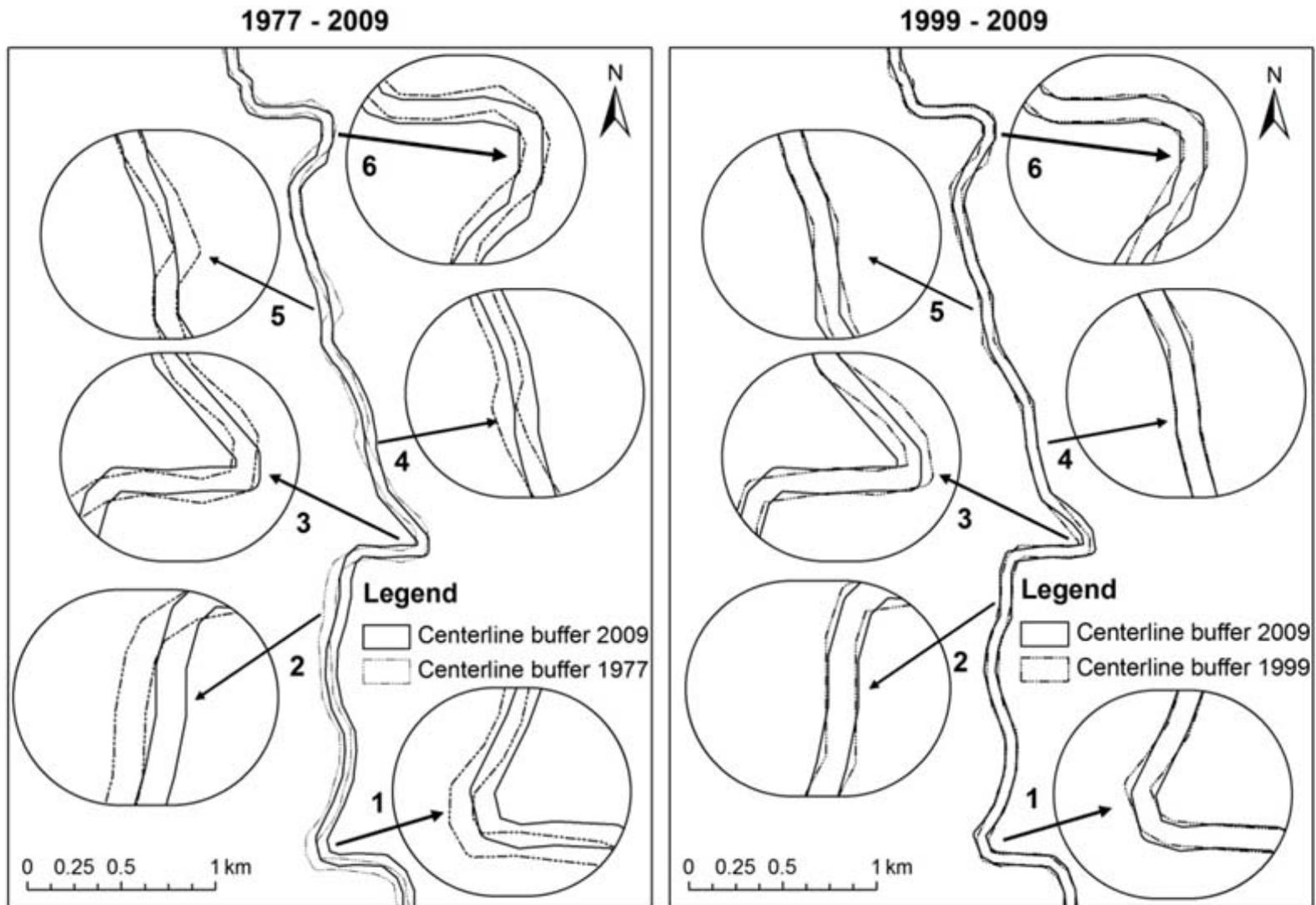


Figure 4: Change in channel plan-form of the *Mayur* River.

To detect the changes in channel geometry we measured the changes in channel width of the river at 12 stations of the river from the satellite images. The location of the stations along the river is shown in Figure 5(a). The channel width found at these stations in the image intervals are presented in Figure 5(b). Besides, the flow rate along the stations during 2009 has been presented in Figure 5(c). As flow rate decreases it also reduces the downstream flux of sediment and thereby increase lateral deposition. Consequently it favours reduction of channel width. Therefore, changes in flow rate can be related with shortening of channel cross-section. Unfortunately, the data for flow rate of this river is not available. However, in the flow rate of 2009, it is seen that the flow rate increases from upstream to downstream (from station 12 to 1) as does the width.

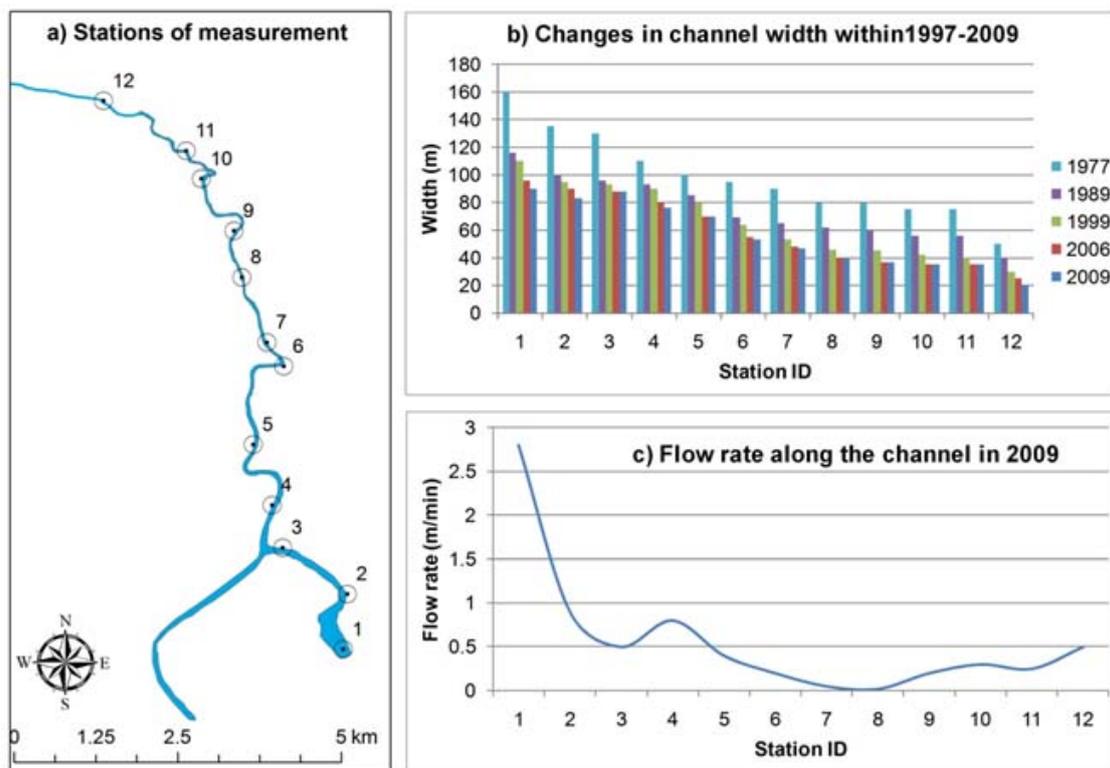


Figure 5: Changes in channel geometry of *Mayur* (a. Location of the stations, b. Channel width, c. Besides, the flow rate along the stations during 2009).

Conclusion

The geomorphology of the *Mayur* has been changed significantly in recent time. This study identified the changes in *Mayur* sub-basin during 1977-2009. Urbanization is the dominant type of change in this landscape in this time period and the conversion of land use occurs from agricultural land to settlements. With the growth of urban area the river is very likely to dry out which is obvious from changes in channel plan-form and channel geometry. The river shows higher stability in last decade although slight migration of the river is seen from the plan from analysis between year 1977 and 2009. Width of the river is found to decline significantly over this time period. Besides, width of the river declines toward upstream as does the flow rate. Considering the results of the study we can conclude that geomorphological changes of the *Mayur* sub-basin has a great influence on the river-scape of *Mayur* and the geomorphological changes of this basin is dominated by anthropogenic stresses.

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