RW11

Environmental Change Detection of the Padma river in the North-Western part of Bangladesh using Multi-date Landsat Data

Shareful Hassan, Dr. A.F.M.Akhtaruzzaman
Bangladesh Forest Research Institute, Chittagong, Bangladesh

***Abstract*—Bangladesh is a land of rivers. About 800 rivers have created a vast river network in the country. However, the whole river systems are disturbed due to low water inflow from the up-streams during the dry seasons. The Padma river is one of the most affected rivers in this respect. To identify its environmental changes with river paths, two multi-dates Landsat TM data of 1989 and 2010 were used in this study., It is revealed from the study that 7 unions of Kushtia, 1 union of Natore and 1 union of Raishahi district are in peril due to the shifting river paths. Another result from rainfall data has shown downward tendency in the study area too. The water temperature of the river has also dramatically declined in 2010 because of huge sedimentation and dissolved water particles. The overall image classification was 92%, 96% in 1989 and 2010 respectively.**

INTRODUCTION

Bangladesh is one of most riverine countries in the world. Total length of the rivers is 24,140 km where catchments area is about 1.61 million km^2. The Padma River is a big river system in Bangladesh that locates in the north-western part of the country. It is 120 km long and about 4 to 8 km wide.

Remote sensing and GIS has been advent as prominent tools in many relevant project as well as river studies. Remote sensing and GIS are widely used tools for detection and monitoring of changes of the physical environment [1]-[2]-[3]-[4]-[5].

The main objective of this study was to assess the river path and its physical environment using temporal Landsat TM data. TM has proved useful in ecological, hydrological and geomorphological river studies [6].

STUDY AREA

The Padma river is located in the North-Western part of the country and passed through Kushtia and Rajshahi district. Geographically it lies between 88° 30′ 0" to 89° 05′ 0" E longitude and 24° 0′ 0" to 24° 25′ 0" N latitude. This area has tropical monsoon climate where mean annual rainfall is 2000 mm which about 70% occurs during the monsoon season.

DATA AND MATERIALS

Two multi-date images of the Landsat TM were used to classify river paths in this paper. Both satellite data were collected from USGS. A 30 year highest and lowest water flow was obtained from Bangladesh Water Development Board (BWDB).

METHODOLOGY

Remote sensing is a promising tool for river and river morphological analysis. Remote sensing technology is uniquely capable of providing the synoptic, detailed data needed to examine the scaling of fluvial processes [7]

Some familiar remote sensing algorithms and equations were followed to identify changes of the river path as well as extract water temperature in this study. In order to carry out these tasks, following steps have been considered-

NDVI: Normalize Difference Vegetation Index (NDVI) is a promising algorithm to differentiate land and water interface. NDVI calculates near infrared (NIR) and RED as equation below where resultant values fall between – 1 to +1. Values near to +1 represent vigor vegetation while 0 to -1 express water, rock, soil, ice etc. NDVI values range between −1 and 1, with values above 0 indicating presence of vegetation and values below 0 indicating no vegetation [8].

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad (1)$$

Ranges from -.10 to - .08 were considered to classify the river path in this study.

*Water Temperature:*It was one of the most crucial parts in this study. Several steps were followed to extract the river temperature as followings-

1. Calculate spectral radiance for the both thermal images. Here LMAX_BAND6= 15.303 and LMIN_BAND6= 1.238 w/ (m sr μm) were considered for DN of 255 and 1 respectively.
2. A regression analysis was done using radiance values of LMAX_BAND6 and LMIN_BAND6. The resultant regression value y = 0.055374x + 1.182626 was multiplied by both thermal images.
3. This step was conversion of spectral radiance into radiant temperature (Kelvin). The equation below was followed to compute this-

$$T = \frac{K2}{\ln\left(\frac{K1}{L_\lambda} + 1\right)} \quad (2)$$

Where,
T= Effective at-satellite temperature in Kelvin
K2= 1260.56 (according to metadata of TM5)
K1= 607.76 (according to metadata of TM5)
L= It was obtained from step 2.

4. Emissivity of water varies at different wavelengths. Since spectral region of the thermal band of TM5 is 104 to 12.5 micrometers, the emissivity of this band is about 0.98. Therefore, to convert Kelvin to degree C, equation below was used -
   [(Step 3 * 0.98)-273.0]
5. An adjustment was needed due to water vapor between the surface and satellite sensor. In this regard, +2.0 were added in the two temperature masked images for solve the problem.

Finally, each classified image of the river path (only water) was multiplied by the same dated temperature image.

ANALYSIS

Figure 1 shows temporal changes of the river path where red color represents the river in 2010 while blue indicates the river in 1989. Unchanged water bodies were found in the north-eastern part where severely changed areas were found in the middle and south-western part of the river. About 10,344) hectare water areas (fig. 02) changed into land from 1989 to 2010.

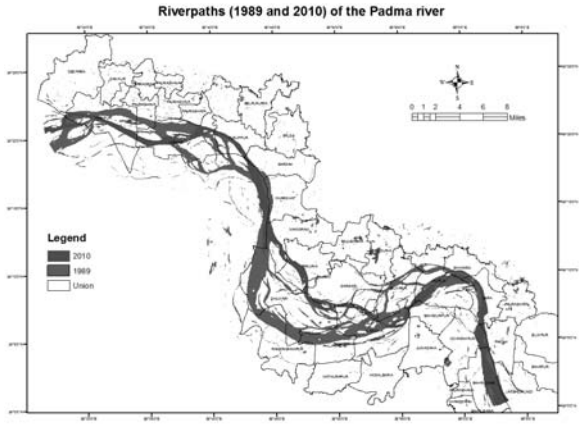

Fig. 1

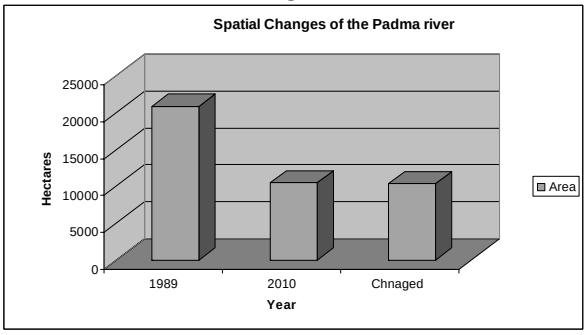

Fig. 2

The result reveals that 7 unions of Kushtia, 1 union of Natore and 1 union of Raishahi district are in peril due to the shifting river paths. Most of these regions are adversely affected due to the changes in agriculture, navigation as well as water supply, sanitation with public health problems. Meanwhile there is observed an acute water crisis problem where groundwater decline rates from 3 -4 meters per year.

Figure 03 shows decline water discharge rate from 1975 to 2005, which depicts an alarming situation along the river livelihoods and existing ecology. As a result, desertification process, induced by low ground water, drying up surface water, low soil humidity, scanty rainfall, increased temperature, low vegetation coverage etc is imminent disaster in the study area.

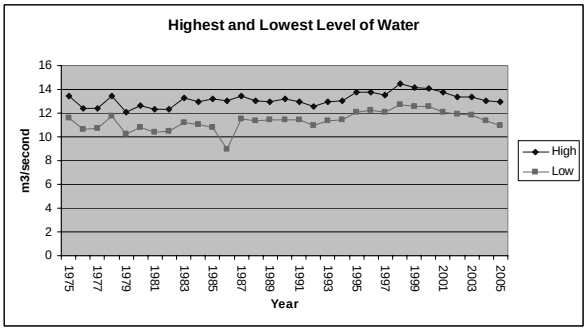

Fig. 3

Water temperature is an important factor for river morphology as well as ecology. River biodiversity also depends on water surface temperature as well. From fig 4, it is observed that the range of water temperature of the river was 14.89 to 47.77 degrees C in 1989 while it is found 11.81 to 13.14 degrees in 2010 (Fig 6). It means lowest quantity of the water volume decreased latent heat of the river water in 2010. Moreover, inflowing sediment loads with its size and dissolve load particles have reduced the water temperature in 2010 by high scattering of sunray.

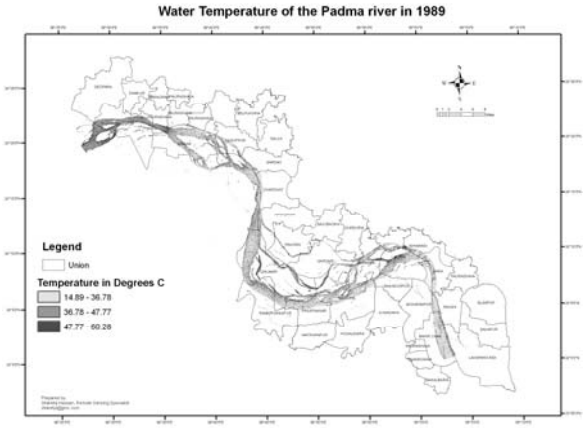

Fig. 4

The highest water temperature is found in the mouth of the Padma river in 1989 while it shows very low in 2010. Naturally, dependent variables of the ecology as well as bio-diversity of the river are disturbed by these changed parameters. As a result, many flora and fauna are extinct. Meanwhile, 21 different animals based on the river floodplain have been recorded at risk.

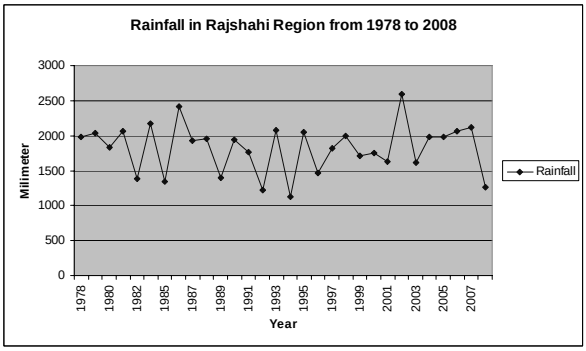

Fig. 5

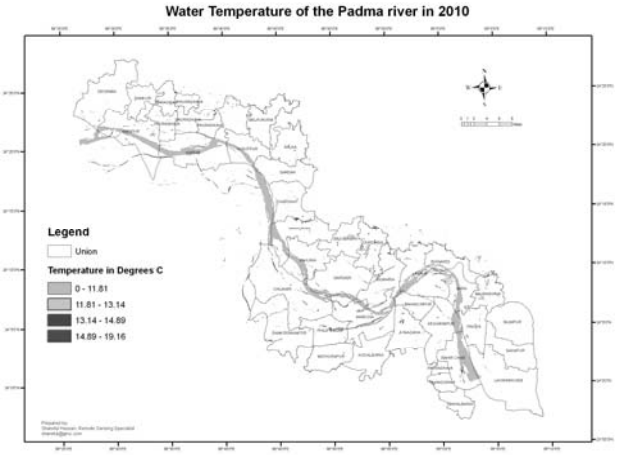

Fig. 6

The annual rainfall has an important role in agricultural development, vegetation growth, river flow as well as for recharge groundwater and restore surface water. But fig 5 shows a decline in rainfall tendency in the study area which normally reflects an alarming situation for both physical and cultural phenomena in the study area.

CONCLUSION

In summary, some unions of three districts of the north-western part of Bangladesh are in danger in terms of the river path shifting. From this study, it is revealed that, the river and its drying up morphological as well as physical entities will pose a serious threat to agriculture, ecology, bio-diversity including adjacent livelihoods. In addition to this, adverse impacts of climate change is playing as grave factor in the physical process of the river too.

Futher investigation is warranted to study the sedimentation size, flow, cross section as well as use of digital elevation model (DEM) to crate a river model for long-term sustainable management and improve depended livelihoods in study area.

REFERENCES

[1] Ahmed. M. H, "Multi-Temporal Conflict of the Nile Delta Coastal Chnages, Egypt," *Littoral* 2002, *The Changing Coast*. EUROCOAST/EUCC, Porto – Portugal, ISBN: 972-8558-09-0.

[2] Andrea. S.L., Douglas. E. J., R.H. and Grant. M. C, "Stream Change Analysis using Remote Sensing and Geographic Information System (GIS) ," *J. Range Manage,* 54,pp. A22-A50.

[3] Jensen. R. J, "*Introductory Digital Image Processing*," 3rd edition. New York: Prentice-Hall, Inc.

[4] Stabel. M. E. and Loffler. E, "Optimized mapping of Flood Extent and Floodplain Structures by Radar Eo-Methods," Editor: H. Lacoste. Published on CDROM, pp. 56.1, *ESA/RSRIN*, Frascati, Italy. 204ESASP. 550E.56S.

[5] Twumasi. Y. A, and Merem, E. C. "GIS and Remote Sensing Applications in the Assessment of Change within a Coastal Environment in the Niger Delta Region of Nigeria," *International conference of Environmenal Research and Public Health*, 3(1), pp.98-106. ISSN: 1661-7827

[6] Smith. C. Laurence, "Satellite Remote Sensing of river inundation area, stage, and discharge: A review". *Hydrological Processes*, vol. 11, 1997, pp. 1427-1439

[7] Mertes. L. A. K, " Remote sensing of riverine landscapes " *Freshwater Biology*, 2002, 47, pp 799-816

[8] Walker. D. Nan, and Kiage, M. Lawrence "Using NDVI from MODIS to Monitor Duckweed Bloom in Lake Maracaibo, Venezuela" *Water Resour ManageI*, 2008. DOI 10.1007/s1129-008-9318-9