Journal of Geology & Geophysics

Rahman and Islam, J Geol Geophys 2017, 6:2
DOI: 10.4172/2381-8719.1000284

Research Article OMICS International

Bank Erosion Pattern Analysis by Delineation of Course Migration of the Padma River at Harirampur Upazila Using Satellite Images and GIS Part II

Rahman MM[1*] **and Islam MN**[2]

[1]*Department of Geography and Environment, National University, Gazipur, Bangladesh*

[2]*Department of Geography and Environment, Jahangirnagar University, Dhaka, Bangladesh*

[*]**Corresponding author:** Rahman MM, Department of Geography and Environment, National University, Gazipur, Bangladesh, Tel: +880 1824-841299; E-mail: muzib09@yahoo.com

Received date: February 17, 2017; **Accepted date:** March 14, 2017; **Published date:** March 21, 2017

Abstract

The river Padma had showed different planform pattern with the changes from meandering to braided, which varied spatially and temporally. Sequential left bankline migration of the Padma river at Harirampur upazila had been explored from topographic and aerial photography maps of 1765, 1860, 1925, 1943, 1952, 1963 and time series digital satellite images from 1973 to 2009, and also using geographic information services (GIS). The Padma was the narrowest channel in 1860 along Faridpur-Harirampur nodal line. The results by interpretation maps from 1860 to 1925 indicated that the left bankline migration of the Padma at Harirampur upazila was limited within a range of 2 km and it was limited to 2.6 km until 1963. But the river caused extreme bank line shifting towards the upazila around 10 km during 1973-2009 and created a deep embayment at this location. A particular erosion pattern developed a meandering bend and in one season, the lateral maximum highest erosion extent was 2200 m/year in 2000-2001. The left bank line has already started to retreat from Harirampur due to the development of a chute cut-off. The three locations (site 1, 2, 3) can be vulnerable to erosion by the construction of river training work at Mawa.

Keywords Padma river; Bank erosion; Satellite images; Left bankline migration; Hariampur

Introduction

The river Padma ranks second as to erosion intensity along its 100 km long reach from Paturia to Chandpur in Bangladesh [1-6]. The rate of erosion along the Padma river in the 1990s was about 2,300 ha per years, which were about 1,200 ha per year in the first decade of the 2000s [7-10].

The interpretation of satellite image bank lines 1973-2009 illustrates that the Padma had eroded both its banks and maximum erosion was at leftbank in Manikganj district (8,600 ha) that completely happened in Harirampur upazila (Figure 1) and there was no accretion in this location [4,6].

In reality, the Padma devoured huge landmass of Harirampur upazila by very rapidly shifting its left bankline towards the upazila and developed a meandering bend at this location within a short period, therefore, drastic erosion of the river had drawn the attention to the geographers, engineers and planners.

The Padma is a very large sand-bed river having bankfull discharge that ranges from 75,000 to 80,000 m^3/s. The annual average flow of the river is 30,000 m^3/s [11].

It is a naturally free flowing unrestricted river with a few recent bank protection works along its right bank at Faridpur [4,12,13].

The banks of the river generally consist of highly erodible materials, except a few kilometers along the left bank at the upstream of Mawa and along the right bank at Sureshwar that have less erodible materials.

These less erodible materials play an important role in developing the planform historically [14]. The nature of bank materials largely controls rate of erosion and erosion pattern [10,15-17].

Figure 1: Harirampur upazila and erosion accretion along the Padma River.

Ashworth et al. examined morphological evolution and dynamics of the Jamuna River [18]. Islam explored the reach scale braiding process of the Brahmaputra-Jamuna river and its impacts on bank erosion and channel morphodynamics over decadal time scale [17].

Yeasmin and Islam analyzed short-term changing trends of channel pattern of the Ganges-Padma river showing the sinuosity and braiding index while Laha and Bandyapadhyay carried out a study on bank erosion due to morphometric change of the Ganga river [19,20]. Sarker

explored the morphological response of the Brahmaputra-Padma-Lower Meghna river system [21]. As part of FAP, ISPAN used satellite images only to study some of the morphological aspects of the Padma River for a project on the physical environment of char lands [22].

Actually, there had any comprehensive investigation in earlier to have better understanding on the morphological changes and long-term erosion process of the Padma River at Harirampur upazila. This study has explored the trend of river course migration and long-term bank erosion pattern along the present study site.

Materials and Methods

A time-series of dry season satellite images during 1860-2009 were used to visualize the historical changes in morphology and to provide the basis for the long-term bank erosion process of the Padma River. Center for Environmental and Geographic Information Services (CEGIS) had developed sophisticated tools and precise techniques for predicting and monitoring bank erosion and morphological changes of the river.

The rate and direction, and tendency of the river course migration had been identified by analysis of CEGIS images data. The CEGIS provided a good number of old maps that included 1765 (Rennell's map), 1860, 1925, 1943, 1952 and 1963. Maps of 1943, 1952 and 1963 were derived from topographic maps that had updated topographic features taken from aerial photography of 1943-1944, 1952-1953 and 1963.

A Corona aerial photograph images were received as 20 km wide strip and more than 120 km long. All the strips covering the Padma river were georeferenced and mosaiced together and this study has only given emphasis on the 30 km long left bank line within the study area.

Time series banklines were delineated on geo-referenced satellite images. The georeferenced images have been used to delineate the banklines of the river. The bankline separates the floodplains from the riverbed. The vegetated char land, bounded by the outflanking channel and the width of which is more than 100 m, has been considered as a part of the riverbed as well [23].

The primary software ERDAS Imagine was used for image processing and raster GIS analysis and the Windows NT based ArcInfo for vector analysis [6].

The ARC/INFO's Arcedit module digitized all historical maps from hard copies in the digitizing coordinate system. The digitized maps were projected into the Bangladesh Transverse Mercator (BTM) projection system. The CEGIS provided computer laboratory facilities for processing and analysing the satellite images.

Results

River course migration and planform in century scale

The present course of the Padma River has not age of more than 200 years of the history [24]. During the period the river had showed different planform pattern with the changes from meandering to braided, which varied spatially and temporally [4,25].

The courses of the river were very far away from the present course in 2009 at the location of Harirampur upazila (Figures 2a-2d). The rate of bank erosion along a river varies with the magnitude of the flood flow, characteristics of bank material and the phases of planform development [17,23,26].

The river course and nodal sections in the Padma river are not fixed rather they change over time because the character of each river reflects the geologic history of the river basin [15]. The Padma was the narrowest channel in 1860 along the Faridpur-Harirampur nodal line (Figure 3).

In the following decades, the Padma has become wider at this section by eroding along the both banks. But the river turned into a gigantic wider form during the 1963 to 2009 along Faridpur-Harirampur nodal section (Figure 4). The Padma eroded along both banks simultaneously at this section but the erosion rate was higher along the left bank at Harirampur [10].

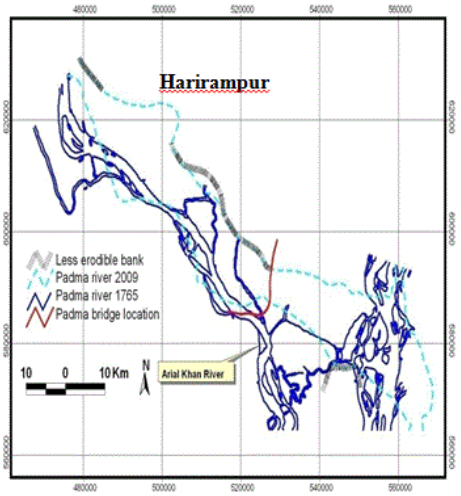

Figure 2a: River course changes at Harirampur since 1765.

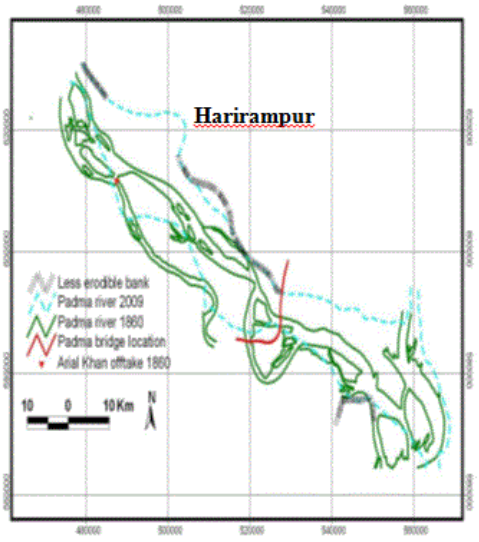

Figure 2b: River course changes at Harirampur since 1860.

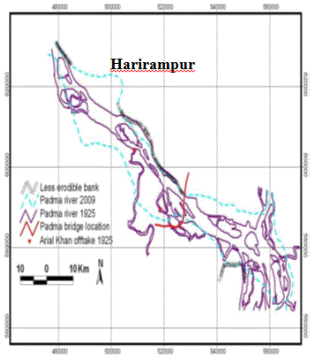

Figure 2c: River course changes at Harirampur since 1925.

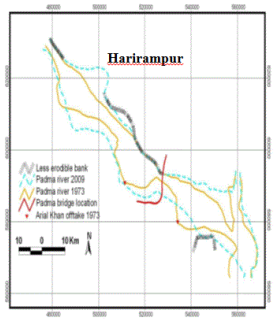

Figure 2d: River course changes at Harirampur since 1973.

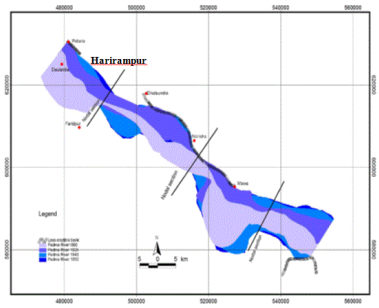

Figure 3: Nodal sections in the Padma River by superimposing historical maps from 1860 to 1952.

Erosion intensity at Harirampur

The left bank of the Padma river indicates that the river caused severe erosion at Harirampur upazila along the section A-A during 1860 to 2009 (Figure 5). Due to the presence of less erodible bank materials, the left bank at Paturia could not migrate substantially but presence of highly erodible bank materials the Padma had shifted its left bank about 12 km during the same period at Harirampur [4,6]. The left bank migration at this location ranged between 2-2.6 km during the period of 1860 to 1963 [4,6]. The river devoured huge landmass and penetrated about 10 km into the floodplain of the study site during 1973 to 2009.

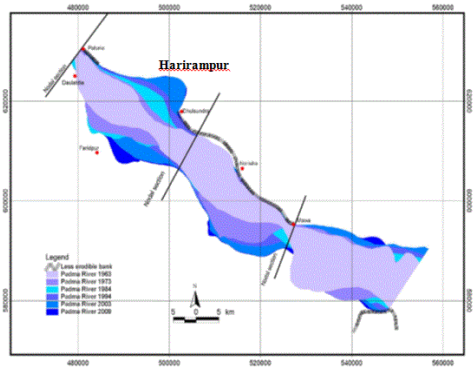

Figure 4: Nodal sections in the Padma River by superimposing the river boundaries from 1963 to 2009.

The significant feature of erosion pattern was along the section (A-A) at Harirampur that left bankline migrated extremely during the period of 1994-2003 (Figure 5). The river has created a deep embayment at this location. The presence of the remnants and scars of channels at the left bank flood plain has allowed the river to develop such a deep embayment at this location [27,28].

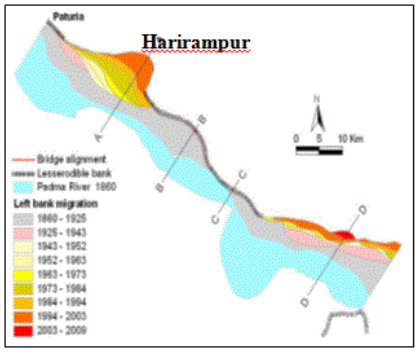

Figure 5: Erosion of the Padma River at Harirampur during 1860-2009.

Bend development process

Bank erosion is especially prevalent and erosion rates are highest on the outside of river bends where fluvial processes, mass wasting and undercutting of riparian vegetation leads to meandering [15,29]. Bend developed at different locations has different erosion pattern and longevity. In the Padma river, the life of meandering bends varies from a few years to several decades and the rate of bank migration is several hundred meters per year [4].

The eroding bend of the left bank at Harirampur upazila (Figure 6) sustained for 13 years 1992-2005 and annual average lateral extension of this bend was around 450 m/year [4,6]. Bank erosion that facilitates meandering and creation of abandoned channel is important because it leads to vegetation succession, which is necessary for riparian diversity [30].

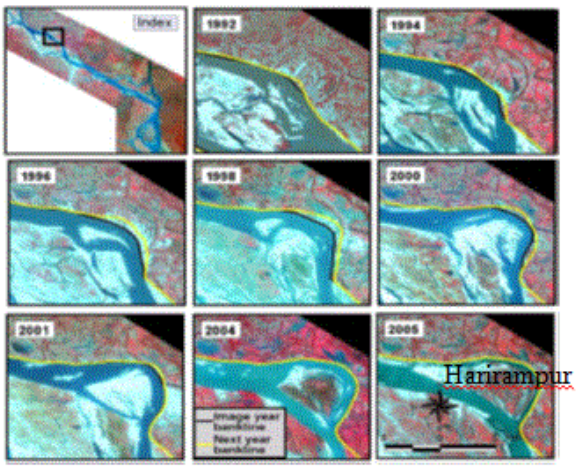

Figure 6: Meandering bend development at Harirampur.

Erosion trend of the Padma River

Erosion rate also varies from one period to another (Figure 7). In mid-sixties erosion rate was around 1,200 m/year. But in 1970s it was increased to around 1,800 ha/year. Later on, it was around 2,240 ha/year in the 1990s.

The rate of erosion was very high at 3,120 ha/year during 1998-1999. The very high flood of 1998 was responsible for such large-scale erosion. The Farakka barrage had great effect on downstream flood intensity and bank erosion by regulating discharge because erosion is sensible to discharge.

A 20 percent increase in maximum discharge will increase annual erosion by 8 percent. In the recent past annual average rate erosion was found to be about 1,000 ha/year [10]. After the mid-ninety's erosion along the Padma river has a decreasing trend. Since the Padma has no bank protection except Faridpur constructed in 2008, the decrease of erosion rate in recent years (Figure 7) possibly due to stabilization of the natural morphological process.

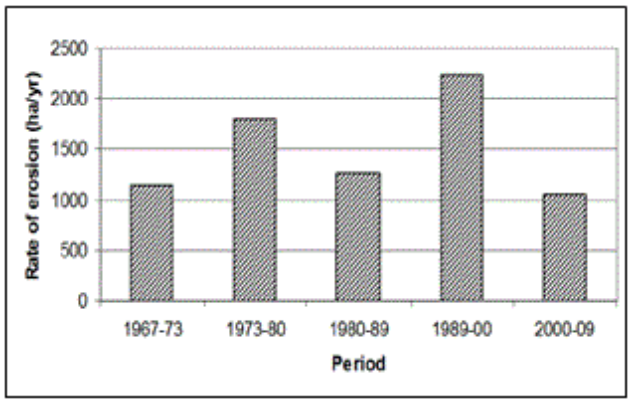

Figure 7: Erosion rate during different periods.

The erosion at Hariampur upazila has been stopped because the meandering bend is about to disappear by sedimentation and chute cut-off. Due to the development of a chute cut-off, the bank line has already started to retreat from Harirampur. The Padma Bridge is under construction at Mawa point (Figure 8) which is 35 km downstream of Harirampur upazila.

There are different types of channel developed due to the construction of river training work and three locations (Sites 1, 2 and 3) can be vulnerable to erosion. Figure 8 and Table 1 show the extent and magnitude of the erosion vulnerable areas that should be considered as indicative one. Total vulnerable area is 4180 ha out of which 820 is along the left bank rest in along the right bank.

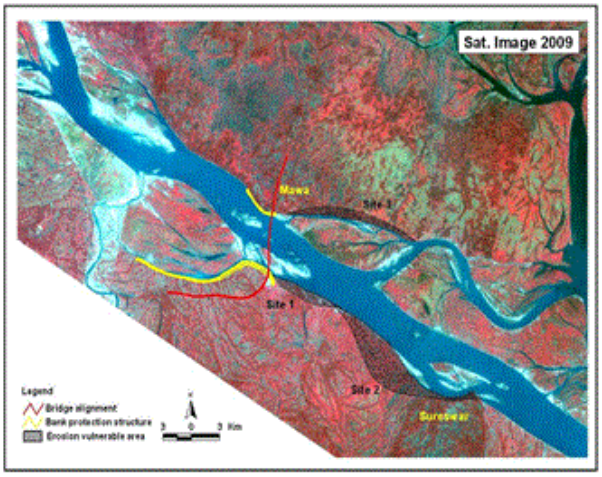

Figure 8: Vulnerable areas due to the structural interventions.

Location	Erosion vulnerable area (ha)
Site 1	550
Site 2	2820
Site 3	820

Table 1: Erosion vulnerable at three locations.

Annual erosion pattern during 1967-2009 at Harirampur

The rate of erosion along the major rivers varies over time and space [4,12,24]. Figure 9 represents spatial bankline shifting pattern over the time specially highlighting the study site, at Harirampur upazila. Most of the stretches of riverbank have been experiencing erosion.

The rate of erosion varies from several tens of meters to kilometers per year. There were number of locations where the lateral extent of erosion was more than 1000-1500 m/year. On one occasion along the left bank, the lateral maximum highest extent was 2200 m/year in 2000-2001 at Harirampur upazila, which was 20 km downstream of Paturia (Figure 9).

Middle part of the left bank is comparatively older hence; erosion rate is very low there.

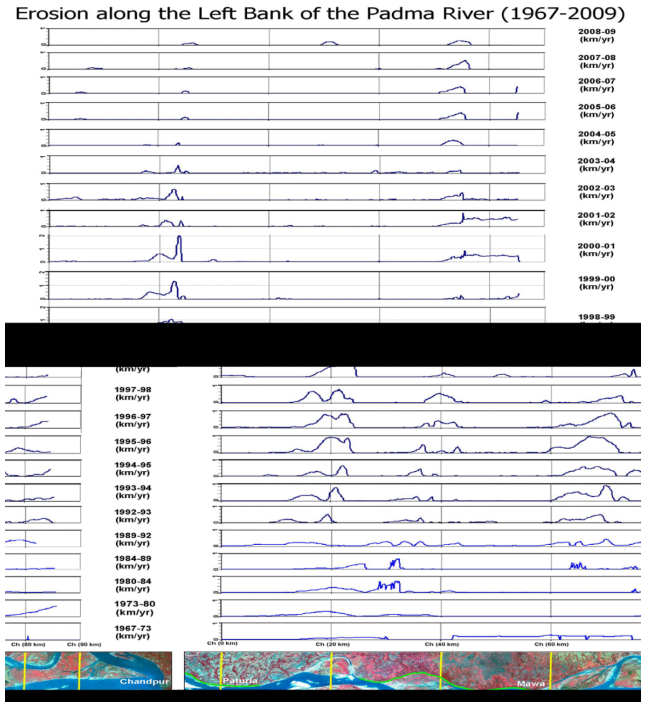

Figure 9: Erosion pattern along the left bank of the Padma river.

Conclusion

The newly formed course of the Padma River has been shifting in a defined corridor. The most part of the left bank reached to the consolidated belt of floodplain except the present observation place Harirampur upazila. The river had penetrated about 12 km into the floodplain of the study area due to severe erosion at this location. A meandering bend developed at the study site by the rapidly bank line migration during the period 1992-2005. The widening of the river is mainly governed by the development of meandering bends hence the width of the river is more at the study area.

References

1. CEGIS (2005) Developing methods for predicting morphological changes in the Padma River, Prepared for Jamuna-Meghna River Erosion Mitigation Project, BWDB, Bangladesh.
2. CEGIS (2005) Prediction of bank erosion and morphological changes of the Jamuna and Padma Rivers 2005, Prepared for EMIN and JMREM Projects, Dhaka, Bangladesh.
3. Sarker MH, Thorne CR (2006) Morphological response of Brahmaputra-Padma-Lower Meghna River stem to the Assam earthquake of 1950, Assoc. of Sedimentologists, Blackwell Publishing, pp. 289-310.
4. CEGIS (2015) Prediction of river, bank erosion and morphological changes along the Jamuna, the Ganges, the Padma and the Lower Meghna Rivers in 2015.
5. Disaster Management Bureau (2015) An introduction to disaster management in Bangladesh and the Disaster Management Bureau: Coordination-Facilitation-Information-Training. Ministry of Disaster Management and Relief. Government of the People's Republic of Bangladesh.
6. Rahman MM, Islam MM, Islam MM (2016) Integrated approach of remote sensing and field survey data in assessment of bank erosion intensity of the Padma river in Bangladesh. Int J Geomat Geosci 7: 285-297.
7. Burger J, Klaassen GJ, Prins A (1991) Bank erosion and channel processes in the Jamuna River, Riverbank Impact Study, Jahangirnagar University, Dhaka, Bangladesh.
8. EGIS (2001) Remote sensing, GIS and morphological analyses of the Jamuna River, prepared for River bank Protection Project, Bangladesh Water Development Board, Dhaka, Bangladesh.
9. EGIS (2002) Developing and updating empirical methods for predicting morphological changes of the Jamuna River, EGIS Technical Note Series 29, Dhaka, Bangladesh.
10. CEGIS, JMREMP (2009) Prediction of river bank erosion along the Jamuna, the Ganges and the Padma Rivers in 2009.
11. Delft Hydraulics, DHI (1996) Floodplain levels and bankfull discharge, Special Report No. 6, River Survey Project (FAP 24), Prepared for Water Resources Planning Organization (WARPO), Dhaka, Bangladesh.
12. Delft Hydraulics, DHI (1996) Morphological processes in the Jamuna River, Special Report No. 24, River Survey Project (FAP 24), Prepared for Water Resources Planning Organization (WARPO), Dhaka, Bangladesh.
13. Delft Hydraulics, DHI (1996) Bed material sampling in Ganges, Padma, Old Brahmaputra and Jamuna, Special Report No. 8, River Survey Project (FAP 24), Prepared for WARPO, Dhaka, Bangladesh.
14. Coleman JM (1969) Brahmaputra River: channel processes and sedimentation. Sedimentary Geology, 129-239.
15. Leopold LB, Wolman MG (1957) River channel patterns: braided, meandering and straight. U.S. Geological Survey Professional Papers, 1-84.
16. FAP 24 (1996) River Survey Project: Bedforms and bar dynamics in the main rivers of Bangladesh. Special Report No. 9. Flood Action Plan, Water Resources Planning Organization, Dhaka.
17. Islam MN (2006) Braiding morphodynamics of the Brahmaputra-Jamuna River. A H Development Publishing House. New Market, Dhaka.
18. Ashworth PJ, Best JL, Roden JE, Bristow CS, Klaassen GJ (2000) Morphological evolution and dynamics of a large, sand braid-bar, Jamuna River, Bangladesh. Sedimentlogy 47: 533-555.
19. Yeasmin A, Islam MN (2011) Changing trends of channel pattern of the Ganges-Padma river. Int J Geomat Geosci 2: 669-675.
20. Laha C, Bandyapadhyay S (2013) Analysis of the changing Morphometry of River Ganga, shift montoring, and vulnerability analysis using space-borne techniques: A Statistical Approach. Int J Scient Res.
21. Sarker MH (2009) Morphological response of the Brahmaputra-Padma-Lower Meghna River system to the Assam earthquake of 1950. University of Nottingham, UK.
22. ISPAN (1993) The dynamic physical environment of riverine charlands: Padma, Irrigation Support Project for Asia and the Near East, Prepared for Flood Plan Coordination Organisation, Dhaka, Bangladesh.
23. Hasan A, Haque I, Huq PAK, Martin TC, Nishat A, et al. (1997) Defining the Banklines of the Brahmaputra-Jamuna River using Satellite Imagery, 3rd International Conference on River Flood Hydraulics, Stellenbosch, South Africa.
24. FAP 24 (1996) River survey project: Morphological characteristics. Final Report Annex 5. Flood Action Plan, Water Resources Planning Organization, Dhaka.
25. Delft Hydraulics, DHI (1996) Morphological Characteristics, Final Report, Annex 5, River Survey Project (FAP 24), Prepared for WARPO, Dhaka, Bangladesh.
26. Mosselman E, Huisink M, Koomen E, Seijmonsbergen AC (1995) Morphological changes in a large braided sand-bed river, John Wiley and Sons Ltd, London 235-247.
27. Klaassen GJ, Mosselman E, Bruhl H (1993) On the prediction of Planform changes of braided sand-bed rivers. Proc. International Conference, USA, Hydroscience and Engineering, Washington 134-146.
28. Sarker MH, Haque I, Alam M, Koudstal R (2003) Rivers, chars and char-dwellers of Bangladesh. International Joint River Basin Management 1: 61-80.

29. Hupp CR, Osterkamp WR (1996) Riparian vegetation and fluvial geomorphic processes.

30. Salo J, Killiola R, Hakkinen I, Makinen Y, Niemela P, et al. (1986) River dynamics and the diversity of Amazon lowland forest. Nature. 322: 254-258.