

Chapter Three

River Bank Erosion in the World

3.1 Introduction to the River Bank Erosion

River channels can be classified into

- Straight – It is almost non-existent among natural rivers. Extremely short reaches of the river may be straight.
- Meandering – It is a sinuous channel of river. A meander is formed when moving water in a river erodes the outer banks and widens its valley, and the inner part of the river has less energy and deposits silt.
- Braided – It is a channel that consists of a network of small channels separated by small and often temporary islands called braid bars. Braided channels occur in rivers with high slope and/or large sediment load.
- Anastomosing – Like braided channel branching of small channels from a single occurs at first, but after that separated channels again merge.

The controlling factor on river development is the amount of sediment that the river carries. Once a water way crosses a threshold value for sediment load, it will convert from a single channel meandering river to a braided channel (Leopold and Wolman, 1957). Bank erosion, however, occurs mainly in meandering rivers. In meandering rivers, river-channel migration takes place through erosion of the cut bank and deposition on the point bar. River-channel migration is the lateral motion of an alluvial river channel across its floodplain due to processes of erosion of and deposition on its banks and bars (Wikipedia definition). Meandering of a river is caused by nature but sometimes by human activities. Due to natural or human or both activities, most rivers in the world are subject to meandering along with bank erosion. But in view of devastation, the Mississippi-Missouri River System of North America, Ganges, Brahmaputra and Mekong Rivers of Asia, Amazon River of South America, and River Nile of Africa are most important among them.

3.1.1 Americas

The larger the drainage area of a meandering river, the faster is its channel migration. Figure 3 shows the relationship between the river channel migration rate and the drainage area of the river (Hudson and Kesel, 2000) . However, the rate of channel migration is not same for all rivers with the same drainage area. This happens because the rate of migration also depends on the material that constitutes the river banks. This is exactly what happens in the case of Guadalupe River (a meandering river) in the United States, where the rate of erosion is less than expected (Gantt and Humberson, 2004).

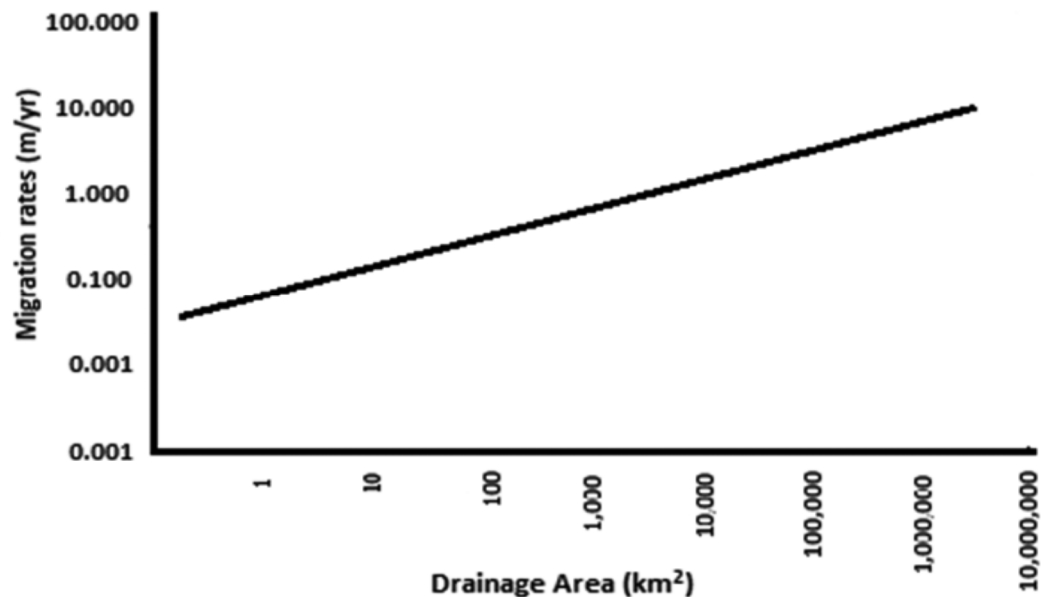


Figure (3.1): Relationship between river channel migration rate and drainage area of the Lower Mississippi River. Image adapted from (Hudson and Kesel, 2000).

Both Mississippi and Missouri Rivers have been facing meander migration. It is a process in which water flow erodes soil on one bank and deposits it on the opposite bank, i.e., a gradual shift of bank line occurs over time (Briaud, 2007). The Missouri River bank is eroding at a high rate on the Lower Brule Reservation central South Dakota in the United States. The long-term impact of bank erosion on cultural and environmental losses is under investigation.

A great amount of channel migration of the Mississippi River has occurred over the last 200 years (Maynard and Martin, 1996). In the early 1800s, U.S. Army Corps of Engineers (USACE) began removing snags and dredging the main channel of the Mississippi River and later the main channel of the lower Missouri River was subject to river engineering like channel straightening, dike construction, etc. to increase the ease and safety of river navigation (Alexander et al., 2012). That effort made navigation easier and safer for the time being, but that human-induced channel migration caused substantial bank erosion. The Modification of Mississippi River is still continuing for better navigation. However, recognizing the “devastating damage done by modifications to the Upper Mississippi River and the importance of wildlife and people living along the river”, the U.S. Congress authorized the Mississippi River Restoration Ecosystem Management Program in 1986 (Prairie Rivers Network, 2012).

3.1.2 Australia

Bank erosion at the meander bend site due to river navigation has been observed in other countries too (Laderoute and Bauer, 2013). An example is the lower Gordon River in Tasmania in Australia. The wakes generated by river traffic are the main driver of bank erosion, and there people have concerns for quality of the drinking water, loss of property, and loss of aquatic habitat. The wakes generated from large vessels in earlier decades were considered negligible or acceptable. But the effects have become noticeable after the introduction of high-speed craft (HSC) that are capable of carrying vehicles and passengers. The adverse effects of bank erosion by boats like large catamarans, which are used as industrial ferries, are mainly due to their high speeds and large size, producing longer wakes than conventional ships (Parnell et al., 2007).

3.1.3 Europe

To regulate the flow and to facilitate navigation, sometimes rivers were not allowed to meander in Europe, especially in urban areas. But this process of straightening along with drainage and dredging had impact on most small rivers and brooks (Beck, 2005, Pearce, 2013). Early phases of river modifications protected the settlements against flood and provided new fields for agriculture, but it did not reduce the risk of bank

erosion. Straitening of rivers caused bank erosion when a bank protection failure had occurred resulting in significant damages and financial losses. Moreover, the modification of river banks has threatened the ecology of rivers in many areas of Europe.

Now most of the countries in Europe realise the need for restoration of rivers to their natural course and application of bioengineering techniques for river bank erosion control (Donat, 1995, Evette et al., 2009). The idea is to allow natural sediment transport systems with acceptable and manageable erosion and deposition rates. The restoration of rivers, however, is not simple as they encompass cities, industries, hydroelectric dams, etc. For the need of restoration, the cities might have to move, hydroelectric plants would have to be closed, and industries would have to be relocated.

3.1.4 Africa

The Nile is the longest river (6650 km) in the world and passes from south to north through eleven countries in Africa, namely Ethiopia, Eritrea, Sudan, Uganda, Tanzania, Kenya, Rwanda, Burundi, Egypt, Democratic Republic of the Congo and South Sudan. The Nile meanders through a watershed that is to more than 30 percent arid (Wong et al., 2007). The lateral erosion on the Nile river banks in Egypt is another example of river bank erosion. Nile river meandering and the associated processes of bank erosion and deposition accelerated with human activities. Erosion has its impact on both economy and environment. Bank erosion has caused decrease in agricultural lands which in turn has reduced the agricultural production (Ahmed and Fawzi, 2009) . It has been recommended to protect the river bank from further movement and erosion. The recommendations are

- to weaken the secondary currents created by the river bends,
- to regularly monitor the river banks and islands and measure the rates of erosion and deposition, and
- to monitor sand bars and subsurface islands and to identify with flash lights to mitigate navigation problems.

3.1.5 Asia

The Mekong River flows over 4800 km through six countries, namely China, Myanmar, Laos, Thailand, Cambodia, and Vietnam (cf. MRC, 2010). The channel pattern of the Mekong is meandering with low sinuosity (Wood et al., 2008). The lower Mekong basin includes Laos, Thailand, Cambodia, and Vietnam. The river bank zone in the basin provides places for human settlement and also consumption goods and inputs to production (Miyazawa et al., 2008). Thus, bank erosion in Mekong River not only displaces population but also brings about loss of household income sources. It was reported that about 600 families in Tonpheung district of Bokeo province in Vietnam were forced to migrate from their homes because of river bank erosion over the past three years (Pongkhao, 2008). Villagers had been moving further inland, away from the Mekong River, to escape the problem. It was reported further that these people will be forced to move out again if the bank erosion process continues. Apart from the socioeconomic problem there is also a political problem. The political border between Laos and Thailand (about 1100 km long) is the deepest line (thalweg) of the Mekong river channel. But this political border has shifted due to excessive erosion of the Laos river bank. Moreover, the altered flow channel made an island that was once part of Laos is now part of Thailand (Brown, 1999). As it is a very sensitive issue, the two countries have agreed to settle the border problem.

3.2 Impact of erosion on human life

All continents are more or less affected by river bank erosion. But its impact on population varies as the socio-economic conditions are different for different regions. Table 2 shows percentage of continent-wise displaced population in the world due to all types of natural disasters in the years 2010 and 2011. Worst sufferer was Asia and least sufferer was Oceania. The displacement was caused mainly by hydrological disasters, which include floods, storms, and wet mass movements. In 2010, the contribution due to hydrological disasters was nearly 85 percent (IDMC, 2011) and in 2011 it was more than 71 percent (IDMC, 2012). Rest of the human displacement was due to geophysical (earthquake, volcanic eruptions, etc.), meteorological (storms), climatological (extreme temperature, etc.) and biological disasters (epidemics, etc.).

Table 2: Human displacement in different continents (percent). (Sources: IDMC, 2011, 2012; WPDS, 2011)

Continent	Percentage of total displaced population in the world		Percentage of displaced population relative to the total world population	
	Year 2010	Year 2011	Year 2010	Year 2011
Africa	4.01	3.91	0.0246	0.0084
Americas	19.34	6.76	0.1186	0.0145
Asia	76.43	89.12	0.4685	0.1906
Europe	0.15	0.12	0.0009	0.0003
Oceania	0.07	0.09	0.0004	0.0002

3.3 Human vulnerability across the world

Landscape degradation, environmental and socio-economic impacts are observed in different countries at different scales due to river bank erosion. But quantitative information on socio-economic consequences of river bank erosion (viz., total human displacement, loss of occupation, loss of property, impact on health and education, etc.) for all the cases, however small it may be, is not available unlike at other natural disasters. Recently, few attempts have been made to collect and analyse data at household and community level. Such attempts are highly needed to quantify the human vulnerability due to river bank erosion, and in turn to formulate appropriate public policy.

One such study was the analysis of socio-economic consequences of the Kolubara river bank erosion in Serbia (Dragićević et al., 2013). The analysis was in terms of land loss, land use changes and economic loss. The study area in this analysis had economic importance, and there was significant density of the agricultural population and settlements. Because of bank erosion in the study area, the farmers who had arable land on the river bank lost their land assets by the river.

The loss of corn production was 3255 tons and of wheat production was 1271 tons till the year 2010. The level of production losses was steadily increasing over time. It was estimated that the total value of the permanent losses of arable land was 80 560 USD, and the total loss in agricultural production was 634 240 USD till 2010.

3.4 Impact of River Bank Erosion

Impacts of river bank erosion are multifarious: social, economic, health, education and sometimes political. The first and foremost impact is social, i.e., homelessness due to land erosion which compels people to migrate (Figure 8). After forced migration they suffer from economic crisis, namely loss of occupation and loss of property, and they are at the risk of poverty and sometimes involvement in criminal activities (Iqbal, 2010). Identity crisis is inevitable to these migrated people as their belongingness to any particular district or state or country is often denied. Other consequences of bank erosion are the lack of medical and education facilities. Medical care units that were on the eroded land are all lost. In their new settlement generally those are lacking. So, they have to travel longer distances than before and bear extra cost for medical treatment. Similar is the case for education. Moreover, due to loss of occupation they are having difficulties to spend money for purposes other than essential items like food and shelter, even if the medical and education facilities exist in their new occupied places. Results are their poor health, sickness and illiteracy of their children.

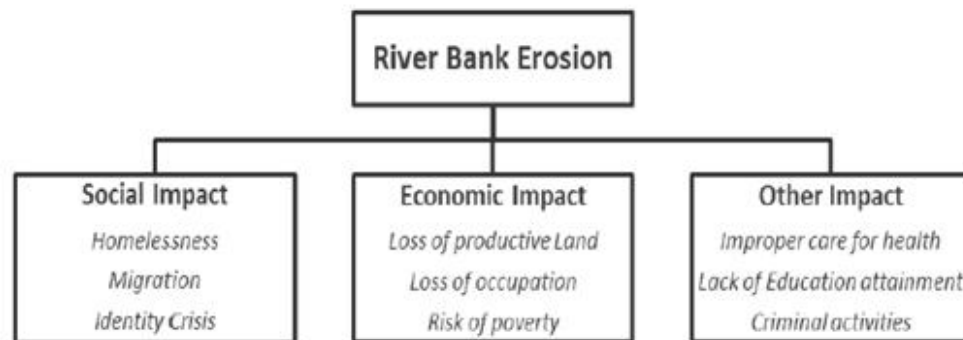


figure (3.2): Impact of river bank erosion

3.5 Conclusion

It is clear from the above discussion that the overall scenario of river bank erosions and their impacts are very depressing. As a result of riverbank erosion and their displacement, forced migrants are at the risk of insecurities in different form. The uncertainties that they face are economic insecurity due to unemployment, erosion of capital and indebtedness, social insecurity due to deprivation of civic rights, health

insecurity due to lack of basic infrastructure, etc. All these insecurities caused by forced migration lead to deprivation, destitute, fragility and more vulnerability of the families. Riverbank erosion thus has negative impact on human life. Conversely, human activities also have impact on riverbank erosion. The poverty of the Malawians has created pressure on catchment areas or rivers. People cultivate on riverbanks because of its fertile land. No fertilisers are needed. River banks provide better yields than upland farms that are depleted of nutrients. Because of these benefits, there is over-cultivation, poor management of cultivated fields, and indiscriminate cutting down of trees (Kaunda and Chapotoka, 2003). All this leads to riverbank erosion along with river sedimentation, water pollution and fish habitat alteration. Therefore, the management of natural resources including riverine resources in poverty-stricken communities is of very complex nature. The literature survey in this review article opens up two important aspects of the above topic that can be pursued in future research. Firstly, more scientific studies on the impact of human intervention are needed. Also, at the same time, it is needed to analyse to what extent human intervention may be tolerable without disturbing the natural dynamic equilibrium of rivers, because rivers always play a vital role in the social and economic welfare of countries. Moreover, there is increasing pressure on rivers to accrue more benefits to the society. Such studies will help in developing river training work, depending on the reach where there is human intervention. The second research question is how to maintain riparian buffers, especially in countries that are suffering from over-population and poverty, since bank erosion is a natural phenomenon even if there was no human intervention. Human vulnerability is of greatest extend, where settlements are dangerously close to eroding banks. Therefore, mapping of the spatial distribution of vulnerability of the people residing along the river bank is very much required to understand the severity of the problem (Kienberger et al., 2009). This research topic demands for an interdisciplinary approach: measurement of human vulnerability and spatial mapping. Such studies are lacking in literature on river bank erosion.