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# SILTATION AND EROSION IN THE SUBANSIRI DOWNSTREAM AND ITS IMPACT ON SOCIO-ECONOMIC CONDITION OF RIPARIAN PEOPLE

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## Abstract

Himalayan rivers are always fast-flowing and heavily sediment-loaded in nature. The present communication emphasizes the frequent channel change behaviour of the Subansiri coupled with siltation and erosion in its flood plain. Riparian people are severely affected by such type of situation particularly after great earth-quack of 1950. More than thousands of families have already lost their permanent settlement, agricultural lands and natural livelihood options. Embankment of right bank is the only site of settlement for homeless families. Rapid deforestation in upstream catchment areas along with construction activities of the lower Subansiri hydroelectric project is the reason of such adverse condition. Migration of river towards west ward is significant.

**Keywords:** *Siltation, Erosion, Riparian, Livelihood*

## INTRODUCTION

Human beings have long been fascinated by the dynamism of free-flowing waters. It is now acknowledged that harnessing of streams and rivers comes at great cost. Many rivers no longer support socially valued native species or sustain healthy ecosystems that provide important goods and services (Naiman *et al.*, 1995; NRC, 2002). River is part of the total landscape, that it is not just regarded as a channel running through the land. Rivers are dynamic systems, which have evolved over a very long time in response to extremely variable climate. They continue to be shaped by events occurring at different spatial and time scales. Rivers are also one of the major forces shaping the landscape. Large alluvial rivers in tropical systems are dominated by lateral gradients that can greatly modify the longitudinal pattern of ecosystem processes along the river; and are characterized by highly pronounced biogeochemical dynamics of which many species are reliant on (Petts, 1994). River morphology is the shape of a river along with its length and width. Rivers flow in channels, the area within the banks of the river. The river channel presents a three-dimensional form defined by its slope, cross section and pattern (Petts, 1989). But according to Ward & Stanford (1989) rivers are open systems which should be considered in four dimensions: longitudinal (headwater-river-estuary), lateral (river-riparian/floodplains), vertical (river- groundwater) and temporal. The present study tries to focus mainly on the lateral dimension of the Subansiri river in certain aspects particularly the socio-economic condition of riparian people.

The largest tributary of the mighty Brahmaputra, the Subansiri, originates from western part of Mount Pararu (5059 m) in Tibetan Himalaya. It is sustained by snowmelt run-off, the ablation of glaciers, monsoon rainfall, and those factors providing the perennial nature of the river. After flowing for 190 km through Tibet, it enters into the Indian territory. Till 1877, it was thought that the origin of the Subansiri and the Sangpo (Brahmaputra) is same. But it was Captain Woodthrop, who first established that the two rivers indeed originated separately (Sharma, 2008). Originating from Tibetan Himalaya, the Subansiri continues its journey through the Himalaya for 200 km and enters into the plains of Assam through a gorge near Gerukamukh of Dhemaji district. The the Subansiri is not only important for its fertile soil and rich aquatic flora and fauna but also equally important for its historic gold mining. During Ahom dynasty, lots of local communities were engaged in gold mining business. According to few villagers of Lathia gaon, nearby Gogamukh, the permit of gold mining to the local people was given by even British government till 1905 (Chatradhora, 2012). Unfortunately, right from the beginning of

21st century, the the Subansiri has been occupying headlines of regional media because of another issue i.e. lower Subansiri hydroelectric project. But keeping this importance in the periphery of my purview, the present communication mainly deals with the frequent change of channel due to erosion and siltation in recent past as well as its impact on socio-economic condition of riparian people.

## MATERIALS AND METHOD

The present study area is confined to only the downstream of the Subansiri, a stretch of about 130 km, from Gerukamukh (just below the ongoing Lower Subansiri Hydroelectric Project) to the confluence of Subansiri with River Brahmaputra. At Gerukamukh, where the river enters in to the territory of Assam, the elevation is recorded as 99 meter above the mean sea level (msl) whereas at its confluence, the elevation is 59 msl. For the convenience of present investigation, the entire downstream was divided in to four study sectors, namely, Sector I (Gerukamukh to Chowldhowa), Sector II(Chowldhowa to Khaboli ghat), Sector III (Khaboli ghat to Dhunaguri ghat) and Sector IV(Dhunaguri to Jamuguri ghat) respectively.

Both primary and secondary data have been collected to analyze the problem.GPS (Garmin 21) was used to localise the study spots. Discharge and sediment load of the recent few years have been collected from NHPC. GIS mapping of the Subansiri downstream for the last hundred years was considered to evaluate the trend of channel migration. Data regarding the riparian people were collected from revenue department, Govt. of Assam.

## RESULT AND DISCUSSION

The average gradient of the river in its downstream is 0.30 m/km. The maximum inclination (2.3m/km) is recorded in Sector I. The inclination of the river in remaining three sectors are comparatively less, i.e. 0.2, 0.03 and 0.12 m/km in sectors II, III and IV respectively (Table 1.1). The Subansiri in its downstream is very wide (> 520 m in monsoon) with a considerable depth and during high flood the river spreads over 2km, but in the dry spell the river shrinks both laterally and vertically. Mean water depth in rainy months varies from 4.17±2.86 m to 6.58±4.77 m in the four study sector, while mean water depth in winter is ranging from 3.7±2.35to 4.96±4.21m (Table 1.1).

| Location | Gerukamukh (A) | Chowldhowa Ghat (B) | Khabolo Ghat (C) | Dhunaguri Ghat (D) | Jamuguri Ghat(E) |
|---|---|---|---|---|---|
| Longitude | N-27$^{o}$33$^{/}$ | N-27$^{0}$ 26$^{/}$ | N-27$^{0}$ 03$^{/}$ | N-27$^{0}$ 00$^{/}$ | N-26$^{0}$ 50$^{/}$ |
| Latitude | E-94$^{o}$15$^{/}$ | E-94$^{0}$ 15$^{/}$ | E-94$^{0}$ 07$^{/}$ | E-94$^{0}$ 01$^{/}$ | E-93$^{0}$48$^{/}$ |
| Mean sea level (m) | 99 | 76 | 65 | 64 | 59 |
| Slope of the river bed (m/km) | (Initial spot) | 2.3 ( A-B) | 0.2 (b-C) | 0.03 (C-D) | 0.12 (D-E) |
| Approx. distance (km) | 0 | 10 | 45 | 35 | 40 |
| Depth in winter (m) | 10.50 ±0.45 | 3.7 ±2.35 | 4.63 ±3.6 | 5.79 ±3.97 | 4.96 ±4.21 |
| Depth in monsoon (m) | 25.50 ±0.80 | 4.17 ±2.86 | 5.34 ±4.19 | 6.48 ±4.66 | 6.58 ±4.77 |
| Width of the river in winter (m) | 74.00 | 170.00 | 210.00 | 180.00 | 250.00 |
| Width of the river in monsoon (m) | 98.00 | 310.00 | 380.00 | 410.00 | 520.00 |

**Table 1.1:** Physical status of the Subansiri (Downstream)

The Subansiri in its downstream naturally evolves and changes their shapes by eroding, transporting and depositing sediments of its own, or alluvial fan deposits created by the numbers of feather streams emerging from the foot hills of Eastern Himalayas. The river bed composition in the different study sectors along with river bank and riparian zone are depicted in the table 1.2.

| | Sector I | Sector II | Sector III | Sector IV |
|---|---|---|---|---|
| River bed | Hard , Rocky and partly sandy | Sand, Silt and Clay | Sand, Silt and Clay | Sand, Silt and Clay |
| Type of sediment | Boulder: 20%<br>Cobble: 25%<br>Pebbles: 35%<br>Sand: 20% | Sand: 90%<br>Silt: 07%<br>Clay: 03% | Sand: 90%<br>Silt: 09%<br>Clay: 01% | Sand: 80%<br>Silt: 15%<br>Clay: 05% |
| Woody debris in R. Bed | Large and medium size | Large and medium size | Small and medium | Small and medium |
| River bank | Stable | Unstable | Unstable | Unstable |
| Mid channel bar | Very few | Numerous | Numerous | Numerous |
| Riparian zone | Woody forest, shrub and grass land | Shrub and grass land | Woody forest patch, shrub and grass land | Woody forest patch, shrub and grass land |
| Human habitation | Scanty in both side | Moderate in both side | Moderate in both side | Moderate in right bank but scanty in left |
| Agricultural practice in river bank | Livestock farming, Tea garden | Both Rabi and Kharif Crop | Both Rabi and Kharif Crop with livestock | Both Rabi and Kharif Crop with livestock |

**Table 1.2:** Geomorphic data of R. Subansiri (2007-2010)

Boulder: Diameter >256 mm. Gravel: diameter 256mm -2mm, Cobble: 64-256 mm, Pebble: 2-64 mm, Sand: 0.06 to 2 mm, Silt: 3 to 60 µm , Clay : > 3 µm

The Subansiri carries a mixture of large and small objects (Table 1.2), including boulders (> 256 mm in diameter), cobbles (64-256 mm in diameter), pebbles (2-64 mm in diameter), sand (0.06 to 2 mm), silt (0.002-0.6 mm) and clay (< 0.002 mm). The river bed mainly consists of fine and medium sized sand with an exception in the first 10-17 km, where it is made up of hard sediment (mixture of cobbles, pebbles and boulders). Coarse sand is predominant at Chowldhowa and Khabolo respectively. Silt and clay were major in the distantly located sample sites (Dhunaguri and Jamuguri). Beside sand and gravel, the river also carries natural debris such as woody debris.

## RIVERBED AND RIVERBANK STRUCTURE

Structural composition of the river bed and banks are influenced by the flow regime inclination and sediment load as well as types. Sharp inclination (2.3 m/km) of the riverbed between Gerukamukh and Chowldhowa coupled with high velocity discharges facilitate the river water to carry hard sediment (boulder, cobble, pebble) effortlessly up to 10-17 km from the Gerukamukh and get deposited in the river bed and banks. The riverbed composition i.e. various size of riverbed components (boulder to clay) and the variation of stability of river bank in different sectors are depicted in Table 1.2. Deposition of large and small woody debris on the riverbed and bank has also been observed in all the sectors under study.

## WATER DISCHARGE (WATER QUANTITY)

Usually rivers and streams have a one way downhill flow and in these lotic environments, flow rate is of prime importance in determining the nature of plant and animal community (Osborne, 2000). The discharge of the Subansiri River fluctuates along with the seasonal cycle. Being a Himalayan river, the Subansiri showed maximum and minimum flows during monsoon and winter period respectively. The season wise daily discharge was measured for a period of four years at Chowldhowa ghat (Sector I). The maximum mean discharge was recorded in monsoon (9713.78±2630.59 cumec) while that of minimum (711.68±128.26 cumec) was recorded in winter. Again post monsoon discharge was more than the pre monsoons discharge (Table 2.1). The water discharge, however, increases to a large extent as discharges from more than 15 feeder streams along with surface runoff from riparian areas in rainy months are added to the main river in its downstream. Seasonal variations of water discharge in the Subansiri during the last four years (2007-2010) are given in Table 2.1.

| Season | Discharge (cumec) | Sediment load ( t/day) |
|---|---|---|
| Pre monsoon | 3292.86±2435.63 | 66264.58±59885.39 |
| Monsoon | 9713.78±2630.59 | 635967.65±189325.56 |
| Post monsoon | 4729.49±3907.79 | 171551.01±141054.93 |
| Winter | 711.68±128.26 | 6524.53±4830.26 |

**Table 2.1** Seasonal variation of mean discharge and sediment load of the Subansiri R. at Chowldhowa (2007-2011)

## SEDIMENT LOAD

The sediment load of the river also varies in different seasons which was ranging from few thousand t/day to more than 6 mt/day (Table 2.1). The data of the season wise mean sediment load for the studied period shows that maximum values (635967.65±189325.56 t/day) is in monsoon whereas the minimum load (6524.53±4830.26 t/day) is observed in winter. The heavy sediment load in monsoon is carried by the river from its upstream as surface runoff. Rapid deforestation activities in and around the LSHE project dam site as well as upper catchment areas has been accelerating the sediment load of the Subansiri downstream. Pearson correlation coefficient between discharge and sediment load (silt) during studied period indicates that except the winter of 2007, a significant positive correlation has been noticed between discharge and sediment load in the river. The said findings established the fact that, before construction of dam, the the Subansiri carried minimum of sediment load during winter which has been significantly distorted by construction activities of NHPC, just after 2007. This unfortunate alteration of the sediment load ultimately disturbing the carrying capacity of the river and results is the uneven deposition and transportation of sediments. The longitudinal profile of the Subansiri downstream also suggested that, the sediment will be deposited in between Chowldhowa ghat and Khaboli ghat.

## CHANNEL MIGRATION

Channel migration of the Subansiri is happening by the process "avulsion and bank erosion". Avulsion is the condition when a river at a particular point keeps on abandoning its original channel and has started following another channel. In case of Subansiri, just from the Gerukamukh up to Khabolughat, the river has been shifting westwards. The GIS mapping of channel shift were shown in the figure which is more prominent after great earth quake of 1950. The most significant feature in the Subansiri Basin is the rapid migration of the stream channels through a very short period of time in context to geomorphology. In the sector I (Gerukamukh to Chauldhowa) the shift is more than 6 km within last 50 years.

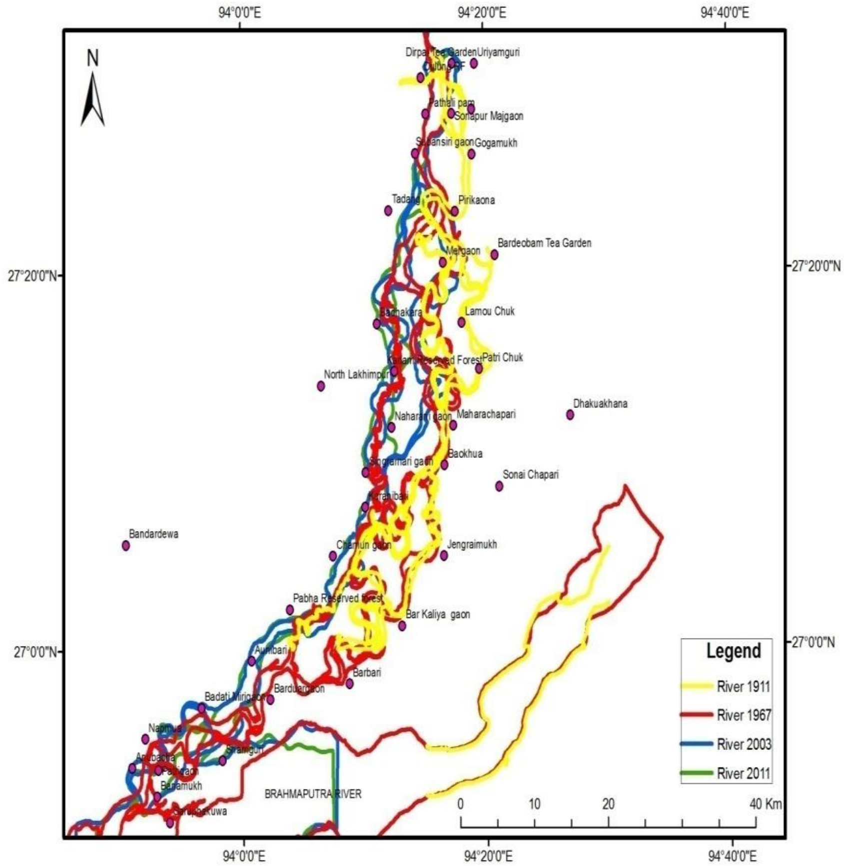


**Fig.** Pattern of Channel migration in Subansiri during last 100 years (1911-2011)

## RIVER BANK EROSION

The another process of channel migration is the bank erosion which is generally occurring by lateral cutting due to meandering nature of the river. The the Subansiri not only erodes the bank but also deposits the sediments near the bank and leaves the area by shifting its course away from the bank by several meters. At present, the extra ordinary increase of sediment load in the the Subansiri making the phenomena more pronounce. As a result, erosion in one area may lead to aggradations in some other area. In our present observation, it has been noticed that, there is large scale erosion in the right bank as well as deposition in the left bank of the Subansiri downstream. During last 100 years, the the Subansiri has been shifting towards west a minimum of two kilometres and maximum of more than ten kilometres in between Chaoldhowa and Khaboli ghat. A lot of riparian wet lands like Bhimpara beel, Kaoimari beel etc have been captured by Subansiri during its channel migration. The major part of two reserve forest of its right bank has been eroded during last 50 years.

Regarding geomorphic characters of Subansiri, Goswami *et al*. (1999) has reported four primary causes for the morphological changes. Meandering bends of the river is more pronounced in dry season due to its low water carrying capacity as well as sand bar development through siltation in the original river course. Under low water-flow condition, the downstream shows 2-4 channels separated by sand bars, a type of platform generally known as “braided” as suggested by Wiebe (2006). During the rainy season, these low level sand bars are submersed and in heavy floods they may disappear entirely due to heavy discharge and high level of the river water. The pattern of channels is quite unstable and changes frequently, usually under flood condition. The changes are accompanied by erosion of flood plain river banks and deposition of sand bars.

## IMPACT ON RIPARIAN PEOPLE

The "livelihood" of an individual, household or community is a term used to express the ways in which people survive and thrive. 'Livelihood' also describes the resources people use, the ways in which they are used and the benefits obtained from them (McCartney, 2007). River ecosystems provide a wide range of commodities and services that are important in supporting the livelihoods of many rural communities. Over sighting the erosion and channel migration record of The Subansiri during last hundred years, whatever has been happening since last ten years are given priority in this paper. The data so far available clearly show that only in the six revenue circles of the right bank have already been severely affected by bank erosion of the Subansiri. Altogether 6363 families of 271 villages of five revenue circles were completely or partially eroded by the river during last ten years. Approximately, 3293 hectors of productive lands have been converted to unproductive land (Table 2.2). Their permanent houses including the horticultural areas, livelihood options are excavated by river. All the victimized people were bound to settle on the embankment of the river.

Riparian people generally earn their livelihoods from their agriculture, horticulture, livestock rearing, fishery etc. Although erosion and deposing is a simultaneous process, but frequent erosion of deposited soil make them useless in context to livelihood earnings. The sand bars of the river were highly significant for riparian people, but newly form younger sand bars are generally barren, devoid of top soils, as a result these are not at all useful for agriculture and livestock farming. Another major livelihood option, the fishery of riparian wetlands become silted and degraded (Hazarika, 2012). The resultant consequence of all these impacts is the loss or depletion of livelihood option of riparian people. Now most of the affected people have been compelled to become daily wage earners doing whatever comes their way.

A number of revenue villages are completely or partially wiped out by the river. Few important revenue villages of Subansiri those are severely affected by erosion and flood are enlisted from Chauldhowa to Jamugurighat. These are namely, Katorichapori, Gerekigaon,Bhimpara,Ghagar,Hatiemora,Tengonigaon,Haziramora,Dorgegaon,Moukho wachapori,Tinchukiagaon,Badhakara,Uriamguri,Naharani,Rangpuria,Singimari,Halmari, Dambukial,Ujanimirigaon,Daphalakata,Gutigaon,Chamuagaon,Bordubi,Bhalukaguri,Bali jan,Michamara,Serpaikhowa,Kerker, Kachikata, Majgaon, Silikhaguri, Dahgharia, Bonpurai, Jamugurimiri gaon, etc. The detail list of the victimized villages is enlisted by Baruah (2012) in his book.

| Name of the Revenue Circle | Nos. Of Affected Villages (Direct & Indirect) | Nos. Of Families affected (Direct & Indirect) | Loss of Cultivable land (hectors) during last 10 years |
|---|---|---|---|
| Kadam | 9 | 685 | 1120.00 |
| North Lakhimpur | 225 | 5201 | 1863.00 |
| Bihpuria | 12 | 68 | 216.26 |
| Narayanpur | 23 | 310 | 64.56 |
| Nowboicha | NA | NA | NA |
| Subansiri | 2 | 99 | 30.00 |

**Table 2.2**: Nos. Of villages and families displaced by the Subansiri (2001-2012)

## CONCLUSION AND RECOMMENDATION

After keen analysis of the said problem, the following suggestions can be made for the betterment of both the river and the people depending on her for their livelihood:

1. Proper scientific catchment area treatment programme in upstream should be undertaken at first to minimize the extra sediment load of the river.
2. Unscientific flood control measures like haphazard construction of embankment should be readdressed.
3. Plantation of river bank stabilizing plants like Vetivera, Ipomoea should be encouraged on the river bank.
4. Establishment of hydel project and its technical feasibility should be scientifically addressed with proper focus on the problem affecting the downstream.

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