Abstract:
From the source till its confluence, Balason river has been degrading severely due to various physical as well as anthropogenic factors. Deforestation and increasing human settlement coupled with massive soil erosion and landslides are responsible for disturbing the catchment regime vigorously. In its lower course, the human induced bed material extraction activities are also disturbing the equilibrium state of the river. Some of the extraction activities such as lowering of bed elevation, changes in its morphology, bank erosion, disturbed sediment distribution and damages to bridges and embankments have been responsible for degrading the fluvial characteristic of the whole basin. Although the concerned authorities have implemented certain prohibitions over increasing rate of bed material extraction mostly due to illegal extraction, but proper long term monitoring and scientific method of extraction followed by integrated watershed planning has to be under taken which can at least control the degradation of Balason river.

Keywords: Human interference, bed material extraction, fluvial characteristic, degradation.

Introduction:
Alluvial channels have historically been an attractive source of sand and gravel for a variety of construction activities. The floodplains and terraces are mostly the sites of sediment storage in stream systems and can contain large quantities of boulders, gravels and sands that can be mined economically (Langer, 2003). There are several advantages for the aggregate operators in using river sediment (Kondolf, 1994), such as: (a) the material is already granulated, rounded, well-sorted, and generally clean (lacking cement and weak materials, and relatively free of interstitial fine sediment); (b) the source of material is generally close to destination or to the markets for the product, reducing transportation costs; (c) active channel sediments can be easily extracted, require little processing, and are periodically replaced from upstream during high flow events.

The study area:
The Balason river has its source at Lepchajagat, located on the Ghum-Simana ridge at an altitude of 2361 m and with latitude of 27˚3’55˝N and Longitude of 88˚14’12˝E. It is the major right bank tributary of Mahananda river. With a total length of about 48.4 km of which 24.27 km is in the hills and remaining 24.13 km flows in the plain region. The fluvial characteristics of the Balason river are primarily controlled by the discharge, bed load and the abrupt changes in the gradient in which the channel adjust itself (Jana & Dutta, 1997). In its piedmont zone, the landforms are mostly fluvial in origin and as such are dynamic (Basu & Sarkar, 1990) in the sense that modification is still active due to fluvial and anthropogenic processes. The fluctuating discharge, excessive bed load supply from its upper catchments and highly erodible banks have resulted in braided nature with sandy bars.
at lower plain. In its lower course, the river bed has been gradually elevated, restricting the free passage to an excessive amount of run-off which follows heavy and concentrated rainfall and causes flood.

**Bed material extraction:**

The rapidly increasing population after independence has continuously changed the region’s land use pattern as well as the natural resources. The establishment of Tea plantation by the Britishers during 19th century has provided an opportunity for local inhabitants to harness the natural resources in its fullest extent. With the development of Siliguri town as a major trade hub, the clearance of forest and expansion of settlements to cater the increasing population has created more pressure over the existing utilization of natural resources available. In this process, the water resources from the rivers Teesta, Mahananda, Balason, etc supported the basic needs of the region. Besides, with the growth of settlement viz. expansion of Siliguri town, the demand for construction materials increased manifold, which flourished the extraction activities of construction materials directly from river bed and also from adjoining terraces and floodplains. Bed materials from the river beds are extracted from almost all rivers of the region, but in Balason river, the extent of this extraction activity is quite high as compared to the river like Rakthi, Rohini, Mahananda, etc.

Extraction of bed materials along the lower course of Balason river is mostly dependent on the size, amount and quality of bed materials available. Along the entire stretch (24.13 km) of the lower Balason river, which falls under 4 C. D. Blocks of Darjeeling district (fig. 2), namely Mirik, Kurseong, Naxalbari and Matigara, the available official records as per District Land & Land Reform Office, Darjeeling, the bed material extraction permits are given to different land holders and extraction volume is mostly size selective depending on the available bed materials. Based on these records as well as the information collected during extensive field surveys, the researcher has divided the whole lower course into 3 important zones (fig. 3), on the basis of size and quantity of extracted volume from different sites. These are –

![Plate 1](A) Bed material being extracted from the Balason river bed (A), deposits of extracted material over river bed (B), extraction pits after bed materials are extracted (C) and extraction of sands directly from main channel (D).

**Zone 1:** This zone extends up to 8 km downstream from the piedmont zone. In this zone, large sized boulder ranging up to 1000 mm diameter is found and mostly extraction of larger sized gravels and boulders are common. Such boulders are broken with the help of human muscles in different sizes according to the demand of the market. Mostly, the extracted volumes from this zone are used for road (sloping), embankment and bridge construction. The important sites in this zone are Dudhia, Panighata, M. M. Terai, Bauni Bhitar Chhat, Dhemal, Tarabari and Gouri.
Zone 2: This zone with a total length of about 9 km extends up to the Matigara Bridge, where due to gradual decrease in sediment size, boulders ranging from 300-50 mm diameter are extracted. In this site, huge amount of medium to small sized gravels along with both coarse and fine grained sand are extracted. The extracted materials are processed both manually at extraction sites and also there are processing centres (Kasari), where bed materials are processed into different grades with the help of mechanically operated sieves. Due to the accessibility of N.H 31 and also other well connected local roads, this zone has the largest number of extraction sites and also the extracted volume is highest in the whole stretch. The extraction sites operating in this zone includes, Lalsara Chhat, Dumriguri Chhat, Bataliguri, Rangia, Nimai, Nengtichara, Pataner Chhat and Tari.

Zone 3: In the remaining length of about 7 km, downstream from Matigara Bridge, the extraction of smaller sized gravels, pebbles and sands predominates. In the extraction sites, mostly instream bed materials are extracted manually, which are washed and sieved simultaneously. Along the lower stretch, mostly sand extraction is done on large scale. The important sites are Jitu, Mathapari, Kalam and Kauakhali.

The construction of well connected transportation networks connecting the rapidly developing trade centre as Siliguri, also arouse the demand for construction materials and due to the nearness and availability of readily available raw materials in the form of bed materials, Balason became the major source for supply of such materials (Tamang & Mandal, 2010). During this process, the extension of extraction activities also attracted huge influx of labourers from different parts of North Bengal, South Bengal, Bihar, Assam, Rajasthan, Uttar Pradesh, and Bangladesh, majority of whom migrated from Bangladesh after 1971. These undocumented migrants are settled along the river banks in temporary built huts and every family member including small children are engaged in extraction activities. The earning of such labourers depends on the volume of materials extracted or the total volume of stones crushed into smaller sizes, as such, extracting 100 cu.ft of Accurate (gravel sized) fetch Rs. 350 and 100 cu. ft. of Bajri gives Rs. 700. On the extraction sites, the bed materials are extracted up to 2 m during the dry season and the larger boulders are collected at some selected places which are broken into smaller sizes ranging between 75 to 90 mm diameters. Other grades of bed materials supplied are Accurate, Misali, Metal, Grid, Bajri, 3/4th, 1/4th and chips from large boulders and mostly coarse and fine sands. During the monsoon period, mostly larger boulders and gravels brought down by the flow are extracted in the upper reaches and finer sands are sieved directly near the
banks along the lower segments. Also the instream extraction of medium grade bed materials are carried in lesser extent, as the river becomes inaccessible with increase in channel flow.

**Fig. 3** Total volume of extracted bed materials (m$^3 \times 10^6$) from different sites during 2002 -2010.

**Effects of bed material extraction along lower Balason river:**

An extensive body of knowledge exists on the expected effect on a river from gravel extraction, the most important of which is river bed degradation. The effects can be classified in three groups: (i) morphological, (ii) hydrological and finally (iii) ecological. It is thought that hydrological and ecological impacts are subsequent to morphological ones due to the role played by substrata change. Such removal of bed materials not only produces localized effects on the river, but their effects are transmitted a considerable distance upstream and downstream, much beyond the area of initial impact. In case of Balason river also, effects of such extraction activity are clearly visible in its fluvial characteristics. Some of the effects which the researcher have noted may be summarized as follows:

1. The continuous extraction of bed materials has gradually lowered the bed elevation as it has been found from the cross profiles taken at same site during the field study not only by the researcher but it had been also mentioned in previous studies on the same river (Dutta, 1995; Lama, 2003; Jana and Dutta, 1997). The lowering of bed has gradually resulted into alteration of the equilibrium profile of the stream bed and the channel has to adjust to the locally steeper gradient upon entering the extracted sites along the active channel. This steeper gradient produces increased stream power and results in bed erosion (Kondolf, 1994).

2. Along the entire lower course of Balason river (24.13 km), mostly extraction sites close to the bank are preferred as it reduces both labour and transportation costs. The effect of such near-bank extraction results in lowering of the bed and in many sites such extraction process has created scours which result into diversion of channel towards the bank during high discharge, thus increasing the bank recession (Jana & Dutta, 1997). In some sites, the bank height ranges up to 4 - 6 m from the riverbed, where the underlying exposures are clearly visible. Besides, the encroachment of adjacent flood plains and terraces by labourers for easy access to river bed has reduced the vegetative cover along the raised banks with merely few patches of grasses available over the eroding banks.

3. Besides, the scouring and filling process is below the bridge constructions due to narrow channel width causing retention of flow has severe impact over permanent construction. Such decrease in velocity results in deposition in the form of channel bars of considerable size at the upstream side (Dutta, 1995). The immediate result of river adjustment under such condition led to destruction of such permanent
construction as it happened on 18th August, 2009. The two piers of broad gauge Railway Bridge over the river bed was uprooted damaging the whole bridge (Tamang & Mandal, 2010).

**Fig. 4** Annual changes in the bed elevation along the lower course of Balason river as obtained during field survey from 2008 to 2010.

Prohibitions for controlling the bed material extraction:
In order to put control over the increasing rate of bed materials extraction mostly due to illegal extarction, the Govt. of West Bengal in “The West Bengal Minor Minerals Rules, 2002, schedule V”, has formulated certain prohibition on bed materials extraction without permit or extraction (Banerjee, 2007):-

- No extraction of minerals shall be allowed within 200 m of both sides of any river bridge or culvert over any waterway or from any embankment and structural works of the irrigation and waterways Department.
- No extraction operation shall be allowed within a distance of 200 m from any hydraulic structure, reservoir, bridge, canal, road and other public works or buildings.
- No extraction operation shall be done within a distance of 5 km of a barrage axis or dam of a river. The distance is to be reckoned across an imaginary line parallel to the barrage or dam axis as the case may be.
- In the districts of Darjeeling and Jalpaiguri, the extraction of boulders and sand shall only be made from the central one-third of the river-bed; provided that where the width of the river is 30 m or less, the extraction of the said minerals shall not be made without the permission in writing from the Irrigation and Waterways Department.
- No tree shall be felled and removed and no public easement shall be interfered without the written consent of the Issuing Authority in this respect.

Conclusion:
Although the concerned authorities have formulated the above mentioned prohibitions but their proper implementation have not taken place due to callousness of the authority and the role played by the permit-holders as middle man. The people dependent upon such activities are not concerned about the ultimate effects and with more demand from local markets; the illegal extraction is a common practice. Extraction near the bridges and embankments has been prohibited but in reality the materials are mostly extracted as per the convinence of transpotation to load the finished extracted materials for market. Hence, the extraction activities are largely degrading the fluvial characteristic and also the huge influx of a number of migrants and resulting occupance of adjacent floodplains are creating additional burden over the available resources of the region. Inspite of various detrimental effects of bed material extraction, if a river is aggrading, extraction of bed material may in some cases also have positive effects for flood-control purposes, channel stability and restoration. Hence, in order to reduce its negative effects, a different approach to bed material extraction is needed, in which, proper understanding and management of sediments at basin level; and a wider application of the available scientific knowledge, particularly
of fluvial geomorphology and hydraulics is very much essential. Thus, the concerned authorities should implement proper long term monitoring and scientific methods of extraction followed by integrated watershed planning which can at least control the degradation of Balason river.

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References: