Disasters - Natural or Manmade? - Some observations

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Abstract

The natural disaster in Uttarakhand especially in Kedaranth and Badrinath area in June 16, 2013 has shattered, shocked and shaked the people of the state as well as the nation. This resulted in death of thousands of people and numerous livestock, destroying/ damaging vast properties subsequent to cloud burst, lake break, floods, numerous landslides and avalanches. Cloud burst, flash flood and landslides, devastated the Kinnaur area of Himachal Pradesh, on the same day. After the incidence, a large no. of voices raised against the cascading hydro projects which has come up/coming up/ planning to come up. Though, the hazard was termed as natural but the interpretation tends to blame anthropogenic activities specially, hydroelectric projects. This paper deals with some observations on the natural calamities during geological periods, ancient/ historical periods and recent past. The studies indicate that the natural disaster like cloud burst, glacial lake outburst, floods, earthquake, landslides, shifting of river courses have been experienced in ancient period/historic and recent past where there was no dams and reservoirs. We are facing the same type of hazard/disaster at present. These natural hazards are a part and parcel of the earth history and we have to bear with it. The main causative factors for this hardship and severe degradation of landforms are fast growing population, unplanned settlement, improper construction like roads, buildings, industries, indiscriminate blasting and mining, improper disposal of excavated muck and waste; encroachment of vulnerable slopes, river regimes etc. However, our efforts should be to minimise the affect of these hazards by proper planning, implementation and monitoring of future activities. We need power, industries, irrigation, potable water to cope up the demand of the fast growing populations. As such, we need hydroelectric, irrigation, water supply and multi-purpose projects to meet the need of the population and to keep pace with the development of our country.

1. What We Learn from the Geological Past:

Most of the inland/ fresh water sedimentary rocks are formed by river systems. These consist of boulder beds, coarse/medium/fine sandstone, siltstone, shale/mudstone indicating their depositional history from a very high energy to a very low energy system of fluvial environment. Their dispositions in vast areas (eg. Gondwana and other sedimentary deposits) indicate migration of rivers to very large extents, like tens of kilometres or more. This implies that rivers in the geological past were also migratory in nature. For example, thick pile of quaternary deposits (Pleistocene and Holocene) in Indo-Gangetic plains. Bengal basin has also resulted due to migration of river system & gradual submergence of the basins. Tectonic activities have also played a vital role on the migration of river system & especially gradual subsidence of the river basins to accommodate huge pile of sediments. Besides, so many changes have been occurred in the landforms due to the impact of climatic changes during glaciation and inter glaciation period.

2. Observation on Ancient/historical Periods and Recent Past:

History of landslides, glacial lake outburst flood, snow avalanches, glacial movement represented by moraine deposits, shifting of rivers as evidenced from terrace deposits in the hilly terrain, paleo channel course, alluvial fan at the debouching point of the river with plains, lateral migration of river in plains, manifested by no. of aggraded abundant channels, meander scars, ox bow lakes, large fans along with a number of distributaries near the confluence with sea etc. are very common. In Himalayan terrain especially in eastern and central Himalaya most of the cultivated lands, settlements are either located on old slide debris or on terrace deposits. The old slide debris, glacio-fluvial and terrace represent ancient landslide activities and migration of river respectively. All these incidences indicate natural hazards occurred long back. Some of the examples are given below:

A. Shifting of Rivers:

i) Teesta Fan: a huge Teesta fan has been developed at the debouching points with plains. Spatio-temporal changes of the river can be seen by a no. of aggraded channels (figure 1). Initially, Teesta was meeting the river Ganga but gradually it has shifted the course towards southeast and presently merging with Brahmaputra River. Some of the historical changes are given below.

The Teesta River earlier flowing due south from Jalpaiguri in three channels, namely, the Karatoya to the east, the Punarbhaba in the west and the Atrai at the centre. The three channels possibly gave the name to the river as *Trisrota* "possessed of three streams" which has been shortened and corrupted to Teesta. Of these three, the Punarbhaba joined the Mahananda. The Atrai passing through a vast marshy area known as Chalan Beel joined the Karatoya and the united stream joined the Padma (Ganges) near Jafarganj. In the destructive floods of 1787, the Teesta River forsook its old channel and rushing south-east it joined the Brahmaputra (Majumdar; 1971).

A no. of devastating flood events have occurred in 19^{th} & 20^{th} century where so many morphological changes in the landforms including river courses have been recorded.

ii) Damodar Fan: Damodar River in West Bengal has changed its course a no. of times before meeting to Bhagirathi (Ganga/Hooghly) River and a major fan has been developed within which numerous aggraded/abandoned courses of Damodar are preserved. Initially, the river was flowing towards south east to meet the Hooghly River (figure 2) but gradually changed its course towards south from a pivotal point located east of Bardhaman town. A Small channel named Behula nadi is following the original course. Gradually, the river takes a 90° rotation and presently flowing towards south leaving a no. of aggraded/abandoned channels in between. These abandoned channels are sometimes named as Kana Damodar (Blind Damodar). Many of these abandoned aggraded channels have been used for mining of sand for construction purposes. The carbon dating of a wood from a sand mine present within one of the aggraded channel indicated an age of 1950 $\pm$50 BP. (Mishra,et.al 1986,87) which indicate river course of

Damodar was along this aggraded channel at about 4000 yr. ago. Later on, during 1950s (net survey) most of the discharges (~90%) of Damodar was diverted to a distributary named Mundeswari River, which merges with River Rupnarayan (figure 2).

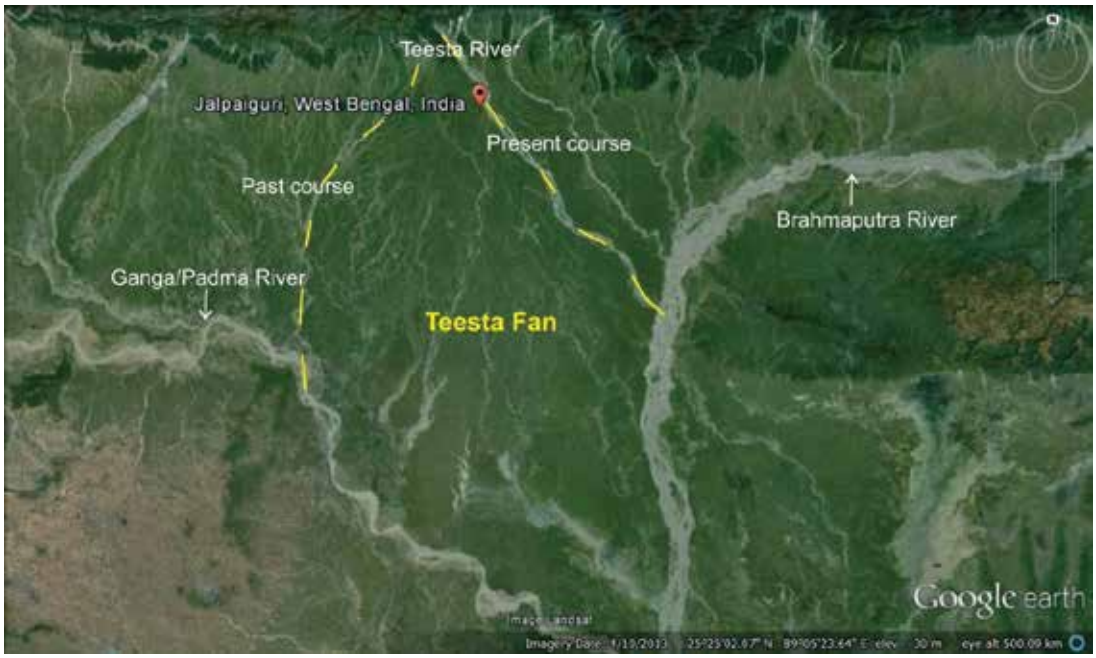

Figure 1 Teesta Fan showing a no. of river courses in between old and present river course

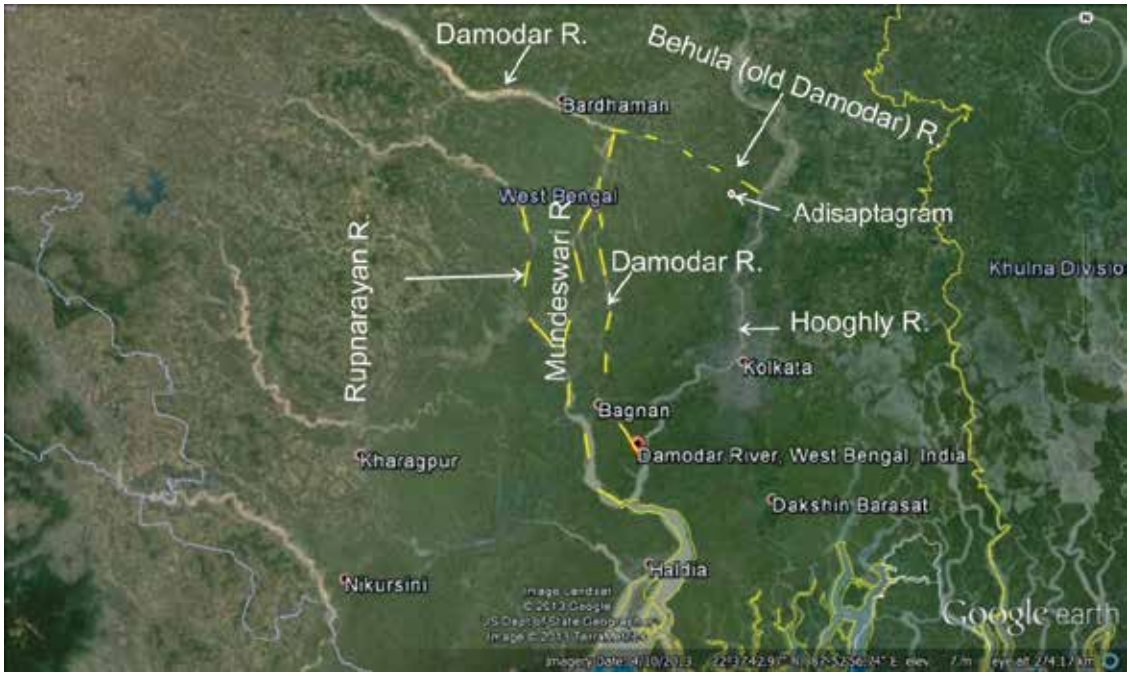

Figure 2 A number of aggraded courses of Damodar

iii) Kosi Fan: Kosi River, also known as sorrow of Bihar, has made a megafan at the plains after emerging from the hilly terrain, due to shifting its courses. Initially, it was flowing towards southeast but with time due to floods and deposition of the sediments it gradually changed its course to southwest (figure 3). Kosi River shows presence of about 12 distinct channels in its megafan.

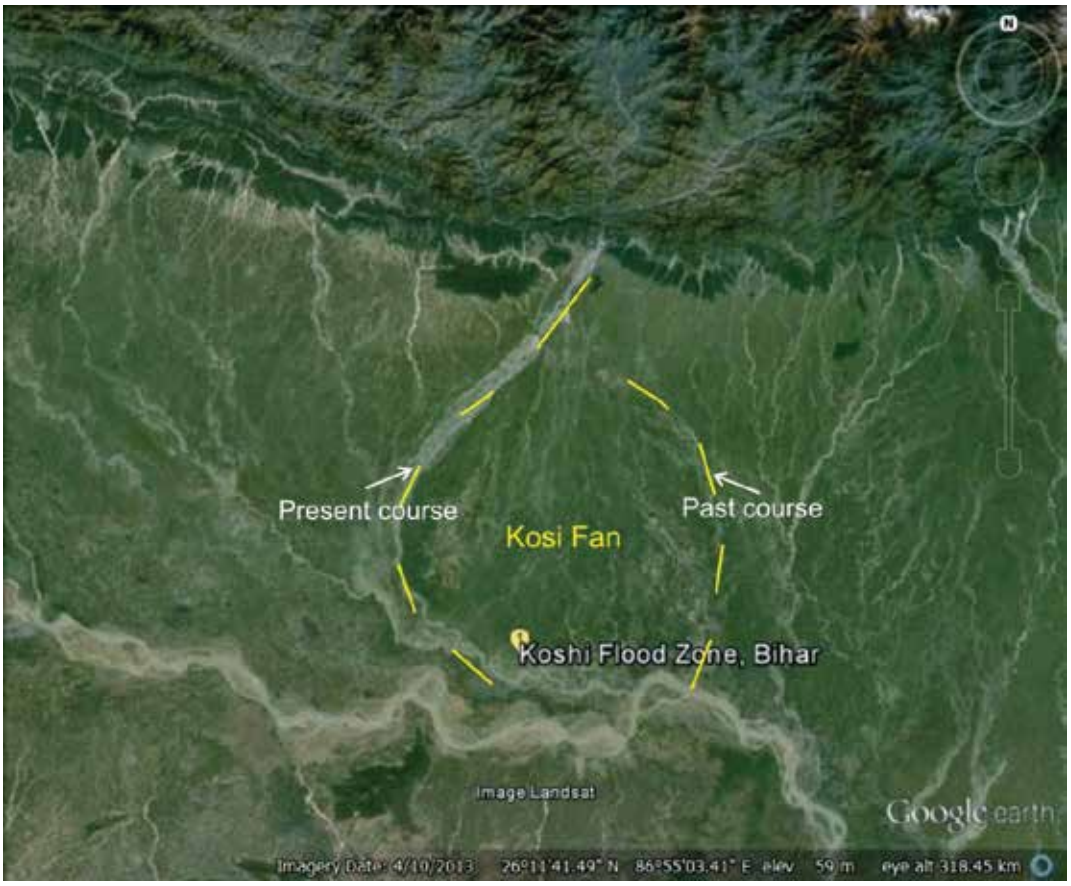

Figure 3 Kosi Fan at the debouching area between hills and plains showing different aggraded courses

Ganga River flowed through the Bhagirathi channel branching into three streams namely Saraswati flowing in south-westerly direction, Jamuna flowing south-easterly and the Hooghly flowing in the middle. Hooghly River glided down and flowed through the Adi Ganga. In the 16th century, the main discharge of the Bhagirathi, which earlier used to flow through the Saraswati, began to flow through the Hooghly. The upper Saraswati is a dead or dry river and the Hooghly has abandoned the Adi Ganga channel and adopted the lower course of the Saraswati to flow to the sea. Some quarters ascribe the virtual drying up of Adi Ganga to its being artificially linked to the lower channel of the Saraswati, whereby that became the main channel for ocean going ships and the Adi Ganga became derelict. This feat is ascribed by some to Nawab Alivardi Khan. Others think that there was only a tidal creek connecting the Saraswati and the Hooghly, near Fort William, Kolkata from where Hooghly River bifurcated from the Adi Ganga. Again, Colonel William Tolly renovated the portion of Adi Ganga to increase the flow and connected the

same through a canal (Tolly nala) to Vidyadhari River for survival of the port Canning. Ultimately, Adi Ganga dried completely in the downstream part and at present there is no trace of the river (figure 4). This may be the impact of human interference, but probably there is no reported environmental degradation in this regard (Chatterjee et.al 1986 and net survey).

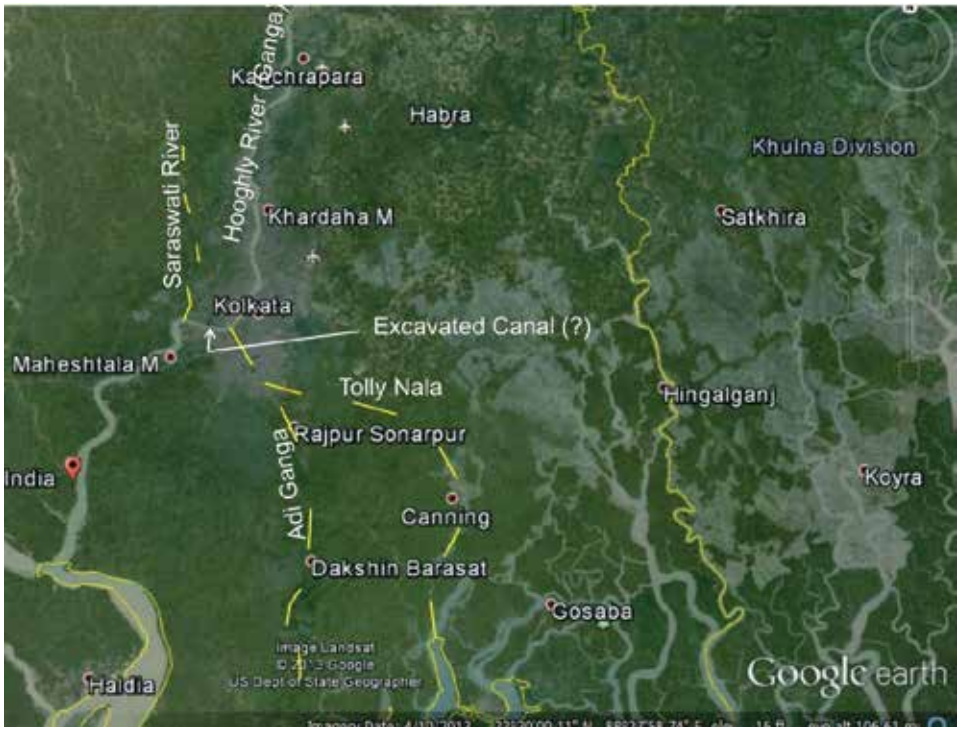

Figure 4 Different courses of Ganga (Hooghly) River including course of Adi Ganga River

The lateral migration of Hooghly/Bhagirathi River is conspicuous through out its courses from the bifurcation of Padma and Bhagirathi Rivers upto Bay of Bengal. Aggraded/abandoned channels, meandering kinks, ox bow lakes etc. are still visible for quiet a large distances on both the banks all along the courses.

v) Besides, there are no. of examples for migration of rivers e.g. submergence of Sadia town of Assam due to shifting of Brahmaputra. Shifting of rivers and its tributaries in the hilly terrains are also evidenced from the presence of abandoned channel courses, aggraded/paleo channel courses.

All those evidences indicate that changing of courses, river piracy etc. were common in the past also to form the present day landform. i.e., vast Indo-Gangetic plains, Brahmaputra planes etc.

B. Earthquake and landslides: Numerous earthquakes had occurred in the past and occurring in present. A large no. of historic and past earthquake data is available and

being used for determination of seismic design parameters of dams. Vast areas of hilly terrain particularly in Himalayas are covered by old landslide debris. In many cases the landslides scar is semi circular in nature and nala generates after occurrence of landslides. Again, toposheet studies reveal that semicircular scarps are generally present at the initiation of first order streams. This indicates that the first order streams may have generated during landslide activities. Besides, there are evidences of formation of landslide dams, lake burst in historical and geological past. It can be stated that landslide, avalanche activities are part and parcel in formation of landform in hilly terrain.

C. Glacial Lake Burst Flood (GLOF): Devastating flood due to glacial lake outburst are also common. It has also occurred during recent Uttarakhand flood where Chorabari Lake above Kedarnath Temple has breached. There are evidences of GLOF in historic times also. Twelve nos. of GLOF has occurred in Bhutan since1935. Breaching of Lunana glacial lake, Bhutan causing severe damages by devastating floods in 1994. Breaching of glacial lakes at Lunana also reported in 1957 and 1969. The glacial lake Dig Tso, Nepal has also breached resulting flood in 1985 (internet survey).

Numerous incidences of glacial lake outburst flood (GLOF) including the above have occurred when there was no developmental activity like dams and reservoirs.

3. Effect without Dams and Embankments:

If we do not construct a dam or embankment then major portion of the sediments, mainly coarser one carried by river will be deposited at the debouching point with plains. The finer particles will be transported and deposited throughout the river course and into the sea depending upon energy condition. In over all, the discharge capacity of the river will gradually decrease due to deposition of the silt. This deposition will force the river to migrate laterally. Neotectonic activity also plays vital role in shifting of the river. Embankments along the river are being provided to protect the localities/towns, vast cultivated lands/ orchards etc. from floods.

Civilisation started on the banks of river. The localities and important towns located by the bank of the rivers will be inundated regularly and vulnerable to devastations including washing out of them. Vast areas of cultivated land will also be subjected to inundation every year resulting damaging of crops. It is also pertinent to say that if we don't construct the embankments along the river, then a large no. of communication route eg. roads, railway line will be damaged/washed out due to inundation every year. Even we have to shift the river crossing system i.e, bridges, culverts etc. in connection with gradual shifting of river courses.

4. Effect of Dams and Embankments:

Construction of dams, barrages, weirs plays a vital role on the development of a country. Hydel power, thermal powers, irrigation facilities, industrialisation, flood control are always related to dams. Once upon a time, Damodar River was called Sorrow of Bengal, as vast areas along the Damodar and its tributaries used to be affected by floods/ flash

floods every year causing damages/ washing out of communication routes, settlements, crops leading to hardship of the people of the area. Later on, it has become a blessing for West Bengal after construction of a series of dams and barrages across Damodar and its tributaries. These dams not only control the flood but also facilitate irrigation to vast areas in both the Rabi and Kharif seasons and providing water facilities for industries and drinking purposes. It may not be required to mention the huge benefit from Bhakra dam, Hirakud dam and so many multipurpose, irrigation, hydroelectric and water supply projects. It is noteworthy to mention that check dams, though in smaller sizes, are provided to prevent erosion is a common practice and is followed by Forest and Environment Departments.

Some of the advantages of dams are:

(a) Generation of hydro power, providing irrigation, and drinking water facilities, flourishing industries etc.
(b) Regulated discharge throughout the year in case of storage dams and benefit is more in lean periods.
(c) Recharging groundwater from the reservoir
(d) Adding moisture content to the atmosphere from reservoir resulting enhanced rainfall which facilitates irrigation, generation of power etc. the surface area of total water body may or may not be same with the reservoir and the stretch between dam and powerhouse. However, in case of storage dams, the surface area of reservoir is likely to be more. Concentration of evaporation will be more in a reservoir like more transpiration occurs in a dense forest area.
(e) Reducing erosion at the upstream of the dam due to raising of base level erosion.
(f) Distributing the silt in different cascade projects instead of dumping at the debouching area with planes/ depositing in planes.
(g) Control floods – There are no. of examples, to name a few (1) dams across Damodar River has not only effectively controlled the floods but also made a boon for crops due to development of irrigation facilities (2) Irrigation from Bhakhra reservoir resulting green revolution (3) Tehri Dam has absorbed the thrust of the Uttarakhand cloudburst of 16th June, 2013 saving the towns like Haridwar, Rishikesh from casualties, damages and floods.
(h) Economic condition, education, communication facilities etc. increases to the local people.

Some of the disadvantages of dams are:

(a) Uncontrolled blasting makes the adjacent rock mass weak resulting in slope failure afterwards/ in long run. Scientific blasting may be adopted to minimise damages in the surrounding rock mass.
(b) Environmental degradation due to disposal of muck. Proper planning with protection measures are required in this regard.
(c) Improper planning and inadequate protective measures for constructing the infrastructural facilities like roads, colonies etc.
(d) Drying up of river course between dam and powerhouse for peaking power generation, resulting threat on the riparian and in-stream habitats. Compulsory flow has been implemented for all the projects to avoid this.

(e) Submergence of land (forest/ cultivated/settlement). Industries, communication projects also occupy land.
(f) Increase in erosion and carrying capacity in the downstream of dams. Guided flow through spillway lead to bank erosion as it is generally located near the intakes, that is, towards any of the river banks. Suitable slope protective measures are required.
(g) Prevention of movements of aquatic animals by dams leads to adverse effect on them. Fish ladders may mitigate the problem to some extent.

The above disadvantages can be sorted out through proper planning and implementation to make the projects techno economic and eco friendly.

Some of the advantages for construction of embankments along river banks:

(a) Checking of river migration to protect cities/towns/localities and cultivated lands adjacent to the river
(b) Prevention of floods to protect cities/towns/localities and cultivated lands adjacent to the river

Some of the disadvantages for construction of embankments along river banks:

(a) Silt deposition is concentrated only within the riverbed between the embankments resulting in raising of riverbed level w.r.t. adjacent localities. Thus, reducing the carrying capacity of the river. It is to mention that siltation along river course, though less in quantities also occurs in normal condition resulting migration of channels. The channel/point bar deposits are common along river courses without embankments.
(b) Breaching of embankments during high flood, inundates the adjacent area and difficult to return back of flood water to the river course during recession of the flood owing to higher river bed level than the adjacent area. This causes water logging which results in water borne diseases.

Scientific mining of the river material to some extent for construction purposes and regular maintenance of embankments will help in mitigating the problem to some extent.

5. What We See in Present:

There may not be much difference between the past historical events and present events. i.e, what we have experienced in the past, we are seeing in the present. The past is the key to the present is well valid. River migration, earthquakes, cloud burst, lake burst, landslides, avalanches are common in present day scenario as also in past. There is a view of large no. of persons that earthquakes are occurring as a reservoir triggered seismicity due to construction of dams. Uttarkashi earthquake (1991) occurred before the construction of Tehri dam, otherwise there may be huge voices correlating earthquake with the dam. Cloud burst, lake burst, landslide dams occurred in historical past without developmental activities (dams, roads etc.) and also occurring at present. Many opinions has related the Uttarakhand cloud burst due to cascading projects of the valley, though there is no such development in Kedarnath valley - the worst affected area. The thick moraine deposits in and around the Kedarnath valley resulted from movement of glaciers/avalanches in the geologic/historic periods. Chorabari Lake (Gandhi Sarovar) has probably formed due to movement of glaciers. All these have occurred when there was

no developmental / anthropogenic activity. The cloud burst at the same time in Kinnaur valley in H.P has also occurred which is devoid of dams till date. Moreover, floods due to cloudbursts have been experienced in Leh (2010), J&K, in Karsiang (1998) and Kalimpong (1996, 2013), West Bengal and so many places in many times which can not be correlated with construction of dams and barrages. Heavy incessant rains are also common in plains causing floods, where there is no dams/barrages.

6. Problems and Amicable Mitigations:

Natural calamities have occurred in the past, occurring in present and will be occurred in future. We have to bear with it. But the most important factor is to minimise the effect by proper planning in our eco-system, awareness and capacity building against the calamities.

Indiscriminate construction in the localities of hilly terrain without proper planning including sewerage system, without assessment of the slope stability, encroachment in the vulnerable slopes and river regime, improper construction of road, infrastructural projects including dams, powerhouse etc. have turned into a complex problem.

Influx of population, poverty and lack of awareness has compelled the population indiscriminate and haphazard constructions of buildings for dwelling and other purposes. Stability of the slopes has generally not assessed. In most of the localities, there is no proper drainage and sewerage system. Moreover, encroachments in the vulnerable slopes and river bed/ terraces susceptible to landslide/erosion are also common. This has made the localities and towns vulnerable to landslides during heavy rains/earthquakes. Construction of multistoried buildings in an unplanned and unscientific way in hilly terrain is an added problem. Proper planning, assessments of stability along the alignment are seldom being carried out before construction of roads. In the hilly terrain the roads are generally being taken along the river banks or along the valley slopes of the river. Half cut and half fill method is also a common practice for laying a road. That is, half of the road bench is excavated and other half is being filled up by the excavated muck. This may result either by encroachment towards river or loading the valley side slope, especially the vulnerable ones, by filled material. Both are not desirable as these may lead to slope instability. It is to mention that a number of buffer benches were kept above the bench of the narrow gauge railway line (toy train) between Siliguri and Darjeeling in West Bengal, at the probable slope instability portions. This railway line was constructed during British regime. At present no one can think to keep buffer benches. In 1998, a number of landslides occurred in Karseang, Darjeeling district of West Bengal due to cloud burst/incessant rain, resulting breaches of NH-55 at several locations mainly due to inadequacy of spill room of the culverts to discharge the flow. It was found that in most of the cases the nalas get widened both in upslopes and downslopes of the culverts i.e. at the road bench, the channel is constricted due to narrow culverts. It was also observed that in some cases the culverts were not along the nala courses, i.e. gradually the nala has shifted laterally, but the culverts have not been shifted/ constructed as per demand of the nala. Probably, the designs of culverts were not changed since construction of the roads hundred years ago, though present scenario has changed a lot. Moreover, chocking of the

spill room of the culverts by nala deposits/garbage have become common phenomena. Lack of maintenance of road side drains/ retaining structures is an added problem.

In plains, renovation of aggraded channels, meander/ ox-bow lakes etc. will help to mitigate the flood problem to some extent as this will be able to accommodate a considerable amount of flood water. This accommodated flood water can be used for irrigation purpose. This will also enhance the recharging of ground water.

Therefore, priority should be given towards scientific and sustainable environment friendly anthropogenic activities especially in hilly terrain. These include proper planning and strict implementation for any construction activities, like construction of hydro projects, infrastructure, settlements, roads, muck/waste disposal etc. Similarly, scientific mining/dredging of river bed may be adopted as far as possible with an aim to utilize the same for construction and other purposes to restore river capacity and to minimize erosion, slope instability and environmental degradation. Similarly, migration of rivers has to be protected in plains also to protect flood, town and localities and vast cultivated lands. Enhance in irrigation facilities to cope up the demand of huge population are also required. Construction of dams & embankments are inevitable to address the same. However, optimum utilisation of the silt deposit along river courses are required to be undertaken by scientific mining and dredging to minimise the adverse effect resulted due to construction of embankments along the river.

7. Conclusions:

A large no. of voices raised against the hydroelectric projects in Uttarakhand after the devastating floods and landslides subsequent to cloud burst and lake burst. The natural disaster like cloud burst, glacial lake outburst, floods, earthquake, landslides, shifting of river courses have been experienced in ancient period/historic and recent past where there was no dams and reservoirs. We are facing the same type of hazard/disaster at present. These natural hazards are a part and parcel of the earth history and we have to bear with it. However, our efforts should be to minimise the affect of these hazards by proper planning, implementation and monitoring of future activities. The main causative factors for this hardship and severe degradation of landforms are fast growing population, unplanned settlement, improper construction like roads, buildings, industries, indiscriminate blasting and mining, improper disposal of excavated muck and waste; encroachment of vulnerable slopes, river regimes etc. We need power, industries, irrigation and potable water to cope up the demand of the fast growing populations. As such, we need hydroelectric, irrigation, water supply and multi-purpose projects to meet the need of the population and to keep pace with the development of our country. Dams, reservoirs are part and parcel of the development. We should not forget the contribution of dams across Damodar River for flood control and irrigation where the sorrow of Bengal i.e Damodar River has become a blessing of Bengal. Similarly, the contribution of Bhakra dam in Punjab and Himachal Pradesh, Hirakund dam on Mahanadi River in Orissa and many dams throughout India are the main contributors for Green Revolution, flourishing industries and solving scarcity of drinking water.

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