

Landslides and Floods in the Tista Basin (Darjeeling and Jalpaiguri Districts): Historical Evidence, Causes and Consequences

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ABSTRACT

The Tista basin is one of the most vulnerable among the Himalayan river basins considering the occurrence of landslides and floods. The landslides occurred in 1899, 1950, 1968, 1976, 1991, 1993, 2003, 2004, 2005, 2006, 2009, 2011 and 2015. The floods occurred during 1950, 1968, 1973, 1975, 1976, 1978, 1993, 1996, 2000, 2003 and 2015. Some of the years of landslides and floods are same. This reflects the joint occurrence of the two hazards. Landslides occur in the hilly portion of the basin (Darjeeling Himalaya) whereas floods occur in the plain portion of the basin (Jalpaiguri district) and the flood events occur after the landslides because of topographic variation effect. This in turn indicates the influence of landslides on the floods. The prominent causes of landslides in the basin are torrential rainfall, fragile geology, earthquake and deforestation. The prominent causes of floods are sudden cloud burst, conditional basin surface morphology, landslides and barrage, embankments and guide bunds construction. The record of consequences of these two disasters brings in to focus the severe impact caused on the basin dynamics.

Key words: Landslides, Floods, Historical Evidences, Tista Basin, Darjeeling Himalaya, Jalpaiguri District.

INTRODUCTION

Both the Landslides and floods are very common disasters in north India. Landslides mainly occur in mountain areas, where as floods prominently occur in plain areas and foothill plains (Agarwal and Narain, 1991). The Tista Basin too is known to be a prominent locale for these natural phenomena. The mountain portion of the basin is affected by landslides and the plain area of the basin is impacted by floods. The onset of monsoon in the north India usually culminates into massive torrential rainfall over the Himalayan foot hill belt. The Himalayan mountain range is the youngest folded mountain range and it is composed of recent sedimentary rocks (Mukhopadhyay, 1982). Due to relatively recent origin soil erosion rate is very high in this region. This has been responsible for formation of major alluvial plains of the northern India. Due to varied geomorphology and prominent seismo-tectonics, the region has become one of the highly earthquake-prone areas. A large number of rivers and their tributaries that originate from the Himalayas erode the mountain, contributing to formation of major alluvial plains to the south of foothill zone (Mukhopadhyay, 1982). The Tista basin is one of the most vulnerable river basins in the Himalayan region from the perspective of the erosive character, landslides, and flash floods (Agarwal and Narain, 1991). The basin receives very high monsoon rainfall every year (200-600 mm and more) and the rainfall variability of the basin is very high due to significant variations in altitude. The mountain portion of the basin receives intense rainfall (Darjeeling Himalaya) in comparison to the plain portion (Jalpaiguri District). When taken into consideration altitude

variability based rainfall distribution one can notice that foothill areas receive high rainfall. From there the quantum of rainfall starts decreasing, with altitude changing from 2000-2400m to 600-800m (Agarwal and Narain, 1991). The river basin yields the highest amount of sediment among the Himalayan Rivers (98.40 cum/ha/yr). The rate of average annual denudation is also the highest (9.8 mm/yr) among the Himalayan Rivers (Agarwal and Narain, 1991). These characteristics indicate the behaviour and sensitivity of the basin to natural calamities.

The present study focuses on an overall scenario of the landslide events and flood occurrences of the Tista basin in Darjeeling and Jalpaiguri districts, in the context of the historical evidence.

Description of the Study Area

The Tista is a trans-boundary river cross the Indo-Bangladesh boundary and the basin area is about 12160 km² encompassing parts of Sikkim, West Bengal and Bangladesh. The Tista river is a tributary of the mighty Brahmaputra river. It originates from the Sikkim Himalaya. The river then drains 30 km to the south and then enters the Brahmaputra plain and forms a mega fan called Tista mega fan (alike the Kosi mega fan) (Mukhopadhyay, 1982; Ghosh, 2014). The river finally meets the Brahmaputra in Bangladesh Figure 1. The course of the river had been changed extensively during the early sixteenth century and after that the present course is being shaped by annual flood events and underlying fragile geology (Mukhopadhyay, 1982). The river flowed into the river Ganga up to the

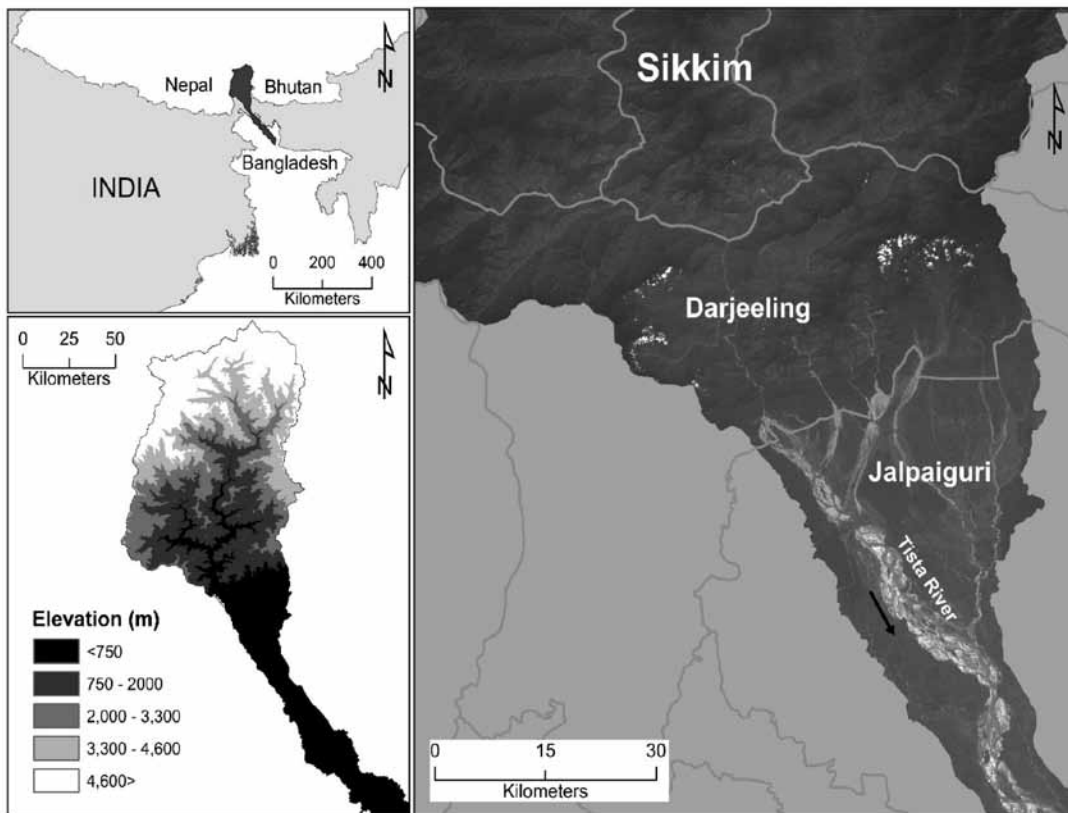


Figure 1. The Tista Basin in the Darjeeling Himalaya and Jalpaiguri District.

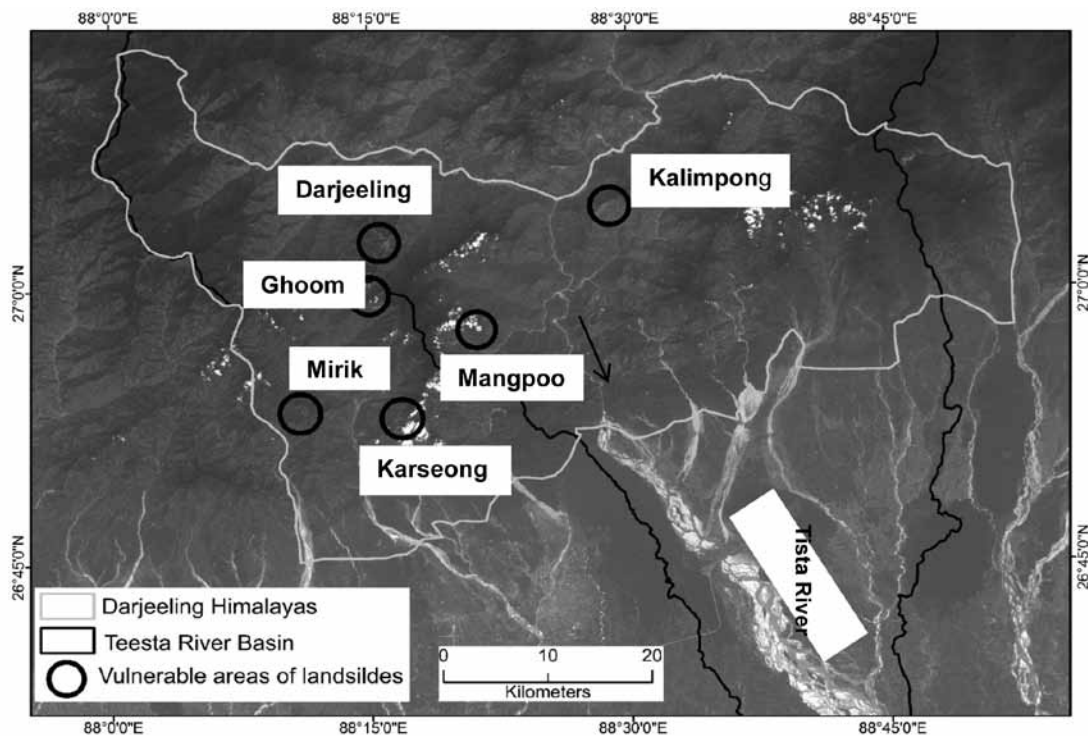


Figure 2. Landslide prone areas in the Darjeeling Himalayas (Kalimpong (1899, 1950, 1968, 2005, 2009, 2011, 2015), Darjeeling (1899, 1934, 1950, 1968, 1980, 1991, 1999, 2003, 2015), Ghoom (1899, 1934, 1980), Mirik (2009, 2015), Mangpoo (1993), Karseong (1899, 1934, 1950, 2003, 2004)).

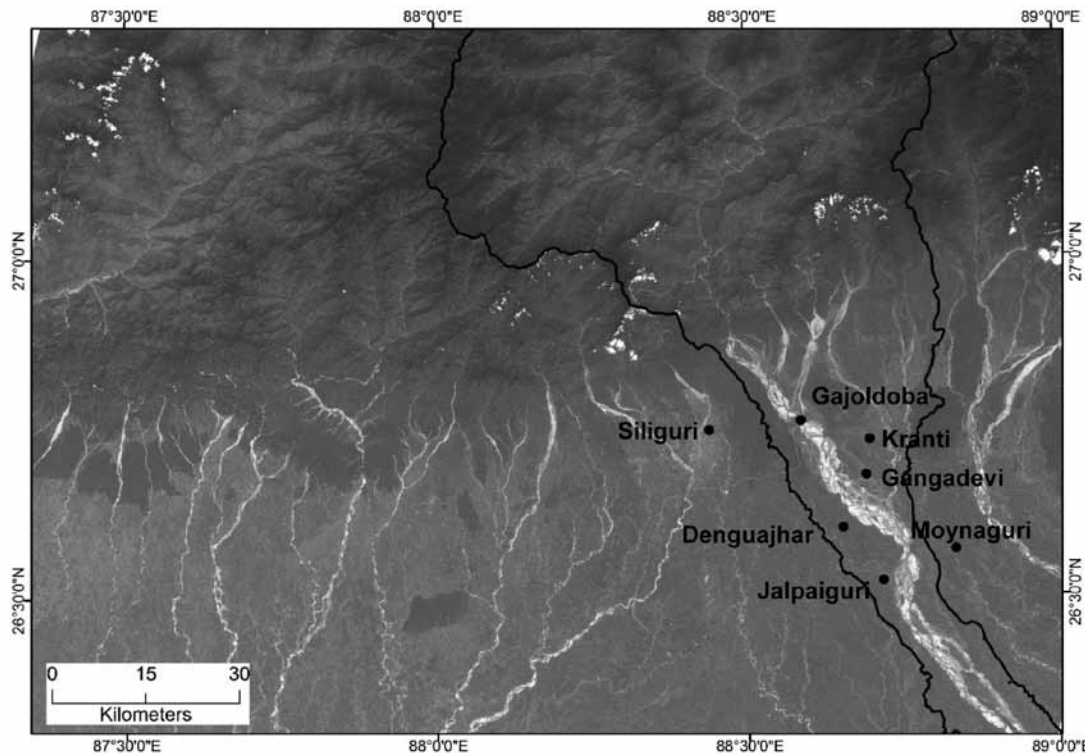


Figure 3. Flood prone areas of the Tista basin in Jalpaiguri district (Jalpaiguri and Moynaguri (1968, 1973, 1975, 1993, 2015), Kranti (1968, 1993), Gangadevi (1968, 1993), Denguajhar (1968, 1993).

end of the 18th century but after the 1787 devastating flood, the channel shifted eastwards and joined the mighty Brahmaputra (Agarwal and Narain, 1991). The Indian portion of the basin is very steep, whereas the Bangladesh portion is gentle in slope. The main rock types of the basin are pre-Cambrian high-grade gneisses and quartzite, high-grade schist phyletic and Calc-silicate and quartzite (Wadia, 1975) (Singh, 1971). The major soil types of the basin can be characterized by high concentration of iron oxide. It is acidic with lack of mineral and organic nutrients. The present study covered the Indian portion of the Tista basin viz. Sikkim and Darjeeling Himalaya and the plain of Tista basin (Jalpaiguri District) (Singh, 1971).

History of Landslides

The upper portion of the Tista Basin is mountainous and affected by landslides. Sikkim and Darjeeling Himalaya mainly covers the mountain portion of the basin. The region is highly prone to the landslide occurrences (Basu, et al., 2009). From the available literature on the history of landslides of the Tista Basin it is known that the mammoth ill-fated landslide occurred in September 1899 at Darjeeling, Tindharia, Kurseong, Kalimpong and Ghum towns. The 1934 landslide in January was also significant and the affected areas were Ghum, Kurseong and Darjeeling towns. In June 1950, a major landslide occurred at Darjeeling

town, Kalimpong, Takdah, Kurseong, Tindharia and Happy Valley. Significant amount of property loss was reported from many parts of the affected area, including Siliguri-Kalimpong railway line and roads. A massive landslide occurred in October 1968, in the same year of the great Tista flood. The landslide affected areas were Darjeeling town, Manipuri, Tista Bazar, Lebong and Kalimpong. Apart from 667 fatalities several tea gardens were destructed. In September 1980, a large landslide occurred and about 215 people died, the Hill Cart Road and NH 31 were destroyed. In the last 35 years landslides occurred several times i.e. 1976, 1991, 1993, 2003, 2004, 2005, 2006, 2009, 2011 and 2015. All the landslides occurred at Darjeeling Town, Pulbazar, Kurseong, Rongtong, Tindharia, Kalimpong, Nimbung and Mirik (outside of the Tista Basin). The 1993 landslide occurred in July and 15 people were lost. A landslide occurred in August 2009 and three people were lost. The 2011 landslide occurred because of heavy rainfall at Darjeeling (152 mm), Kalimpong (60 mm) and Kurseong (60 mm) and snatched many lives. In June-July 2015 landslides occurred at Tingling, Mirik, Nimki Dara, Sukhia Pokhari of Darjeeling and Pedong of Kalimpong. Sudden cloud burst in Darjeeling and Sikkim Himalaya triggered the occurrences of the landslides (Agarwal and Narain, 1991; Sarkar, 1999; Starkel and Basu, 2000; Basu and De, 2003; Basu, et al., 2009; Chakraborty, et al., 2011; The Hindu, 2015) Figure 2.

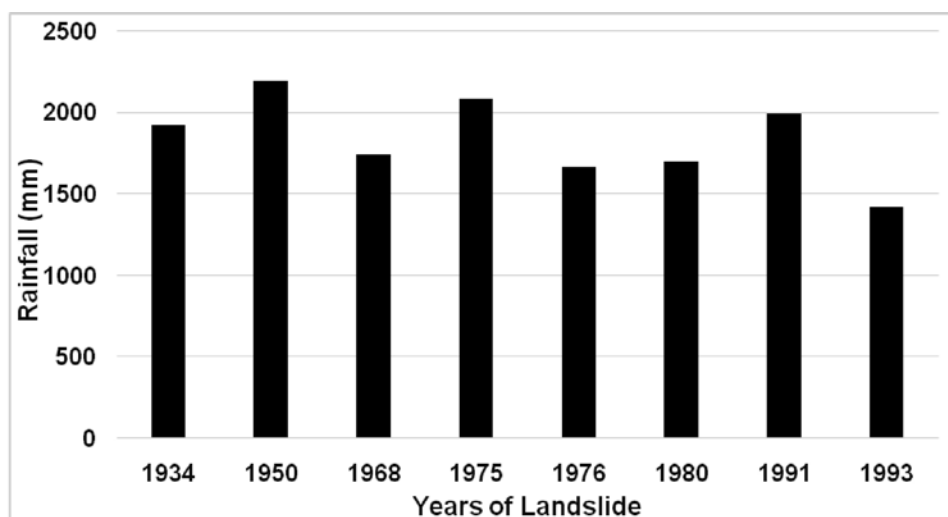


Figure 4. The years of landslides and very high rainfall that reflects the impact of rainfall on landslides.

History of Floods

Flood is very common in the Tista basin. The plain area of the basin is flooded annually. The earlier catastrophic floods occurred in 1950, 1968, 1973, 1975, 1976, 1978, 1993, 1996, 2000, 2003 and 2015. Among these the 1968 flood is most disastrous in the last sixty five years. The cyclonic storm started on October 2 and lasted for 3 days, coupled with localized cloud burst resulted in huge land slides in the Sikkim and Darjeeling Himalayas, huge landslides, leading to catastrophic flood in 1968. More than 600 landslides occurred during this cloud burst that played a significant role in generation of the 1968 flood. Numerous bridges were demolished and washed away (e.g. Tar Khola, old Anderson Bridge and Tista Bazar Bridge etc.). The water level was above 20 m from the extreme danger level at Tista Bazar and Domohani embankment. The flood lasted for four days (2nd-6th October). Many major floods have also occurred after the 1968 flood, though it was the most catastrophic (Agarwal and Narain, 1991). Tista barrage and the Tista-Mahananda Canal were started functioning in 1993. Gajoldoba Barrage was constructed after the 1968 flood mainly for irrigation of North Bengal. Though the barrage was constructed, the flood could not be prevented fully because of monsoon cloud burst and short-term heavy rainfall. In July 2015, a large area of the Tista basin (Jalpaiguri district) got inundated by the flash flood. The sudden cloud burst in the Sikkim and Darjeeling Himalaya on 30 June 2015 resulted in significant increase in the river water level, leading to a record amount of extra discharge (5500 cumecs) from Gajoldoba Barrage. Most of the areas of Jalpaiguri and Maynaguri blocks were inundated for four days (1st-5th July). It was the largest flood in the last two decades (Bhattacharaya, 2015) Figure 3.

Causes of Landslides

Torrential Rainfall

All the reported landslides occur during the rainy season, especially during short term very high rainfall. Intense rainfall causes the earth material to lose compactness. This in turn leads to a decrease in the value of the safety factor that enhances the occurrence of a landslide (Agarwal and Narain, 1991). Figure 4 displays the years of the landslide occurrences and very high rainfall (Data Source: http://www.indiawaterportal.org/met_data). Rainfall intensity has a major role in the occurrence of landslides (Dahal and Hasegawa, 2008; Bhusan, et al., 2014). But there is no availability of such data for each event of landslide and only total yearly rainfall data is available. For that reason an effort is made through this study to establish that there is a considerable role of high rainfall in the occurrences of landslides.

Fragile Geology

The bed rock structure of the upper Tista Basin is extremely fragile and divided by many rivers. It is one of the prime causes of the landslides in the Tista Basin (Agarwal and Narain, 1991). The high erosion rate in the upper Tista basin and toe erosion in the foot hill areas of the basin enforces the landslide processes. The rock consists of shale, quartzite, mica schist and sandstone. The rocks are folded and thrust and in a disintegrated condition in many places that lead to high erosion (Agarwal and Narain, 1991). In addition, in Darjeeling Himalaya Mirik has become a zone of the regular landslide. There may be an important role of Mirik Lake on the occurrence of landslides.

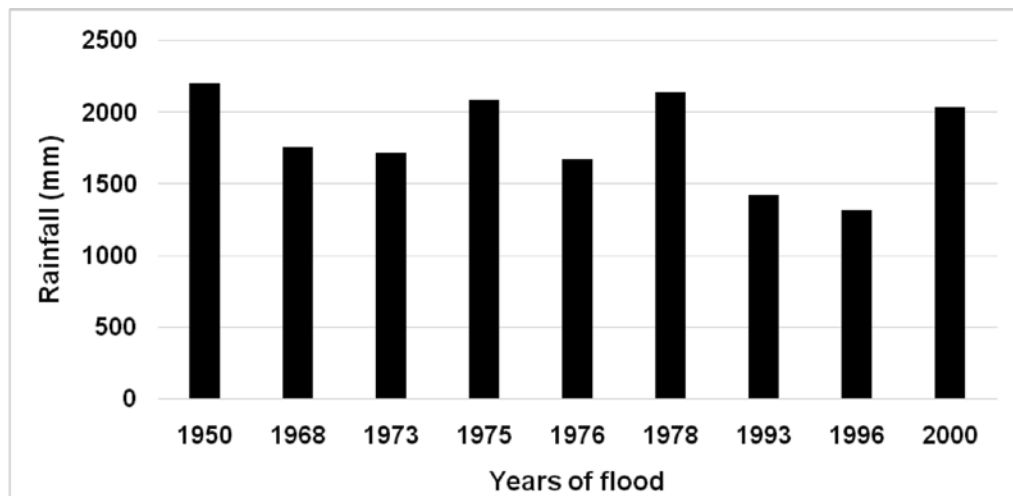


Figure 5. The years of floods and very high rainfall that reflects the impact of rainfall on floods

Earthquake

The Tista basin along with the Himalayas is a highly earthquake prone area. There is a strong connection between earthquake events and landslides. Some of the major earthquakes are Bengal earthquake 1885, Shillong earthquake 1897, Assam earthquake 1918, Bihar earthquake 1934 and Assam earthquake 1950 (Mukhopadhyay, 1982). Several mild earthquakes were recorded before the 1968 landslides in different places in Darjeeling and Sikkim Himalaya (Agarwal and Narain, 1991). The 2011 landslide occurred due to an earthquake in Nepal and Sikkim Himalaya (Chakraborty, et al., 2011). In the same way, before the 2015 landslide several earthquakes of high magnitude were recorded in Nepal and its surrounding Himalayan region magnitudes. The report of Geological Survey of India has said that one of the main causes of the 2015 landslide is the Nepal earthquake. The 25th April, 2015 Gorkha earthquake of Kathmandu valley triggered more than 400 landslides.

Anthropogenic Causes

Continuous deforestation due to the construction of roads and buildings, the changing cropping pattern and tea gardening etc. is a significant cause of loosening of earth materials that enforce the occurrence of landslides (Agarwal and Narain, 1991). The construction of buildings at different hilly towns' viz. Darjeeling, Mirik, Kurseong and Kalimpong has become a major cause of deforestation. In order to develop the tourism and to increase connectivity several new roads have been constructed that also triggered the landslide processes. Landslide, therefore, itself also a major cause of deforestation (Agarwal and Narain, 1991; Sarkar, 1999). Deforestation controls the occurrence of shallow landslides and has no role in the occurrence of

deep landslides. Among several human induced factors, the construction of roads has a considerable role on landslides (Agarwal and Narain, 1991).

Causes of Floods

Sudden Cloud Burst

One of the prime reasons of Tista floods is sudden cloud burst in the Darjeeling and Sikkim Himalaya in the pre and post monsoon period. Sudden orographic rainfall leads to catastrophic flow of water through the channel that enforces the channel flow breaching the embankments on both the banks. Most of the Tista floods are the flash floods and occurred in the monsoon period (Agarwal and Narain, 1991). For example, the 2015 flood is the result of cloud burst and heavy rainfall in the Sikkim and Darjeeling Himalaya in the pre monsoon period. Intense rainfall at different stations is recorded viz. Sevoke (220.2 mm), Gajoldoba (37.8 mm), Kalimpong (137.1 mm), Gangtak (68.3 mm) and Champasari (112.0 mm) (Bengali News Agency, 2015). The basin received over 1700 mm rainfall during the 1968 flood (2nd-5th October). Figure 5 displays the total monsoon rainfall in the years of floods (Data Source: http://www.indiawaterportal.org/met_data) It shows a very generalized detail. However, it clearly depicts significant relation between the occurrence of floods and the high rainfall.

Geomorphic Causes

Tista River is flowing from the north to south. The river enters the plain at Sevoke. Between Gangtak and Sevoke the channel flow is about 80 km and the difference of channel bed height is about 800 m. But between Sevoke and Mekliganj in the downstream the channel flow is about

Table 1. Consequences of landslides and floods (the events of 1968 and 2015).

Disasters	Years	Death of people / Marooned people	Loss of resources
Landslide	1968	667	The Hill Cart Road and NH 31 were destroyed.
	2015	38 killed and 23 missing	The NH 10 and 55 disconnected Kalimpong-Lava and Siliguri-Darjeeling.
Flood	1968	about 1000 people were either dead or missing	Flood-protection embankment at Moinaguri, Domohani and Jalpaiguri. Hectors of the agricultural field were inundated.
	2015	Over 20,000 people are marooned (about 5000 people were evacuated till 7 nd October, 2015)	Hectors of agricultural field and numerous houses were inundated.

75 km and the difference of height is about 80 m. The sudden change of relative relief of the trough of the river, within a span of 200 km, and the valley gradient of the river and its tributaries is very high. The channel width is about 200 m in the mountain region whereas it is about 1000 m in the Tista Plain. The main flow and the tributaries deliver a large amount of sediment to the downstream. They play a key role in the occurrence of floods. Moreover, the river in the plain has formed a Megafan called Tista Mega fan because of the change in slope. Because of this the river has formed a braided structure. The reduction of slope and the channel depth enforce to overtop the embankments by the mighty flow of Tista during very high rainfall (Mukhopadhyay, 1982; Agarwal and Narain, 1991).

Role of Landslides

Continuous landslides in Darjeeling Himalayas have a considerable role on the floods in Tista plain (Jalpaiguri district). Sometimes, the occurrences of landslides impede the river flow that increases the possibility of flash floods. There is no such evidence that indicates the role of landslides in the occurrence of flood events. One exception is the 1968 flood. Some experts believe that there is a link between the two supreme calamities i.e. landslide and flood in the Tista Basin. The 1968 landslides occurred in Darjeeling Himalaya before the incident of the 1968 flood and hence, the landslides triggered the flood event (Agarwal and Narain, 1991). Figure 4 and Figure 5 display the occurrence of landslides and floods in the same year for some years that indicates an indirect involvement of landslides to the flood calamities.

Anthropogenic Causes

A large number of bridges have been constructed along the river viz. Tista Bridge and Sevoke railway Bridge etc. In 1993 Gajoldoba Barrage was commissioned for irrigation purposes. The channel flow close to the

bridges in the upstream of the river is affected, because of the embankments and the guide-bunds (short bell-bunds). In such a scenario, the channel flow breaches the embankments and overtops the banks by extreme water pressure in the upstream of the constructions, during very high rainfall. During 1993, the barrage did not control the flood events properly because of the huge water pressure in the upstream of the barrage during the high rainfall period. Hence, the sudden release of water has become the cause of the flash flood. Moreover, the engineering constructions (bridges, Gajoldoba barrage Tista low dam (NHPC) etc.) have triggered the process of channel bed sedimentation and braiding and the reduction of channel depth, which compel the flow to breach the embankments and inundate the basin.

Consequences

The occurrences of landslides and floods have a significant role in the Tista Basin morphology especially the impact of floods on the structure of the Tista Megafan. A high amount of new deposit during each catastrophic flood has changed the stratigraphy. The migration of the channel, the bifurcation of the trunk segment of the Tista into many, braided channel formation and the changes of tributaries etc. are the major geomorphic consequences.

Each event of landslide and flood results in the loss of life, property and natural as well as cultural resources. As the Tista Basin has a long history of landslides and floods, it can be assumed that the loss of resources is very significant. Soil erosion is one of the major consequences of landslides. It is greatly caused by human intervention. The rate of denudation is now greater than that in the past in the Himalayan river basins, including Tista. Denudation rate ranges from 0.5-20.0 mm/yr (Agarwal and Narain, 1991). There are no sufficient records of damage of each event of landslide and flood. In this study, the history of landslides and history of flood sections indicate some evidence of consequences of landslides and floods in the basin.

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Table 1 exhibits some example of the loss of resources due to landslides and floods in different years of occurrence.

CONCLUSION

Thesevere character of the Tista River can be characterized mostly by intense rainfall than earthquakes and tremors (Agarwal and Narain, 1991). The location and physiography of the basin have shaped the basin configuration. There is no significant obstacle to the south of the basin that allows to receive extremely high monsoon rainfall. Along with intense rainfall fragile geology and human intervention make the basin highly vulnerable in the context of landslide and flash flood. It is almost impossible to prevent the natural causes of landslides and floods but the human induced factors viz. deforestation, agricultural expansion, building and road construction, embankment, bridge and barrage construction etc. can be controlled to reduce the severity on the basin dynamics. Increasing population density and tourism in the Tista basin make the basin riskier because any calamity of landslide or flood can cause many deaths. Many times landslide and flood occur at the same time. Such a combination is also responsible for more deaths and loss of resources. This reflect the basin`s vulnerability to the two natural calamities; landslides and floods.

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