Landslide and flood hazards consequences and community based management initiatives in Nepal Himalaya

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The loss due to landslides and related problems in the Himalayan region alone constitutes about 30% of the world's total landslide-related damage value which is extensively within Nepal. About 12.9% of the total development expenditure is spent on response and recovery activities. Landscape complexities, scientific data base lacking, and poor socio economic situation, hydro-met disaster is becoming serious concern. The mechanism, consequences, and management initiatives pertinent to landsliding, and flooding events are studied using multi-approaches. The landslides mainly concentrated on, 1) slate, phyllite, dominated sites, 2) slope angle ranging between 30-40 degrees; and 3) along the non engineering road side slopes. Community based hazard mitigation approaches are in practice to mitigate the problems but capacity of the local community to cope problems is inadequate.

Key words: geo hazards, steep slope, land use, community based management

1. BACKGROUND

The loss due to landslides and related problems in the Himalayan region alone constitutes about 30% of the world's total landslide-related damage value (Li, 1990). Along the Himalayan chain of 2400 km, landslides (includes shallow, deep seated and debris flows) occur extensively in particular within Nepal Two major geophysical events viz. landsliding, and flooding are frequently taking place throughout the country. However; landslides are more concentrated on the mid hill parts and flooding/inundation is common in southern most Siwalik-Terai region (major ecological regions of Nepal). So as to examine the consequences and management initiatives, two typical watersheds in Mid-hill and Siwalik region is selected. Mid hill region is characterized with dense population with intensive cultivation in steep slopes. Thick soil formations are found because of deeply weathered rocks. Slopes are very prone to landslides after intense rainfall. Improper agriculture practices generally create landslides or reactivate old landslides and usually damage villages and agriculture land. In Churia, sliding/ flooding events are posing danger to the different social entities like settlements, fertile agriculture lands, and forest biodiversity. The landscape is geologically young and composed of unconsolidated loose materials originating from soft rocks such as mudstone, sandstone, siltstone and shale. In addition, comprises gravel, boulders and loosely bounded unconsolidated soil rock mass with high weathering state. The area is not only structurally weak, but also located in the high volume precipitation zone (2500 to 3500 mm/yr.) of the country. The area is facing high sediment production, which is to be estimated at the rate of 900-20000 ton/km^2/yr. (Paudel, 2012). Due to huge amount of sediment deposited in the river bed, river morphology is frequently in changing state eg. avulsion, formation of new channels, river bed widening (changed from 100 m to 1 km). Water from one river enters into another river through its distributaries during monsoon season resulting flash floods in downstream area. About 12.9% of the development expenditure of Nepal and 5.39% of its real GDP are spent on response and recovery activities (Paudel, 2012 a) Inaccessibility, technological shortcoming, a low level of awareness, and poverty are prominent reasons to cope with the hazards. In this study, two typical watersheds viz. Sisneri watershed and Pasaha Khola watershed representing from Mid hill and Siwalik regions, respectively are examined to understand the sliding and flooding hazards consequences and mechanics. The objectives of the study are mainly to examine 1) landslide and flooding consequences 2) geo-hazards management

initiatives taken by the government, non government and local communities to mitigate the growing problems.

2. STUDY AREAS

2.1 Mid hill region (Sisneri watershed)

2.1.1 Geology

Study area is located in the central part of the country comprising low-medium-grade metamorphic rocks of the Lesser Himalaya. The Lesser Himalayan Zone lies to the north of the Main Boundary Thrust. The area mainly consists of phyllites, slates, quartzites, limestones and dolomites. Alluvial, colluvial, and residual soils are abundantly distributed.

2.1.2 Land use

The area mainly consists of forest, cultivated land, barren area and settlement. It is usual practice that the local communities are dependent upon the agriculture system and farmers grow varieties of products (rice, wheat, maize and cereals crops) even if in steeper slope (> 30 degrees) as shown in **Fig. 1**. Usually farmers are depending upon the subsistence agriculture farming for their daily life. The rural villages are residing into the foothill slopes which are very prone for landslide No proper land use planning is practiced.

Fig. 1 General glimpse of study area (land use and slide view)

2.2 Siwalik region (Pasaha watershed)

The study area is located in central Nepal, Bara District and is one of the major River originating from the fragile Siwalik/Churia landscape as shown in **Fig. 2**. The watershed area comprises both steep slope (northern part) and flat (southern part) where landslide and flooding problems are prominent, respectively (DSCWM/UNDP, 2012).

Fig. 2 Glimpse of Siwalik region site (River bed view, catchment shape)

In the northern part, there is steep dissected topography with abundantly distributed unconsolidated loose materials originating from mudstone, sandstone, siltstone and shale. The general geological distribution and land use pattern are shown in **Fig. 3.**

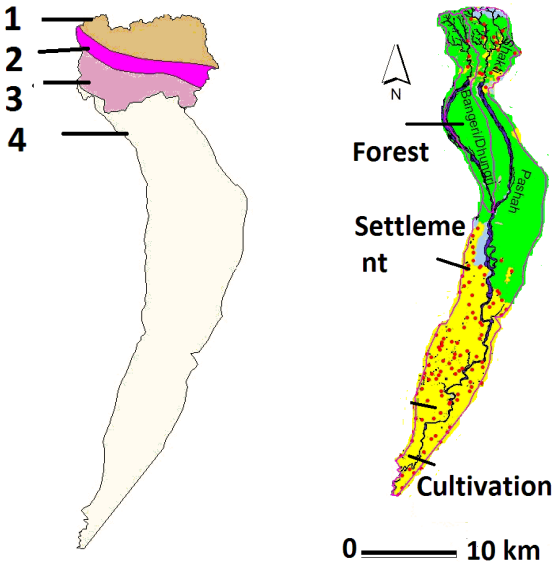

Fig. 3 Geology and land use maps
Geology (1: Upper siwalik group, 2: Middle siwalik group, 3: Lower Siwalik group, 4: quaternary deposits).

The fertile agriculture lands, settlements, are located along the both side of the River course. Geologically comprises, three distinct units, in upper, middle, and lowland parts. In upper part, coarse boulder, sandstone, sandy clay and

conglomerate are more dominant. In middle parts, fine to medium grained sandstone and mudstone are common. In the lowermost part, medium to coarse grained sandstone, clay and conglomerate. The land use types include, sparse and poor quality forest, degraded land, with steep topography. In lowland sites, fertile agriculture area is abundantly distributed.

2.2 METHODOLOGY AND APPROACHES

Multi-approaches including field survey, GIS application, direct interaction with the local people and concerned authorities were used. The topographic and land use maps of scale 1:25000 prepared by the Department of survey was used. The daily rainfall data of the nearest rain gauge station (Simara airport station) was used. Hourly rainfall intensity data was not available and only the cumulative rainfall data are used for the analysis purpose.

3. RESULTS AND DISCUSSION

3.1 Mid hill region (Sisneri watershed)

The landslides are mainly shallow translational type, and the scarp surface is covered by the regenerated vegetation. About 50% (15 slides) of total slides were occurred on the slopes ranging from 30° to 40°. No slides are observed in the slope less than 25°. According to land use pattern, about half of the slides are located in the forested land and remaining are either on the cultivated or over barren/bushes sites. About 70% of the total slides were observed over the slopes underlying with schist, and phyllites dominated landscape, **Fig. 4**. The causes of the landslide can be attributed to the highly fractured and highly weathered weak phyllite with the addition of concentrated precipitation and steep slope. The road construction along the unstable slope was triggered the slides. The thin soil mass located immediately above the bed rock is slided and bed rock is exposed. The exertion of pore water pressure might have also the important role for sliding. The root of the species *Alnus nepalens*is and *Shorea robusta* are not providing the sufficient strengths/reinforcement to control the sliding. Besides the bedding and foliation, discontinuities are found in the rock mass. The discontinuities are responsible for the development of failure by forming wedges and plane failures. Plane rock failures are especially common on the dip slopes, whereas wedge failures are observed mostly on the counter dip slopes.

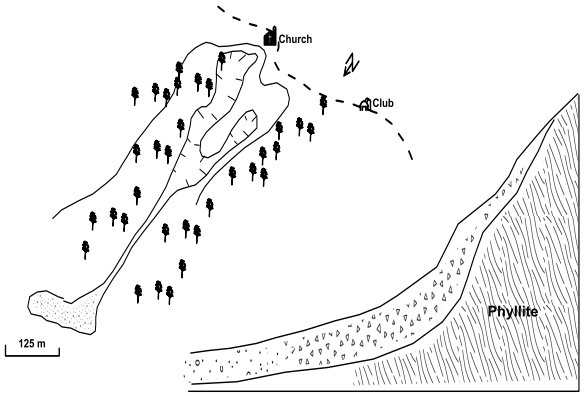

Fig. 4 View of slides underlying above phyllite

(Underlying topographic situation and photographic view)

Further, improper land use on the steep slope has contributed in this slope failure (irrigating paddy field on very steep slope). Rural road construction without slope assessment was another important causes. In some locations, groundwater seepage can be seen and underlying water might have created the lubricating effects. In addition, small gullies are abundantly distributed and it can be assumed that such small sized gullies might have developed into the slides during the course of time.

3.1.1Major consequences

About 15% of the total watershed area is under eroded slope and about 50% of the total populations (about 2000 no.) are directly affected. Majority of the people are living at the immediate foot slope of the landslide sites and are always under the threat. The cultivated land (includes paddy field and other non irrigated land) is buried by the debris deposition and rural poor farmers are facing the problems on how to rehabilitate such fertile agriculture land. In some locations, the drinking water source like well school building, irrigation canals are also destroyed. The forested landscape is also sliding and forested landscape is converting into the denuded slopes. Immediate reforestation programs are not implementing. The rural roads are constructing

investing huge amount of money but due to the recurrent sliding such roads are not efficiently in use for the transportation. Periodic maintenance cost is very high and state of difficulties is always facing. The properties like houses and agriculture land of some of the people are swept away and resettlement for such people is becoming problem. The government is not providing the alternative schemes for such people because of lack of concrete policy to address such situation.

3.1.2 Rainfall condition

Continuous antecedent rainfall for about 7 days has triggered the slides in Sisneri watershed areas. A daily total of 370 mm (**Fig. 5**) rainfall was observed. It was difficult to relate with the intensity duration because of unavailability of intensity data. The local community has established the digital rain gauge station and local people are taking the daily records. If excess rainfall is observed the operator warns by producing the large sounds so that local communities may aware of sliding events. It is the just initiation on Early Information system rather than the Early Warning System. It looks to be good initiation to disseminate the idea of landslide management.

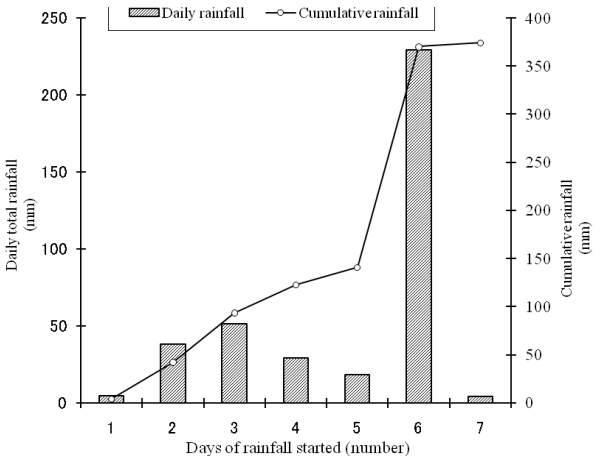

Fig. 5 Rainfall condition during sliding

4.2 Siwalik site (Pasaha watershed)

4.2.1 Flood hazard assessment

In Pasaha watershed, two distinct geomorphological units can be seen. In the upper most part, there is steep hill slope characterized with weak geological settings. Many smaller to medium sized Rivers are originating from this landscape. The debris originated from the hill slope is transported through these Rivers and tributaries. The settlements are located very adjacent to these River course and such settlements are severely affected by the flooding and inundation mainly during the rainy seasons (May-July). The general settings of the river flow path and location of the settlements is shown below in **Fig. 6**. The area receives an average annual rainfall of about 2500-3500 mm and is concentrated during monsoon seasons. There is sharp slope slope gradient change within the span of 2-5 km (from hill to down gentle slope) span along the landscape and flow velocity is also changes suddenly. This sudden change in landscape gradient affects the water flow and ultimately influences on bank cutting, and debris deposition along the River bed. Hence River avulsion (branching) was become prominent. The flood severity zone is most severe for those people living very adjacent to the flow path. About 50% of total population of the catchment are residing along the River path and are supposed to be flood affected every year.

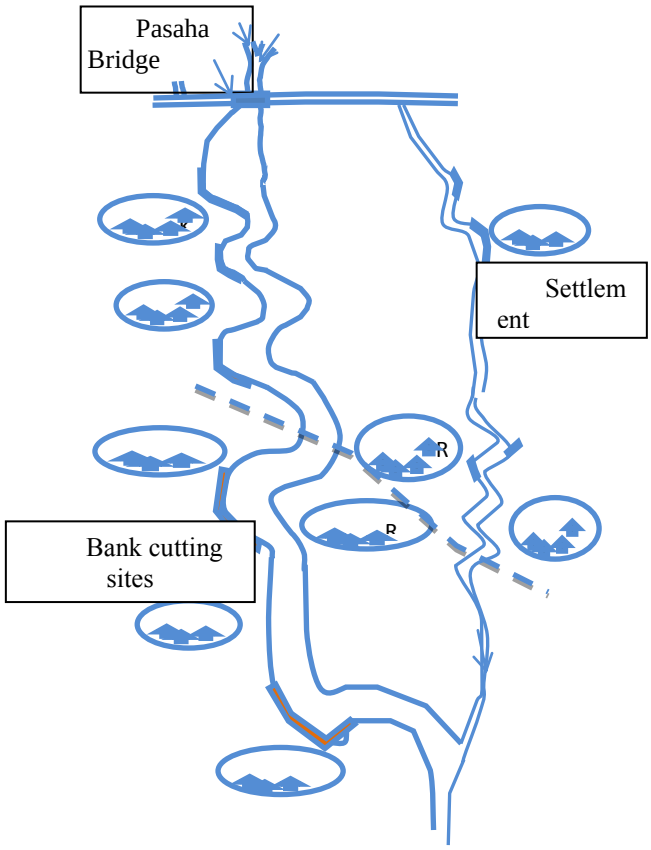

Fig. 6 Settlement and bank cutting view along the River path

It was found that generally that poor people are living adjacent to the river course because their agriculture land was around the vicinity and land value was also cheaper. But they do not take care about the potential danger from the flood. It shows that awareness level is very low.

The sediment originated from the hill slope flows with the high velocity and because of high energy destroyed everything along the path. The general glimpse is shown in **Fig. 7**. The school,

electric poles, agriculture lands, bridges were damaged.

Fig. 7 Bank cutting, and other damaging effects

Despites the annual loss due to flooding still majority of people are living under the adjacent to the severe flood prone sites as shwon in **Fig. 8** and still effective preventive measures are not implementing.

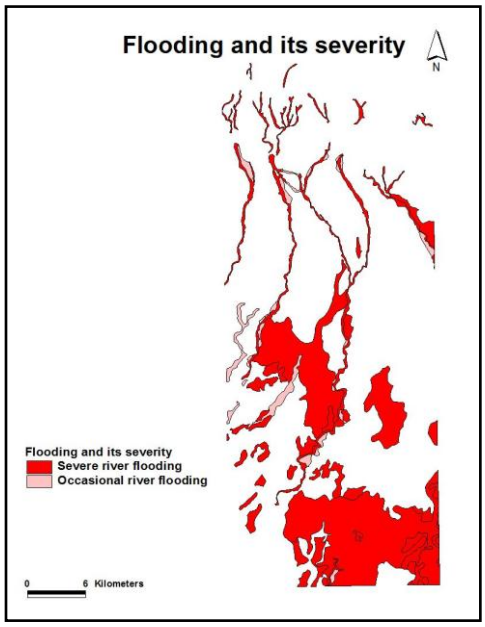

Fig. 8 Flood severity map

The flood severity map indicates that stil majority of the people (about 500 no) are living around the flood prone areas. This indicates that people still prefer for their easy agriculture practice rather than safety.

4.2.2 Major consequences

1. About 200 hac, of fertile cultivated land was damaged,
2. Annual flooding and inundation have threatened about 500 Households along the River course,
3. Major Infrastructure like road, bridge, school, electric poles are under constant threat,
4. Mass wasting have caused forest cover depletion/degradation.
5. Forest biodiversity was severely affected
6. It is estimated that there is annual loss of about one billion US dollar..
7. There is strong upstream and downstream linkages. In the upper catchment there is causes (sediment source) and in the downstream side the is effect (damaging effects) as seen in **Fig. 9**. The agriculture land is now converted into grass land cover (covered by *Saccharum* as seen in photo right hand side).

Sediment near bridge land damage (conversion from cultivated land into grass cover)

Fig. 9 Upstream (cause) and downstream (effect) linkages

Altogether Nepal comprises about 6,000 rivers and rivulets and most them are located in Siwalik/Terai region and most flood disaster contributing watersheds causing 29% of the total annual deaths and 43% of the total loss of properties in Nepal. The study carried out ii typical catchment and if we analyze throughout the nation, the result is alarming. In the context of global warming, the probability of potentially damaging floods occurring is likely to increase as a consequence of the increase in the intensity of extreme precipitation events i.e. >100 mm/day (Baidya 2007).

4.2.3 Management initiatives

There is multiple consequences and high scale dame caused due to landslide and flood hazards. In one side, there is huge amount of annual loss of life and properties, and in another side people are still living in and adjacent to hazardous prone areas. Hence always the extent and scale of damage is higher. The local people are not so much aware about the possible danger. The Government is also not addressing the problem in an appropriate and

adequate ways and chaotic state is always existing. Within such situation, Department of Soil Conservation and Watershed management in collaboration with the United Nations Development Program initiated the Community based disaster management initiatives in the Pasaha River. Identification of the most vulnerable communities is followed by the formation of community based institution to carry out flood and landslide risk management initiatives in the area. Thus formed institution is institutionalized/registered in the local government agency and other required institutional set up procedures such as opening of bank account, development of working guideline. Capacity development of the local communities, formation of disaster management committees, awareness generation, and mobilization of youths, collaborative/partnership with other relevant institutions are some of the important initiatives. Planning and implementation of the activities are done mainly through mobilization of the local users committees. Upstream and downstream dwellers are involved while formulating the users committee to link the cause effects relationships. The disaster management is the cross sectoral issue and always the coordinated and collaborative efforts are emphasized. Due to the poor rural society, little education, and inaccessibility, the progress are still inadequate. However, initiation of the approach will gain experience in the coming days. The involvement of the local people has strengths for building local ownership and resource efficiency. Government activities until 1982 were mainly directed towards post-disaster activities, viz., rescue, relief, and rehabilitation, only as voluntary social work (Dixit 2003). The Natural Disaster Relief Act 1982 provided a legislative framework for disaster management in the country.

4. DISCUSSION

In mid hill region of Nepal, mainly surface failure events are common. The extent of damage is greater compared to deep seated slides (rarely seen). Both inherent characteristics (steep slope, loosely consolidated rock soil mass) and external factors (improper land use paten, deforestation) are responsible for recurrent sliding. In the Siwalik/Churia region, there is large scale deforestation and massive erosion is at the upper catchment as can be seen in **Fig. 10**. The illegal (encroacher) people enters into the forest and cut down the trees. Gradually after firing, they people converts the forested land into the agricultural lands. After few years (when the productivity declines) they again shift into the another area and adapt the similar practice. Hence gradually large area of the landscape is converted into the agriculture land. The area is steep and surface soil ersion is very prominent. The natural setting is disturbing by anthropogenic activities (settlement, firing etc.) and supporting for the flash flood and debris generation.

Fig. 10 Glimpse of highly eroded slope and sediment origin zone deforestation

The deforestation rate is assumed to be at the rate of 1.7% (by area) per year (Department of forest, 2014). The government of Nepal is putting the Siwalk/Churia issues in high priority and current president of Nepal is showing concern for the environmental protection. Hence ' Government of Nepal is implementing President Churia/Siwalik Conservation Project" under the top priority. The project is giving emphasis for the forest management, soil conservation, livelihood support, and river corridor management (river bed land reclamation, vegetative embankment along the river side). Although, the finding are case examples, but the scenario resembles in other mid hill and Siwalik watersheds too. The government is giving emphasis for the scientific research based decision making for the restoration of the landscape affected by the landslide and flood hazards.

5. CONCLUSION

Landslide and flood are major geo-hazard in Nepal causing severe damage to the lives and properties of people. Community based hazard mitigation are in intensive practice. There is heavy dependence on agriculture and its low production potential and poor people are living adjacent to flood prone areas for easy agriculture practice. There is no concrete torrent control law and land use policy to manage the appropriate land use system. The mobilization of rural institutions is also not adequate because of capacity of the local community is still inadequate. It was mainly linked with their little awareness and poverty conditions. The topographic, inappropriate land use systems, greater anthropogenic activities and concentrated rainfall during monsoon are the major causative and triggering factors. The community based disaster

management system initiation by the Soil conservation and watershed management department with the collaboration of United Nations Development Program (UNDP) seems to be strengthened in the coming days in line with their target to community mobilization with sufficient technical backstopping. The Geographic Information System (GIS) based landslide/flood hazard mapping along the major River systems from hill to Indian border is recommended for mitigating the extent and scale of disasters. Because of the topographic inaccessibility, economic conditions community based hazards mitigative approaches are more effective compared to act by the Government alone.

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