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Disaster Hit Pithoragarh District of Uttarakhand Himalaya: Causes and Implications

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Abstract

The area devastated by disastrous on 1st July 2016 is located in Didihat and Thal Tehsils of Pithoragarh district and fall in the catchments of East Ramganga and Charma rivers respectively. Heavy rains caused landslide incidences and damages in the area around Didihat, Bastari and Naulra villages. As many as 21 human lives were lost in these incidences. The impact on these localities of landslides caused by heavy rainfall events and fast changes in landscape. Landslide incidences are attributed to construction on loose soil/overburden material and drainages. Increasing anthropogenic activities, venturing in unsafe areas due to limited land availability and heavy localized precipitation. These are continuously increasing the vulnerability of these to landslides. In view of that, the paper will provide insights into suggestive measures that may help in preparing a roadmap towards sustainable development within the affected areas.

Keywords: Pithoragarh; Causes; Suggestive measures; Uttarakhand

Introduction

All mountain regions across the world have their unique vulnerabilities to different natural hazards large proportion of which are attributed to the evolutionary history of the terrain that is reflected in geology, structural set up and physiography of the area concerned. Of the different hazards landslide is common to almost all the mountainous regions and is attributed to their high relative relief.

Landslide is nothing but downslope movement of rock mass and debris with varying proportion of water [1-3]. It however requires an external trigger to set the ball rolling otherwise it would defy the Law of Inertia that states that unless external force is applied an object in motion would keep moving and that in the state of rest would remain stationary perpetually. In howsoever unstable state the rock mass be it cannot therefore descend downslope and thus for a landslide to initiate external force or trigger is essentially required.

Climatic and rainfall variations are major forcing factors behind orogenic deformation in the Himalaya [4]. Water however plays an important role in triggering landslides and it is no surprise that major landslides occur during or after prolonged heavy rains as was the case of Malpa and Okhimath landslides of 1998 [5-7]. Water increases pore water pressure and increased weight of the soil and debris due to absorption of water results in increased magnitude of the forces acting in downslope direction. Water at the same time reduces frictional forces resisting downslope movement. Water thus facilitates downslope movement by reducing the forces resisting movement and increasing the forces trying to destabilize the slope material. Water thus triggers landslides. Slope failure incidences took place at many places in the Pithoragarh district on 1st July 2016 amid heavy rainfall around 160 mm within 4- 5 hours in Didihat region (Data source; District Emergency operation Centre). In order to investigate the affected areas, the present paper provides general inferences, remedial concepts and guidance for the site based on preliminary surface observations only.

The study area

The area investigated lies in the Lesser Himalaya in Pithoragarh district of Uttarakhand, India. The small township of Didihat (29°48' 8.84" N and 80°15' 9.44" E) is situated around 55 kilometers from Pithoragarh on the left bank of Charma Gad. The areas devastated by disasters are located in Thal and Didihat tehsils of Pithoragarh district and fall in the catchments of East Ramganga and Charma rivers respectively (Figure 1). Urma village is located on the downhill side of Bastari (29° 52' 20.70" N and 80° 09' 54.12" E) and both these villages are situated on the left flank of south flowing Charma river and can be approached by Didihat-Ogla-Singhali motor road. Naulra (29° 52' 20.70" N and 80° 09' 54.12" E) is located on the right flank of southerly flowing local stream and can be approached by Thal-Munsiyari motor road (NH 309A).

Geological setup

Geologically the area falls in Lesser Himalaya and the rocks of Pithoragarh area belong two tectonic units; one belonging to the Almora Crystalline Zone and the other belonging to the sedimentary zone of Garhwal Group. In the area the rocks of Almora nappe are observed to be thrust over quartzites and limestones of Garhwal Group along North Almora Thrust. Granites and augen gneisses of Almora Crystallines are observed around Didihat and Bastari area. Quaternary deposits (RBM) and limestones of Garhwal Group are observed around Naulra landslide zone [8,9].

The rocks exposed around the area are traversed by numerous joints that comprise important structural discontinuities affecting the strength of the rock mass and stability of slopes. The phylites exposed in the slide zone of Bastari are generally observed to strike NW-SE and dip towards northeast at angle of around 35°. Prominent joints observed in the area are also observed to strike NW-SE parallel to the foliation and dip at moderate to high angles (55°) towards SSW.

At Kumalgaon landslide area exposed limestone rocks are observed to strike E-W and dip onwards south at an angle of around 50°. These rocks are observed to be well jointed.

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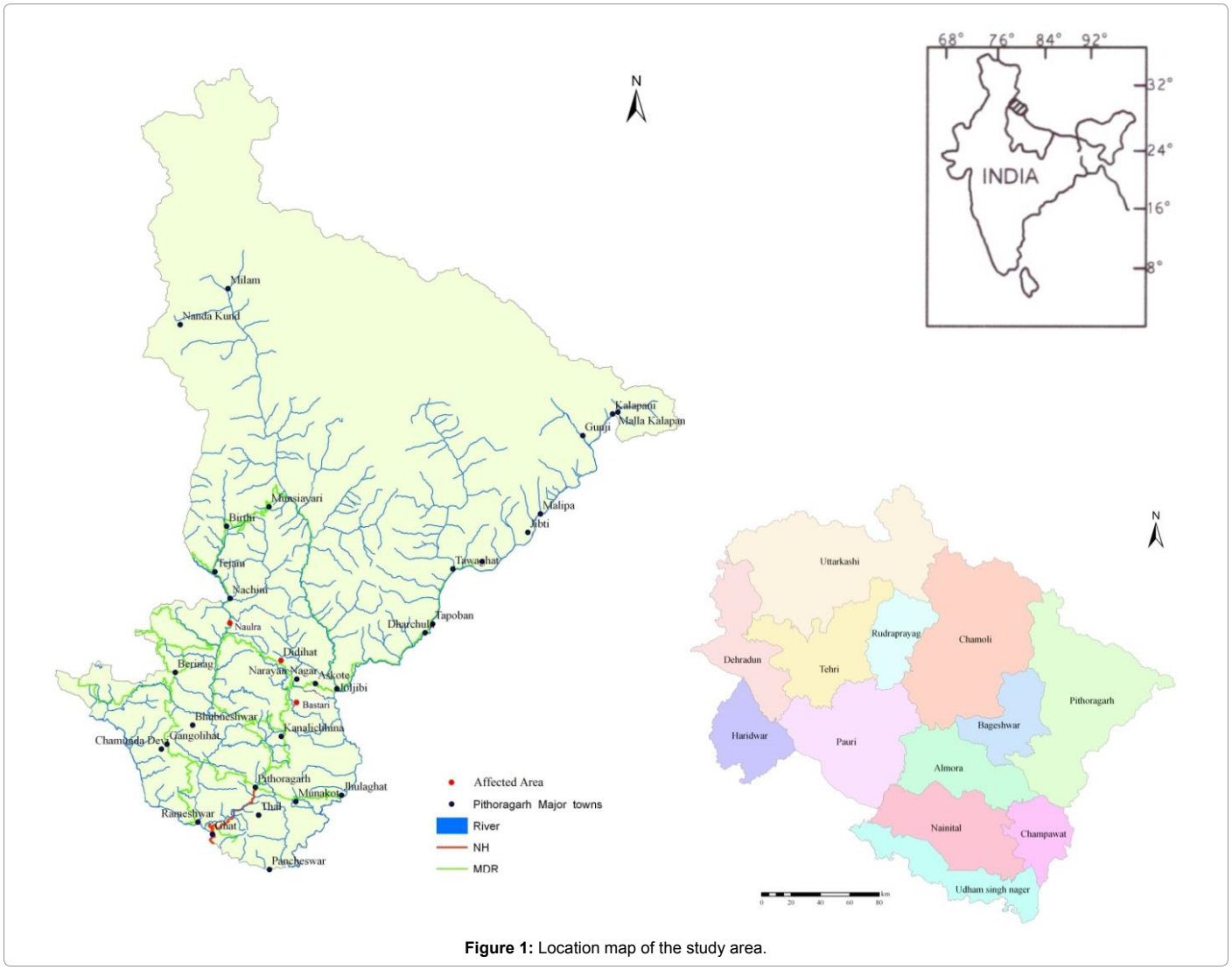

Figure 1: Location map of the study area.

Main Causes of Landslide Incidences

The heavy precipitation increases discharge through streams and artificial channels, and also the subsurface seepage, leading to bed erosion, and ground saturation and consequent failures in the affected areas. Main causes of the slope problems are as follows.

- Frequent presence of very weak natural materials around the area.
- Steep slope cuttings in weak materials.
- Construction close to natural water courses.
- As the space between slope and house is very less.
- Lined artificial drains with insufficient dimension.
- Unlined natural water channels.
- Increased percolation from damaged drains and flattened areas.
- Inadequate surface water management and unregulated seepage.
- Loading of weak slopes by heavy constructions.
- Unplanned road construction without taking necessary slope treatment.
- Landmasses undercut due to water from natural and artificial sources.
- Heavy rainfall in the area causing saturation of internal friction of the weathered rock and soil materials.

Landslides during June, 2016

Around Didihat town rapid unplanned urbanisation is deduced to be the causative factor for the slope failure. This is reflected absence of proper drainage network, overloading of debris slope, excavation and left untreated, construction on old landslide debris and road construction. Newly constructed road around Bastari in which there would have been use of explosives and ground excavation for the construction around Kumalgaon (Naulra) are such changes observed during the field investigation. Details of landslide incidences are described in the sections below.

Event 1

The topography of the Didihat town area is in active state of

degradation and most of the slope failures have been caused due to saturation of the soft and weak weathered rock/soil materials together with heavy rainfall. Due to this, a total of 232 families are affected by the landslide incidences in the area around Didihat, out of 101 families live in GIC Ward alone. This is followed by 92 in Tehsil Ward, 32 in Ambedkar Ward and 07 in Shiv Mandir Ward (Data Source: Nagar Panchayat, Didihat). Maximum landslides incidences was observed to be occurred in GIC and Tehsil Wards while moderate in Ambedkar and less in Shiv mandir Wards.

The landslide is located just below the Didihat-Adichaura motor road that is occupied by outcrops as well as thick overburden. Due to heavy rainfall a major landslide took place in Ambedkar ward and Deendayal Park was severally damaged. This slide has partially damaged two houses on its left and right flanks and these are under severe threat (Figure 2a). Besides, some houses in Shiv Mandir and Tehsil Wards were also affected by landslide incidences (Figure 2b and 2d). Debris slide is located near District Institute of Education and Training (DIET), Didihat. Presently, Govt. polytechnic is conducted in a building of DIET, situated just above the landside (Figure 2c).

At some places including Nain Basti in Tehsil Ward, Shiva Colony in Ambedkar Ward and Kandai village on the uphill side to Shiva colony subsidence, cracks on buildings and landslides are attributed to construction on recent material/loose soil/overburden material and poor drainage network.

Since, the area around Didihat town has abundance of very weak materials, lies in a high precipitation region, and already has many constructions; water management is the key to safety in this town. This should be comprehensively planned for the entire area, and should take into account the following measures, however, site specific conditions must be considered in detail while applying the measures.

- It is recommended that the drain sections sufficient, with regard to gradients, for the monsoon and seepage discharge that they are meant to carry.
- It is recommended that wear resistant drain lining in higher gradient reaches of drains to withstand abrasion.

Figure 2: Landslide incidences in the area around Didihat; damaged Deen Dayal Park at Ambedkar Ward (a), slope failure in back and front of some houses at Shiv Mandir Ward (b), debris slide in front portion of District Institute of Educational and Training (DIET) at GIC Ward (c) and mass movement in front part of house at New Basti area in Tehsil Ward (d).

- It is recommended that all existing or proposed retaining and other walls, and any other coverings on slopes, must have proper arrangements to allow free drainage of slope material so that harmful pore pressures do not develop in the slope.
- It is recommended that as the space between slope and house is very less, anchored concrete curtain wall must be considered at the same.
- It is recommended that the rock fill buttress or gabion wall can be provided to protect the completely weathered rock/soil slopes.
- It is recommended that the low retaining walls at different levels of the slope with free draining backfill, to support the fill around building.

Event 2

According to eyewitness accounts cloudburst like incidence took place around Bastari village on 1st July 2016 in two phases. Debris flow occurred after heavy rainfall in the morning hours (around 0430 hrs) in which one house was damaged. The inhabitants of the same were rescued by the villagers. Thereafter most people of the village (around 24) took shelter in a well-constructed house in the village that was perceived to be safe by the people. While they were still waiting for rain to stop another debris flow took place around 0600 hrs. This engulfed the very house in which people had taken shelter. All the persons were thus burried in the debris that flowed down along a 1st order drainage passing through Urma village, which is situated below Bastri village. 19 persons were killed in this incidence. Of these bodies of 08 could not be recovered. Total 16 buildings were destroyed or damaged and 174 cattle were lost.

The slope in the area is generally observed dip towards southwest at steep angles (55-60°). This has facilitated fast downslope movement of debris. A number of agricultural fields along with houses were thus damaged due to debris flows in the Bastari area (Figure 3). The thickness of the debris accumulated in the area is observed to be around 3.5 to 4.0 meters. This material is observed to comprise of hill wash and debris consisting of brown, fine grained silty-sandy matrix with rare boulders and fragments of granitic gneisses.

Suggested Measures

Based on preliminary field investigation, it is perceived that necessary precautions are required to be taken, especially in view of the fact that the slide is in close proximity of densely populated area of Urma village and remaining part of Bastari village. Besides major

Figure 3: View of Bastari debris flow (camera looking east).

landslide several landslide scars are also observed on the uphill side to Bastari village. Activation of these has the potential of posing danger to the village. Geologically, the area is deduced to be in a critical state of equilibrium and the following suggestive measures are suggested:

- The hill slope around Bastari village is deduced to be highly susceptible to failure, particularly in the event of heavy or prolonged rainfall. The residents are therefore advised to keep safe distance from the vulnerable slope and vacate the area, especially during heavy or prolonged rainfall.

- It is highly important to ensure all future constructions only on firm ground. At the same time excavation on steep slope should not be allowed. The excavated slope if left untreated is sure to pose threat during heavy rainfall.

Event 3

Heavy rainfall also accelerated gulley erosion on river born material (RBM) and debris flow took place at Kumalgaon (near Naulra village) as well. 3 persons were killed in this incidence while houses of 5 families were burried under the debris. Around 70 animals were lost in the incidence. 2.5-3.0 m thick pile of debris was observed at the site. Presence of river born material (RBM) is observed behind the habitation. Slope at this location is observed to dip towards east at an angle of around 40°. Indications of heavy rainfall induced gulley erosion and debris flow are observed during field investigation. RBM is always vulnerable for the slope failure due to the roundness of its constituents and poor cohesion. The debris slide is observed to have occurred on the eastern slope of N-S trending ridge. The width of the failure slope is about 50 meters along the cultivated fields and height of the crown from cultivated fields is about 30 meters.

The landslide debris that descended down from the area upslope of the village is observed to have overrun both agricultural fields and houses (Figure 4a and 4b). The thickness of the debris accumulated in the area is observed to be around 3.0 meters. This overburden material is observed to comprise of river borne material consisting of dark brown to reddish, fine grained silty-sandy matrix with rounded boulders and pebbles.

The landslide is deduced to be highly susceptible to failure, particularly in the event of heavy or prolonged rainfall. Geologically, the area is deduced to be in a critical state of equilibrium and the following suggestive measures are suggested:

- The residents are therefore advised to keep safe distance from the vulnerable slope and vacate the area, especially during heavy or prolonged rainfall

- During field investigation it was observed that the devastation mostly occurred along areas where Quaternary deposits were present.

Figure 4: Debris flow on slope made up of RBM at Kumalgaon near Naulra village (a) and devastation around Kumalgaon village (b).

Construction on RBM and old landslide debris should therefore be avoided.

The remedial advices given in this paper are provided, along with the preliminary geological information of the site. In order to be effective, the treatment measures must be designed in detail by adequately qualified and experienced geotechnical/civil engineer, with due respect to the ground conditions and details of the specific sites.

Discussion and Conclusion

The villages affected by disaster incidences are traditional habitations where people had been living happily for ages. Even though mass movement is a function of a number of factors of which presence of water plays a decisive role, none can really claim that the area has never in the past received this kind of heavy rainfall. So it can be deduced that despite spells of heavy and prolonged rainfall these habitations were not affected by mass movement in the past. One therefore needs to investigate if the area has witnessed some physical changes in the recent past (5 to 7 years) and if there has been increase in the frequency of such incidences after these changes. These changes could be related to landuse, construction, drainage, road, forest, agriculture and the like.

Didihat town, like any other urban area in the hills of Uttarakhand, is faced with the dilemma of striking a balance between fast growing population and limited availability of land for fulfilling their housing and other related needs. Earlier (before 10 to 15 years ago) people living there were not vulnerable to landslide hazard and had the option of choosing a better site for settling down. The scenario has changed dramatically in the present times largely due to fast land use/land cover changes. Rampant excavation of toe portion of slope for building and road construction is observed to be common place around Didihat. Indiscriminate construction, overloading of debris slope, encroachment along drain/streams and absence of drainage network for safe disposal of rainwater are some other factors responsible for slope failure.

Indiscriminate and unscientific construction should be banned especially in landslide affected areas. Besides this safe disposal of rainwater needs to be given due importance. Both surface and subsurface drainage measures should therefore be planned and executed. For this drain pipes could be provided on debris slope. The planned drainage network should be stepped and wide enough to accommodate heavy downpour events.

Excavation of slope often introduces changes in slope characteristics and in the hills it mostly transforms moderately sloping land into steep sloping land. Tendency of leaving the excavated slopes untreated is dangerous, especially during spells of heavy rainfall. In case indiscriminate construction could not be regulated all suggestive measures would remain a mere formality and would be of little use.

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