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Geo-Environmental Study of Kaliasaur Landslide in District Rudraprayag of Garhwal Himalaya, Uttarakhand, India

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Abstract: *This paper deals with historical and massif landslide of Kaliasaur in district Rudraprayag of Garhwal Himalaya, Uttarakhand. The study area lies between the two districts of Uttarakhand state i.e., Pauri and Rudraprayag, belongs to lesser Himalaya of Garhwal Region. Kaliasaur landslide is located along Srinagar-Badrinath Highway about 15 km upstream of Srinagar at left bank of Alaknanda River. This slide is very important because it is located on NH-58 which is the only connecting road to outer world and affects daily life of the people.The main focus of the paper is to understand the nature of landslide and its causes, and finally with the help of the intensive field observation, the authors suggested treatment and concrete solution of this geo-environmental problem of the study area.*

Keywords: *Massif Landslide, Lesser Himalaya, Alaknanda, Disintegrated rocks, causes and treatment, Physical landscape, Geo-environmental and Geo-tectonic activities.*

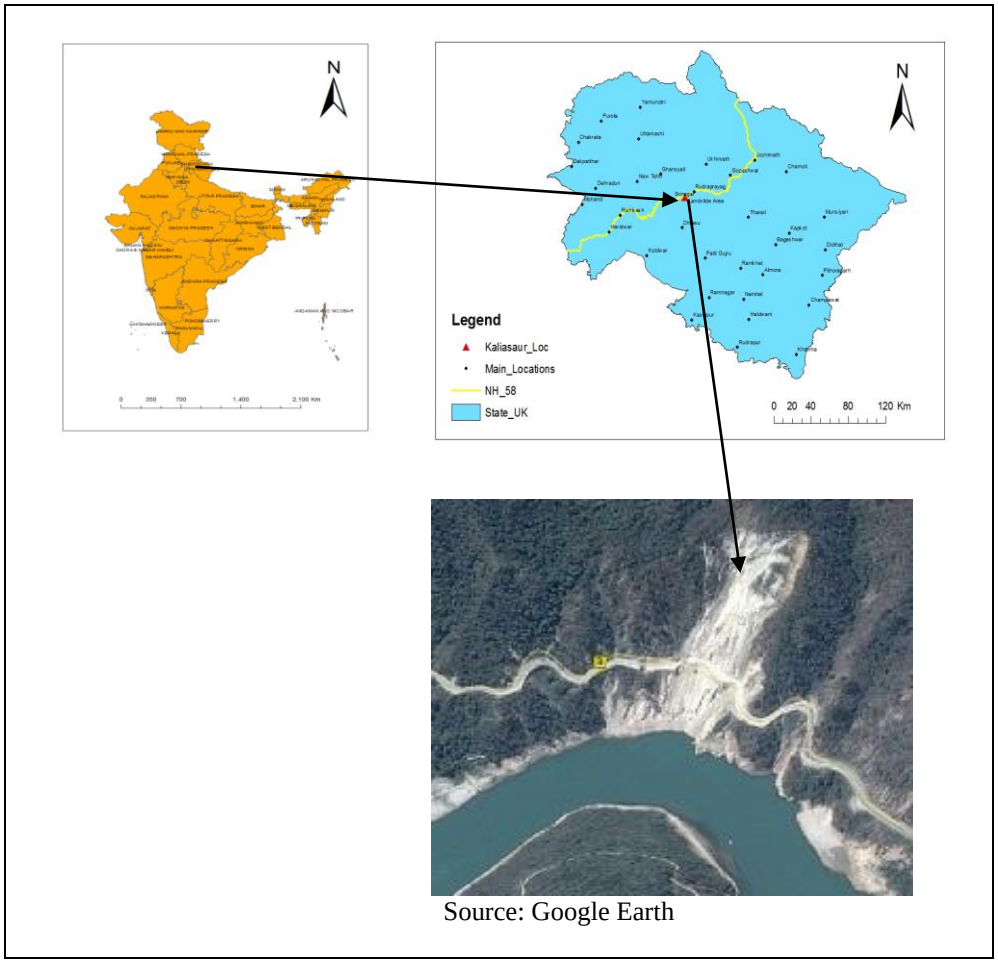
I. Introduction

In the Himalayan region most of the slopes are moderately stable. The natural process such as weathering and erosion of the formation make them unstable. Weak rock zones and unfavourable hydro-geological conditions are also responsible for the slope failures. It has also been noticed that most of the rock failures occur along road cutting. This process further aggravated due to the presence of a perennial river near the slide site. Landslide is one of the major phenomena in the Himalayan Region and becomes barrier in communication during rainy seasons. 30% of landslide has been found in Himalayan regions due to its geotechnical/ geomorphological activities (MHA 2011) in which Garhwal Himalaya has more experience of landslide because of its different kind of topography and physical characteristic. According to Survey of India, Kaliasaur landslide recognised in 1920 (Indervir S. Negi, Kishor Kumar, 2013) at Rudraprayag District and NH-58 one of the major National Highway passes through this hill which is connecting Dehradun Rishikesh road to Badrinath and other religious places of Uttarakhand. Kaliasaur Landslide located on NH-58 and about 15 km away from Srinagar to Rudraprayag road. Whenever the situation of landslide occurs, the road gets blocks and the process of sliding is still active.

Generally landslide occurred due to heavy rainfall, slope failure, highly weathered rock, natural and man-made activity and river meandering. This research work focuses on above mention activities regarding landslide. With the help of the intensive site observation, proper treatment of the problem has been suggested. The fundamental theme of this paper highlights the study of geo-environmental and geo-tectonic activities of Kaliasaur landslide and suggests a concrete plan and solution for the up-gradation of the physical landscape.

II. Location of The Study Area

The study area is located at 30° 14’ 29.98” N latitude, 78° 53’ 55.90 E longitude in the middle of Pauri and Rudraprayag district and belongs to lesser Himalaya of Garhwal Region. It lies on the left bank of Alaknanda River and about 15 km upstream of Srinagar to Rudraprayag road NH-58.The study area falls in Survery of India Toposheet No. 53 J/15. The most important historical and religious place i.e. Dhari Devi, located just nearby this slide. The landslide mainly consists of metamorphic rocks, which has been highly weathered due to the tectonic activity of that area (Negi et al, 2013).



Source: Google Earth

Figure.1: Location Map: Kaliasaur Landslide

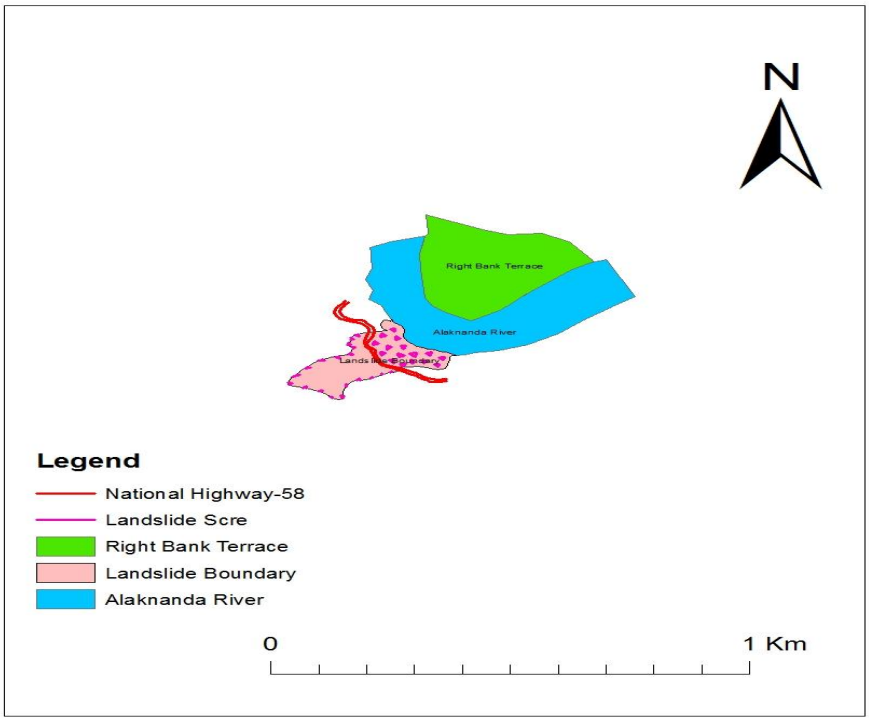


Figure.2: Structural Map of Kaliasaur Landslide

Blockage of the NH-58 due to slope failure in 2013 (Source: Indervir S. Negi, Kishor Kumar, Anil Kathait & P. S. Prasad, 2013)

Condition of NH-58 in January 2016

III. Physiography of the Study Area

Kaliasaur Landslide is a historical slide which lies in Garhwal Himalaya. This slide is approximately 400-500 m above the hill and about 22-23 m below road level up to the river Alaknanda. The width of the slide varies between ± 40 and 100m. It is located on deep slope of the left bank of Alaknanda River. This river generally flows through a 'V' shaped valley (R. Anbalagan, Atul Kohli and D. Chakraborty, 2015). This indicates the youth stage of a perennial river. The slope varies from 60º-70° and dipping 240° towards south west from its location. Generally the slide is covering a distance of 100-150 m wide along the road (NH-58) and total height is about 1 km from the bottom of the river to the top of the slide. The whole slide is covered by Quartzite rock, highly weathered and the rock has been converted into pulverization. The material involved in the sliding process is mainly quartzite greyish pink in colour. It appears that this is geo-structurally controlled area. Which is further aggravated by toe cutting and because of acute meandering of river. This area has been studied in past but no fruitful mitigation measures came out.

The top layer of the slide is highly weathered, broken rock pieces of quartzite mixed with clay developed due to attrition/movement of quartzite blocks. The area was dry during the field visit. It remains wet with surface run-off during rainy season. The slide creates lot of problems during monsoons due to which most of the time the road remains blocked for transportation.

Show retaining wall made by BRO

Shows Quartzite rocks

The entire slope of the landslide is along a rising trend of the hill which is further rising towards northeast. The entire area is partially covered with forest and wash materials are also noticed along the slope. The right bank of the river initially shows the depositional terrace followed by rising hills. The river has an acute meandering in this area just at the toe of the slide.

Shows pulverization of rocks

Alaknanda river at the toe of the landslide

IV. Slope And Material Analysis

In general the governing slope of the slide varies between 60º and 70°. The entire slope present is devoid of natural vegetation. The highly weathered and disintegrated rock mass is the characteristic of this slope. The rock mass is bisected by three sets of joints. The prominent joint set is foliation which is governing the slope along where mostly slope failures have been observed. Due to attrition rock powder has been spread throughout the slope.

Table.1: Category of Slope Gradient

Slope Category	Slope Gradient (Degree)
Gentle	<20º
Moderate	20º-40º
Steep	40º-60º
Very Steep	>60º

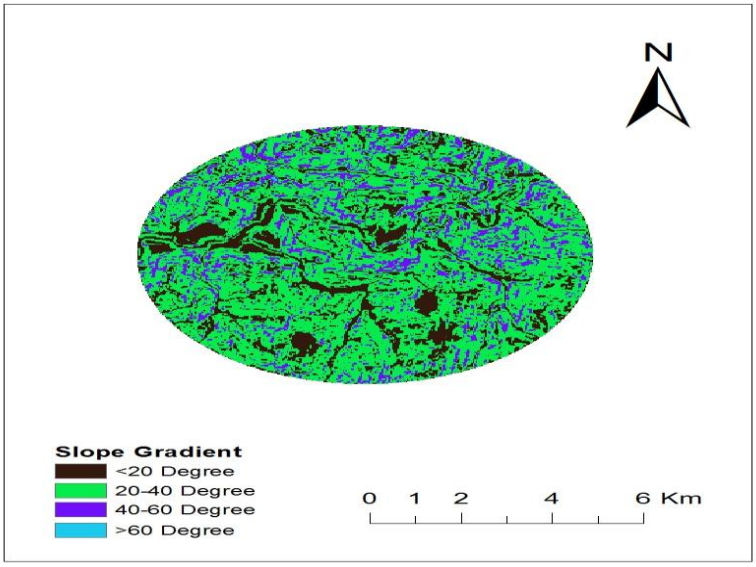


Figure.3: Slope Gradient of Kaliasaur Landslide

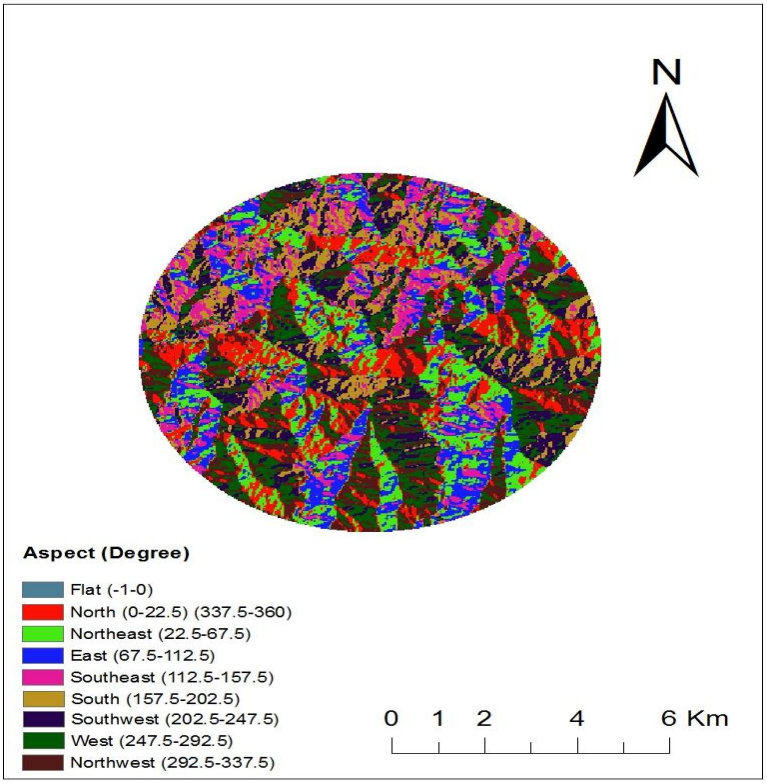


Figure.4: Aspects of Kaliasaur Landslide

V. Drainage Pattern of the Area

The area is governed by dendritic drainage pattern. Alaknanda is the major stream of this area. During rainy season Alaknanda river is flooded with its tributaries. Except rainy seasons, the area remains dry which indicates absence of perennial surface flow.

VI. Analysis and Discussion

The Himalayan geology is highly prone to all kind of hazards except cyclone. After the incident of 2013 disaster many landslides have been activated in this area. The Kaliasaur landslide lies on NH-58 which is the only connecting road between Rudraprayag and Srinagar. Because of highly weathered rocks and steep slope the soil is falling into the river in a huge quantity. Due to toe cutting the slope is becoming more vulnerable to slope failure and resulting into the mass movement. Apart from toe cutting, the process of weathering and erosion is

increasing the rate of slide, due to this process the area under landslide is also increasing. If any unplanned construction will be take place in such kind of area, it will also result into the failure of slope. NH-58 is the only road which is connecting Dehradun and Rishikesh with Badrinath and Chamoli districts, is crossing this slide.

Through the past experiences, it has been observed the slide blocks the road, the slided material is always cleared by Boarder Road Organisation for transportation and this activity of clearing the road is very frequent due to active landslide. So this continuous activity of slope failure and road construction is one of the main causes for making this area more vulnerable. If a slope is highly unstable with the process of toe cutting increases the chances of slope failure. This slide is active and creates havoc during monsoon seasons. The Himalayan region receives heavy rainfall during monsoon seasons and most of the rivers get flooded. At that time the mountains get totally wet which increases the chances of landslides and most of the time system collapses for more than 15-20 days because of slope failure of this slide.

There have been lots of attempts made by Boarder Road Organization (BRO) to protect this sliding activity by making heavy concrete retaining wall etc. In additional to the measures, there have been many other attempts done in the past and the mitigation process is still continued. Many activities are taking place for stabilizing or mitigating the slide like making of contour drains, grouting etc but none of them are giving fruitful results. Ultimately a dozer has been kept in the road for maintaining the transport and communication.

Keeping all the above mentioned observations in view, it appears that, this is a rock slide having highly weathered and disintegrated rock mass which is presently dry in nature. No slip circle has been noticed all along the slide body. The entire slide body is devoid of plantation and other natural substances. Toe cutting is one of the important characteristic features of the slide in addition to the structurally controlled slope. No perennial small stream has been noticed along the slope but during rainy season the entire slope remains wet which aggravate the problem as well.

VII. Recommendations and Conclusions

Based on the field study and findings, it can be concluded that role of existing slope, type, nature and geo-structural conditions of rocks, soil characteristics, drainage pattern, construction of roads and flow/meandering of river plays an important role for developing the landslide. Socio economical and developmental activities like creating a reservoir, human settlements etc also pay an important role for enhancing the said slide. Deforestation of the area is also responsible a slope failure.

There are following suggestions to mitigate this landslide through the intensive study of area and understanding the mechanism of Kaliasaur landslide:

- Detailed geological and geomorphological study is required to be done at first hand.
- Application of remote sensing and GIS technology is imperative for confirming the field data.
- Construction of contour drainage in different levels from top shall be useful to divert the surface run-off during rainy season.
- Construction of pillars in different levels shall be useful to monitor the slope.
- Shotcretting with wiremesh along with anchoring may prove a successful tool towards controlling this slide.
- If possible, cement grouting can also be undertaken.
- Toe protection remains very much useful for such type of slides which are directly in contact with river meandering.
- Construction of massive RCC walls in different levels along existing slope shall also be useful to control the falling rock mass/fragments.
- A serious thought is required to be given for alternate proposal of road or making a long road tunnel near road above Dhari Devi Temple up to village.
- Last but not least always keep a dozer on both the ends of the slide in the road to provide transport facility to the people.

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