Ukhimath landslide 2012 at Uttarakhand, India: Causes and consequences

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ABSTRACT

Being a tectonically active zone with fragile geological condition, Himalaya possesses high potentiality of both rainfall and earthquake induced landslide occurrence in Uttarakhand, India. These landslides eventually cause many casualties as well as huge property loss. Just On 14th September of 2012, there was a shocking rainfall induced landslide in the form of debris flow at Ukhimath, Rudraprayag district in the lap of lesser Himalaya. Present study is focused on this recent event of Ukhimath landslide. The primary aim is to find out possible causes and it’s after math, mainly the assessment of damaged areas with the help of detail field observation and subsequent remote sensing techniques by comparing very high resolution Geoeye-1 and the Cartosat-1 imagery of prior to and after the event with special emphasis on building, road and agricultural land. Detail investigation after the calamity in the study area suggests that relatively less resistant highly fractured low grade metamorphic rocks and prolong rainfall for three days might be the main conceivable reason for the initiation of the debris flow near Ukhimath town and its surroundings. Considerable number of buildings, several important roads as well as cultivable lands were badly affected and damaged by the landslide event which has subsequently been analyzed by pre and post event imagery.

Keywords: Ukhimath landslide 2012, GeoEye-1, Remote sensing techniques and Damage assessment.

1. Introduction

Landslide, one of the major destructive natural disasters in the world occurs in mountainous region in response to a wide variety of conditions as well as triggering factors like heavy rainstorms, cloudbursts, earthquakes, and unplanned human activities. In India, approximately 15% of its territory is prone to various degrees of landslide hazard, frequently affecting human life, livelihood, livestock, living places, structures, infrastructure, and natural resources in a big way. In addition to direct and indirect losses, landslides cause significant environmental damages as well as societal disruption. Statistically it is estimated that about 300 human lives and properties worth of approximately Rs.300 cores are lost every year due to the landslide occurrences (GSI, 2009). Most landslide affected areas of India is the lower Himalaya exhibiting fragile tectonics and sensitive mountainous terrain (Ghosh and Suri, 2005). Because of very high altitude, rugged terrain (relative relief around >600m), less agricultural land, extreme environmental conditions and lesser amount of industrial development restrict the economy of any area to flourish at its full extent. Thus frequent landslides are one of the greatest threats for the fragile economy of this mountainous terrain especially Uttarakhand state of India. The problem of landslides becomes more aggravated especially during monsoon period though the main causative factors behind the instability of slope surfaces are mainly geomorphological and geological in nature. In this particular zone,
interaction between local geology and long-term climatic conditions result varying degree of susceptibility to land sliding significantly in different landforms (Kuldeepp et al., 2012). Frequent seismic events also play a major role in prompting such a large number of landslides since the investigated area having number of faults surrounded by main central thrust. Specifically in Garhwal Himalayan region, these events are reported very often. The history of Garhwal Himalaya where the present study area is located being well familiar with landslip events, among these some is devastating in nature. The 20th October 1991 the Uttarkashi earthquake caused numerous massive landslides, particularly landslides on a 27 km road stretch between Uttarkashi and Bhatwari and landslides at Varunavat Parvat in Bhagirathi valley of Uttarkashi (Gupta and Bist, 2004; Sarkar and Gupta, 2005) are the few examples of large landslides in Garwal Himalaya.

In 1998, more than 300 people were killed including 60 pilgrims in Kailas-Manasarover due to Malpa landslide in Uttarakhand (The Hindu, 1998). Landslides induced by earthquake further aggravated the situation in 1999 in Chamoli district of Uttarakhand (Kimothei et al., 2005). On 16 July 2001, heavy rainfall in Phata Byung area of Rudraprayag district, Uttarakhand, triggered more than 200 landslides and killed 27 people of Ukhimath area in Garhwal Himalaya. In this region, landslides occurred in two phases along the lower catchments of the Madhyamareshwar and Kaliganga rivers affecting a total of 20 km² and took 103 human lives (Naithani, 2002). The remarkable Varunavat landslide in the Bhagirathi valley on the upslope of the Uttarkashi town makes the history by damaging huge loss of lives and property in the year 2003. Due to heavy downpour on july-august 2004, at least 25 people died and more than 5000 people were stranded for days without food on the Joshimath-Badrinath road (Sahoo, 2009). Very recently, a devastating landslide in the form of debris flow has occurred and killed 33 people and damaged a number of houses, roads and crop lands at Ukhimath region of Rudraprayag district of Uttarakhand. This particular research was an attempt towards identification of possible causes of landslide and to detect the potential and actual landslide prone areas together with damage assessment based on high resolution earth observation imagery at Ukhimath area.

1.1 Study area

The study area is bounded between 30°25′0″ N and 30°32′35″ N latitude and 79°02′25″ E and 79°08′10″ E longitude (Figure 1) having aerial coverage of 96 km² which is a part of lesser Himalaya, one of the global hotspots for landslide hazard (Nadir et al., 2006) situated on the confluence of the Mandakani and the Madhyamareshwar rivers. Major part of the study area is located around Ukhimath town and its surroundings up to 13 km downstream of the Mandakani river valley. It is a tehsil of Rudraprayag district, part of Uttrakhand state. Average elevation of the study area is 1300 meter where elevation ranges between 867 meter and 2626 meter with a high relative relief. The region experiences a subtropical temperate climate with annual rainfall ranging between 1,200–1,500 mm. The rainfall pattern is highly seasonal with bulk of the rainfall occurring during the monsoon period (June to October) eventually triggers many of the landslides.

Geomorphologically this area is characterized by dominantly dissected hills. Glacial landforms are also found in this region, but over a period of time those have been modified by the denudation process, in fact some of such landforms having relatively gentler slope is converted into agricultural terraces. The main land use practice in the study area is terrace farming. The agricultural lands are mostly developed around sparsely distributed villages and the next dominant land cover unit is forest being degraded due to rapid urban growth and
agricultural practices. Soils consist of dominantly sub-angular rock fragments which are being transported with high proportion of sandy-silty matrix.

![Location map of the study area. a) GeoEye-1 image showing the aerial extent of the study area and b) Cartosat-1 ortho-image showing exact three dimensional views of Ukhimath town and its surroundings.](image)

**Figure 1**: Location map of the study area. a) GeoEye-1 image showing the aerial extent of the study area and b) Cartosat-1 ortho-image showing exact three dimensional views of Ukhimath town and its surroundings.

### 1.2 Regional tectonics

Since Himalayan region is somewhat a remote and rugged terrain therefore limited reference regarding detail geology and structure is found. However this lacking is also found in the present study area due to its inaccessibility and lack of detail geologic data. This zone regarded as exceptionally complicated geological structure with intensive tectonic fragmentation. Nevertheless it is very important to gather clear idea about lithology and tectonics for better understanding of landslide mechanism. A generalized stratigraphic table (Bist and Sinha, 1980) has been given (Table 1). The present study area mainly comprises of Vaikrita (Central Crystalline group) consist of the basal part of the Central Crystalline thrust sheet encompassing medium to high grade amphibolite–almandine rocks which are mainly garnetiferous schist, porphyritic biotite gneiss, and marble-cal-gneiss (Bist and Sinha, 1980) and Garhwal group also termed as Chail Nappe rocks found underlying the rocks of crystalline Vaikrita group. Dominant rock types are mainly low grade green schist facies.
which is quartz schist, amphibolite-schist with thinly bedded quartzite, crystalline limestone and talcose schist, besides intrusive granite and slate and phylite with limestone (Bist and Sinha, 1980). All the rock units are mainly low to high grade metamorphic rocks (Rawat and Rawat, 1998) associated with thrust faults and number of joints contributes dissections of the whole terrains. Being a tectonically active zone, this particular area is controlled by structural elements like faults and lineaments (Figure 2), eventually responsible for landslide occurrences during earthquake. Seismicity creates disturbance in these tectonic features and eventually causes landslide with in their vicinity. For instance the main central thrust dipping N to NE passing through this region attributes a neo-tectonically active regions which eventually causes shearing of rocks rendering them very vulnerable to landslide during earthquake. However these structural features are relatively weaker and incompetent in nature than surrounding host rock hence disintegration might take place more quickly during extensive rainfall.
Table 1: A generalized stratigraphic succession of the study area (Bist and Sinha, 1980)

<table>
<thead>
<tr>
<th>Group</th>
<th>Formation/Member</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaikrita (Central Crystalline)</td>
<td>Kalimath</td>
<td>Garnetiferous schist, mica schist, marble, porphyritic biotite gneiss, sillimanite gneiss, graphitic schist.</td>
</tr>
<tr>
<td></td>
<td>Ukhimath</td>
<td>Metabasite (amphibolite gneiss hornblende gneiss, chloride schist) schistose, quartzite, granitoids, streaky gneiss, quartzite and quartz-sericite schist.</td>
</tr>
<tr>
<td>Garhwal (Chail)</td>
<td>Chandapuri (Bhatwari)</td>
<td>Mylonitised quartzite, amphibolite schist with thinly bedded quartzite, thin bedded crystalline (marblised) limestone/calc schist and intrusive granite gneiss/mylonite gneiss.</td>
</tr>
</tbody>
</table>

Apart from this major structure, the prime importance of minor structure in the studied area is mainly the bedding foliations being defined by the parallel alignment of the flakes of biotite in the major rocks i.e. schist and gneisses having north south alignment with relatively higher dipping angles.

2. Materials and methodology

For the identification and mapping of landslides (Figure 3c), the present study is mainly focused on visual interpretation of high resolution optical imagery. Very high resolution panchromatic and pan-sharpened satellite imagery could be a valid alternative to traditional aerial photographs (Nale, 2002; Weirich and Blesius, 2007). A proper landslide inventory is obvious for damage assessment and however infers distribution of landslides that have moved in the present or past. In this context multispectral GeoEye-1(19-09-2012) as post event and Geoeye-1(27-03-2012) as pre event, both having 1.6 m (multispectral) and 0.4 (panchromatic) spatial resolutions were taken instead of aerial photos. Besides Cartosat-1 image of pre event was also taken for cross check the inventory map. Relevant image enhancement techniques i.e., histogram equalization and look up table (LUT) stretching were done for better visualization. Subsequently geometric correction using Auto sync tool in Erdas imagine 11 were done for exact matching of both imagery (pre and post event). Brief flow chart is given in (Figure 3a). Due to small areal extent, the visual interpretation method was adopted rather than computer software operated semi-automated or pixel-based change detection using pre and post (GeoEye-1) imagery; hence identification of damaged areas was done manually in ArcGIS 10 environment. The active landslides were identified by the distinct tonal appearance of bluish-white to white color from the surrounding areas. The active landslides refer to those which are currently moving or have moved in the very recent past. The old landslides refer to those which are at least 20–50 years old in terms of movement and the potential landslides refer to those which are not presently active but the risks of sliding cannot be neglected. One of the major limitations was similar tonal appearance in standard color as well as false color composition, exhibiting white to light grey color for both the new debris flow, roads and to some extent the buildup areas. To overcome this aforementioned constrains, exact aerial extend, dimensions and perspective view of landslide areas were clearly identified by 3D view of orthorectified DEM (Cartosat-1) using Arc Scene 10 (Figure 3b) since hilly areas implies positional errors due to its rugged
topography. Apart from this, the concept of feature association was also considered for meaningful mapping of the affected areas. Settlements, roads and agricultural lands were considered as vulnerable elements, digitized over GeoEye-1 pre-event image (Figure 3d) and subsequently cross checked with post event image (Geoeye-1 and Cartosat-1) to identify the damaged areas due to Ukithmath landslide 2012. As the landslide focused in this study was an adverse consequence of rainfall, henceforth climatic data i.e., rainfall was examined and an extensive field work was carried out to discover the possible cause of this particular rainfall. Few soil samples were collected from debris flow sites and were analyzed in laboratory (Electronic Direct Shear test) to examine the shear strength and the internal frictional angles of soil particles.

Figure 3: (a) Brief flow chart of damage area assessment. (b) Panchromatic Cartosat-1 ortho-image draped over DEM of 10m resolution derived from the Cartosat-1 stereo-pair showing detail terrain condition and dimension of debris flow near Ukhimath town. (c) Inventory map of landslide and (d) Vulnerable elements i.e., Buildup areas, roads and agricultural lands derived from GeoEye-1 Pan image (before event) and cross checked with Cartosat-1.

2.1 Causes of Ukhimath landslide (Field observations)

Rainfall is a recognized as one of the major trigger of landslides. Rainfall induced landslides are initiated by the buildup of water pressure into the ground (Campbell, 1975; Wilson, 1989). Groundwater conditions responsible for slope failures are related to the nature of rainfall infiltration, soil characteristics, antecedent moisture content, and rainfall history (Wieczorek, 1996). Undoubtedly Ukhimath landslide 2012 was ensued due to three days (13-15 September) prolong rainfall and also attributed by local geological settings. Therefore, the precipitation data of the Ukhimath region has been analyzed (Figure 4) to assess the triggering of the landslide. The given graph shows a sudden increase in 13 day cumulative rainfall approximately 350 mm (highest of that month) corresponding with the initiation of the landslides, however it is evident many of the landslides in and around the present study area occurred in September relatively towards the end of the monsoon period.
Ukhimath landslide 2012 at Uttarakhand, India: Causes and consequences
Islam, M.A et al

Figure 4: 30 days cumulative rainfall data near Ukhimath collected from ground rain gauge station. The arrow indicates initiation of landslide (debris flow).

A detailed field inspection (Figure 5) was carried out on local geology and other relevant parameters were documented to find out the possible causative factors for this specific event. Close proximity to the source area it had been observed that exposed rock types area are mainly banded Quartzite, Chlorite mica schist, and Quartz sericite schist. However dominant arrangement of rocks were observed as bands of Quartzite (40cm to 1m) interbedded with Chloride-sericite-schist (20-50cm) characterized by numerous joints. As a part of dissected hills, rocks of the debris flow source area comprises of number of joints having attitude of various directions (Table 2) as well as few micro faults.

Table 2: Detail of joint orientations in the initiation area

<table>
<thead>
<tr>
<th>Set no</th>
<th>Orientation</th>
<th>Aperture</th>
<th>Spacing</th>
<th>Roughness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set 1</td>
<td>30.295</td>
<td>Tight</td>
<td>0.3m to &gt;1m</td>
<td>Smooth plane</td>
</tr>
<tr>
<td>Set 2</td>
<td>25.245</td>
<td>Tight</td>
<td>0.4m to 1m</td>
<td>Smooth plane</td>
</tr>
<tr>
<td>Set 3</td>
<td>65.135</td>
<td>Tight to partial opening</td>
<td>0.8 to &gt;2m</td>
<td>Smooth undulatory</td>
</tr>
<tr>
<td>Set 4</td>
<td>70.200</td>
<td>Tight to partial opening</td>
<td>0.5 to 2m</td>
<td>Rough undulatory</td>
</tr>
</tbody>
</table>

*Joint Orientation is in degree, amount of dip and structure direction

Among these joint sets it was observed that sets (i.e., S1andS4 from table 2) dipping towards 135° and 200° eventually form a wedge shape mass. Moreover interaction between soil friction angle and topographic slope angle are directly related to instability based on the Mohr failure criterion. Soil samples from the debris flow site gives an estimation of internal friction angle which is 33°. From the result it is inferred that the internal friction angle is exceeded by the terrain slope (65° and 70°), however these joint sets was characterized by tight to partial opening having 0.8 to 2m spacing and smooth plane to undulatory plane. All these characteristics attribute the unstable slope condition in the initiation zone of the present debris flow. Additionally the three days prolong rainfall eventual increase the pore pressure and reduced the shear strength (from the lab analysis it was found 2.12 Kpa) of material (dominantly sandy in nature) along deeper slip surface.
Besides, the main source area as well as its adjacent affected areas was carefully surveyed to find out the type of the debris materials. Materials were found mostly of granular type having diameter range i.e., 80mm-800mm with huge silt/clay matrix and angular in nature. The torrent was approximately 1000 m and semi-channelized having less water content. Major landslide affected areas were examined and few GPS points and photographs were taken to validate the inventory maps (Figure 3c). However the study area had witnessed a number of landslides in the past of various dimensions and some of them clearly identified during field investigation ranging in small to moderate dimension even though they are covered with fresh vegetation. Most of the landslides are debris flow in nature; however few rockslides besides the major roads were checked during the field investigation.

Figure 5: Field observations of Ukhimath landslide 2012, (A) Houses were washed off at Mangali village due to debris flow run-out, (B) Half of a building destroyed at Brahmankholi village, (C) Joints of different orientation makes a wedge shaped block near the source/ initiation area eventually trigged the slope failure during the event, (D) Channel of debris flow run-out path near the initiation area, (E) Main initiation zone of debris flow, initiated by rock fall and subsequently transformed to debris flow, (F) Synoptic view of Ukhimath town showing the main locations of debris flow, (G) Road blocked due to rock fall, (H) Damaged connecting road between Ukhimath town to Kund and (I) Main debris flow entrainment zone close to the initiation area.
Major concern was the road, the only way of transportation near the Ukhimath town had been affected many places, few places roads were damaged fully and other places blocked by the falling materials (Figure 5G). Rescue operation of a remote area is a time consuming process and still few of the recovery was going in Ukhimath town. Violent damage at Mangali village washed off most of the houses was clearly evident in field investigation. Most of the agricultural land near Ukhimath town had been damaged due to run-out materials. The cumulative effect of all the aforementioned phenomena resulted sudden falls of whole rock mass in the form of debris flow. Additionally hill slopes near the source areas are consist of loose regolith and highly fractured seepage zones as well as considerable number of joints and foliation planes also attributed to this failure.

Moreover landslide affected areas were examined carefully and essential measurements were taken in a run-out zone which was responsible for violent damage at two villages named Mangali and Chuuni. But unfortunately it was not possible to identify the debris materials which actually inundated the villages due to the fact that meanwhile most of the materials had been removed as a part of rescue operation. Anthropogenic activities like road, barrage and house construction were observed during field investigation. Construction materials were taken from the adjacent hillslope mainly for repairing of damaged road. In general the topography is very rugged with high relief and dissected by ridges and valleys where ridges are mostly covered by moderate dense forest, however near the main debris flow location forests are highly degraded having relatively very steep slope compare to other areas. All the above mentioned factors could be the possible causes attributed the Ukhimath landslide 2012.

3. Consequences of Ukhimath landslide 2012

As a consequence of the rainfall induced landslide, approximately 505 landslides (Figure 3c) have been identified and affected areas were assessed with a major focus on the settlements, roads and agricultural lands. From the inventory map it is clearly evident that landslides (debris flow) are particularly widespread in the northern (Ukhimath town) and middle portion of the study area, whereas the southern part is relatively less affected. Major locations were selected for final damage assessments which are given detail in the following sections.

3.1 Assessment of building damage

According to the various news reports, the death toll rose to 50 and about 20 people were reported to be missing and nearly five villages affected badly at Ukhimath region. Moreover they mentioned that the cloudburst proceeded by incessant rains in the hilly region rendering almost 500 people homeless and destroyed several buildings mainly by debris flow. Visual interpretation near Ukhimath town and its surrounding were done with the help of high resolution imagery to locate the damaged areas. Image elements like shape of building, tone and associations were used to clearly identify the affected buildings. Pre and post GeoEye-1 together with Cartosat-1(before event) imagery were used to identify the buildings being mostly or partially damaged by the debris flow. According to the building footprint maximum damage was clearly identified in a village named Mangali (Figure 6A), another village situated downslope named Chunni has also been affected by the same debris flow (Figure 6C). Near the confluence of Mandakini and Madhyamaheshwar river a place of religious retreat for Hindus called ashram has totally been washed away and the Madhyamaheshwar river has also been changed its course near the confluence of Mandakini river (Figure 6B). During field investigation, affected areas were checked and relevant photographs were taken for better understanding how much damage occurred in that particular area. Most of the places
buildings were affected due to run-out zone of debris flow even though the source of the landslides is located far away from the place of incidence. Manual counting of building footprint suggest that more than 100 buildings have been damaged totally due to debris flow run-out near at Ukhimath town. Among these Mangali village has got 30 building damage whereas other areas like Chunni has got 10 buildings. However according to (NRSC, 2012) approximately 126 building were damaged fully or partially. Most affected village was Mangali has lost 32 building, whereas both Chunni and Semla has lost 12 for each, few other villages together like Brahman Koli, Saari, Paldwari etc have lost more than 70 buildings.

Figure 6: Showing damaged houses due to recent debris flow showing in pre (27 march 2012) panchromatic and post (19 September 2012) multispectral GeoEye-imagery. (A) Damaged houses in a village called Mangali, (B) Damaged building (ashram) near the confluence of Mandakini and Madhyamaheshwar rivers, (C) Damaged houses in a village called Chunni, (D) Damaged houses near Simla (south of Ukhimath town) village.

3.2 Assessment of road damage

Since roads are the only means of transportation in Ukhimath area, one of a serious problem after the event was damage of few major roads which eventually rendered the after evacuation works at the affected areas. Roads that connects Ukhimath town with other places even with district Rudraprayag has totally been destroyed and blocked some places. However few minor connecting roads were also affected and disconnected some while after the event. National highway (NH-109), from Rudraprayag to Gaurikund, passing through this area was completely destroyed at several places. Similarly road between Kund and Ukhimath was blocked at several places by the materials carried by run-out of debris flow which has also buried few villages at Chunni and Mangali (Figure 7A). Connecting road from Kund to Guptkashi (Figure 7B), road connecting Ukhimath to Chopta (Figure 7C) and road beside the Mandakani River between Guptakashi and Kalimath (Figure 7 D) were also being affected due to landslide. These roads have also been affected in several places on their way to other destinations. All the damaged area were clearly identified and checked in pre and post imagery visually. Preliminary landslide assessment of Ukhimath 2012, by National Remote Sensing Centre reported that a total of 7 km road was damaged due to debris flow (NRSC 2012). Satellite based work would rather give quick identification of an affected area than onsite investigation. Local district administration could take the map and start necessary
initiatives for quick removal of materials and make the roads clear for further transportation and further rescue operation in affected areas.

**Figure 7:** Showing damaged roads due to recent debris flow in pre (27 March 2012) panchromatic and post (19 September 2012) multispectral GeoEye-1 imagery. (A) Connecting road from Ukhimath to Kund, (B) Connecting road from Kund to Guptkashi, (C) Connecting road from Ukhimath to Chopta and (D) Connecting road from Guptakashi to Kalimath, apart from these locations many other places, the same road was also being damaged fully or partially. Road attributes are taken from preliminary report on Ukhimath landslide 2012 satellite based study, (NRSC, 2012).

### 3.3 Assessment of agricultural land damage

In Himalayan region, the rainfed agriculture on steep terraces are irrigated exhibiting 15-20% of the total cultivated land is very limited and precise land use. Average elevation is 1500 m msl and two crops are taken in one calendar year. Due to limited scope of working facilities majority of the population is involved in agriculture practice whereas Ukhimath is not the exception. In reality, availability of agricultural land might be the main intention for people to settle down at that particular location where other facilities are not sufficient. Crop lands near Ukhimath have been disrupted due to sudden debris flow brought from upslope areas. As the debris flow occurred in the monsoon time, ultimately resulted in loss of huge crop. Most of the debris flow initiated upslope area far from crop land and disrupting this particular landmass. However few of them have occurred within the agricultural land only (Figure 8B), the largest area damaged having areal coverage of 8 hectares near Ukhimath town (Figure 8C) whereas nearer few damaged field were also identified (Figure 8 A, D and E) in post event imagery approximately covering 4 hectares of land. Moreover few scattered damaged agricultural land were identified found mostly in southern portion of the study area. More than 120 areas were detected visually and digitized to delineate the partial or total damage with respect to agriculture land.
Ukhimath landslide 2012 at Uttarakhand, India: Causes and consequences
Islam, M.A et al

Figure 8: Showing damaged agricultural lands in pre (27-03-2012) panchromatic and post (19-09-2012) multispectral Geoeye-1 imagery in different parts of Ukhimath region (A) At Barsal village, North West of Ukhimath town, (B) North of Guptakashi town, (C) Near Ukhimath town, (D) South of Ukhimath town and (E) South of Kimana village, a small village 1.5 km south from Ukhimath town.

4. Conclusion

High resolution satellite imagery together with remote sensing techniques could be a great solution in quick damage assessments in any particular region after a natural calamity ultimately decreases cost and time in rescue operations. Targeting a very recent phenomenon, the present study investigates landslide damage assessment in a topographically complex as well as with remote area in the Himalayan region. Since the geospatial techniques i.e., remote sensing and GIS is a robust tool therefore it is extensively used many other places in Himalayan region where landslides are frequent every year. Recent landslide dated 14.09.2012 at Ukhimath, Rudraprayag district; Uttarakhand, India caused a considerable amount of loss due to the cloudburst preceded by incessant exceptionally high rainfall in the region attributes regional-scale landslides. Tectonic activity with highly disturbed and fractured lithology together with loose regolith over exceptionally steeper slope also enhances the potentiality of landslides. Moreover prominent seepage zone, shallow soil depth and rapid soil loss might be another possible cause make the source area more vulnerable to landslide. However due to rapid urbanization, wrong land use practices, ill planned road construction and uncontrolled blasting due to the fact of raw materials extraction for dam
and barrage construction eventually attributes the opening and widening of joints and fractures in the sheared rock of the MCT zone also added high probability of landslide. Present approach is accounted more than 7 km road damage together with 40 km$^2$ of agricultural land damage, however number of destroyed house identification was rather a difficult task but form the image analysis it is observed that more than 50 houses damaged partially or fully. This particular approach based on earth observation high resolution satellite imagery could help the local administration to take necessary steps after a disaster, however it would give the planning agencies and civil engineers for preliminary slope management and land use planning as well as identification of risky areas indirectly.

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