A Technical Report on the Recent Floods in District Kangra, Himachal Pradesh

Prepared by

State Centre on Climate Change

HP Council for Science Technology & Environment
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Abstract	**Susceptibility of the State of Himachal Pradesh to vagaries of climate change and natural disaster has now been well documented. During the current monsoon season, Kangra District witnessed flash floods after heavy rains on July 11 and 12, 2021. Due to heavy precipitation, the khads originating from the Dhauladhar range flowed with heavy discharge causing enormous damage in the downstream areas of Dharamshala region. The major damage occurred along Manjhi khad, Gaj khad at Shilla, Cheturu and Rajol localities due to toe erosion and channel course change resulting in heavy damage to infrastructure etc. At Boh village of Shahpur Sub Division, a massive landslide occurred due to rock failure leading to temporary blockade along the stream and by the movement of debris flow causing huge devastation in the village wherein 10 people lost their precious lives with 5 injured seriously alongwith loss to the infrastructure etc. The major damage that occurred at Rajol and Chetru was mainly due to change in the river course leading to the damage along the new course and toe erosion. At Bhagsunag, the damage was mainly due to the change in the land use of the stream which after chocking flowed with heavy discharge inflicting colossal damage in the downstream areas of the region.**

A Technical Report on the Recent Floods in District Kangra, Himachal Pradesh

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1. Introduction:

Himachal Pradesh a small hilly state in the Western Himalayan Region has made a remarkable progress over the years in almost all sectors withstanding the challenge posed by the specificities such as fragile topography, hostile climate, inaccessibility, scattered habitations, marginal and small land holdings. It has a rugged terrain, with elevation ranging from 320m to 6975m. Rock materials in the region are largely from the Indian craton and their ages range from the Paleoproterozoic to the present day. The collision of Indian Craton with Asia 50-60 million years ago concomitant with significant rock thrusting and folding during the collision. Apart from this the area has also been shaped by focused orographic precipitation, glaciation and rapid erosion. The elevation of Himachal Pradesh increases from SW to NE, and the orogenic materials making up this area also vary in the same direction. There are 5 major tectonic units in the form of fault-bounded NW-SE trending belts. From SW to NE they are named the Indo-Gangetic Plain, Sub-Himalayan Sequence, Lesser Himalayan Sequence, Greater Himalayan Crystalline Complex and Tethyan Himalayan Sequence.

Being predominantly a mountainous state of the north –western Himalaya, The drainage system of Himachal is composed both of rivers and glaciers. Himalayan rivers criss-cross the entire mountain chain. Himachal Pradesh provides water to both the Indus and Ganges basins. The drainage systems of the region are the Chandra Bhaga or the Chenab, the Ravi, the Beas, the Sutlej, and the Yamuna. These rivers are perennial and are fed by snow and rainfall.

It represents a unique physio climatic and ecological profile, such that it can be easily taken as a representative sample of Himalayan Eco-System as a whole. The perpetual snow clad mountain ranges are followed by alpine meadows acting as sponge for regulating the snow and glacier melt run – off into five major river systems i.e. Chenab, Ravi, Beas, Satluj and Yamuna that drain the Middle and Lower Himalayan ranges and after piercing through softer sediments of Shiwalik hills before debouching into the plains of Punjab.

Based on the agro climatic zonation, the State has been divided into four distinct zones viz. Sub –Mountain-Low Hills Sub tropical, Mid Hills- Sub Humid, High Hills -Temperate wet an High Hills -Temperate dry zones.

1.1 Zone-I: Sub –Mountain-Low Hills, Sub tropical

The terrain in this part of the zones is characterized low relief mountains. Rainfall varies between 800mm to 1600mm. The areas suffers perpetual summer shortage of water due to high run off. The valleys are generally narrow with flat areas where agriculture grows. The altitude ranges between 350 to 650m amsl. and it includes areas falling in Chamba, Kangra, Hamirpur, Sirmour and Bilaspur districts. It occupies about 33% of the total geographical area of the State and 33% of the cultivated area.

1.2 Zone-II: Mid Hill, Sub –Humid

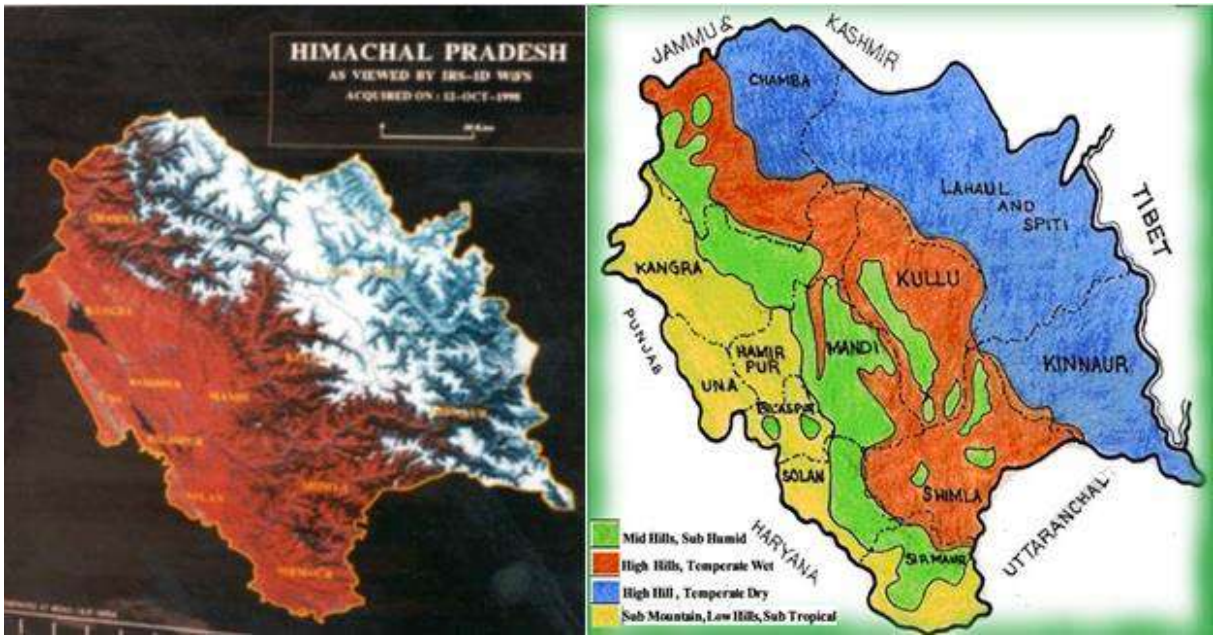
This zone comprises of areas of Lesser Himalaya, south west of the Dhauladhar and the valley areas of Ravi, Beas and the Chenab Rivers. It occupies about 32% of the total geographical area and 53% of the total cultivated area. Altitude ranges between 651 m to 1800m amsl. Average rainfall is about 1800mm.

1.3 Zone-III: High Hills, Temperate Wet

This zone occupies 25% of the total geographical area and 11% of the cultivated area of the State. Altitude ranges between 1801m to 2200m amsl. The annual rainfall ranges between 1000 - 1500mm. This zone comprises of Chamba, Kangra, Mandi, Sirmour and most parts of the Shimla and Kullu districts. The zone is characterized with humid temperate climate.

1.4 Zone-IV: High Hills, Temperate Dry

The Trans –Himalayan zone lying between Great Himalayas and the Zanskar Ranges, altitude is generally above 2200m amsl and due to the rain shadow effect of the Great Himalayan Range, the annual rainfall is less than 200mm. This zone occupies 8% of the total geographical area and 3% of the cultivated area of the State. This zone includes areas of Lahaul & Spiti and Kinnaur districts and Pangi Tehsil of Chamba and northern parts of the Kullu districts of the State.



(Source: Department of Agriculture, H.P.)

Fig.1: Agro Climatic Zone, Himachal Pradesh

2. Study Area:

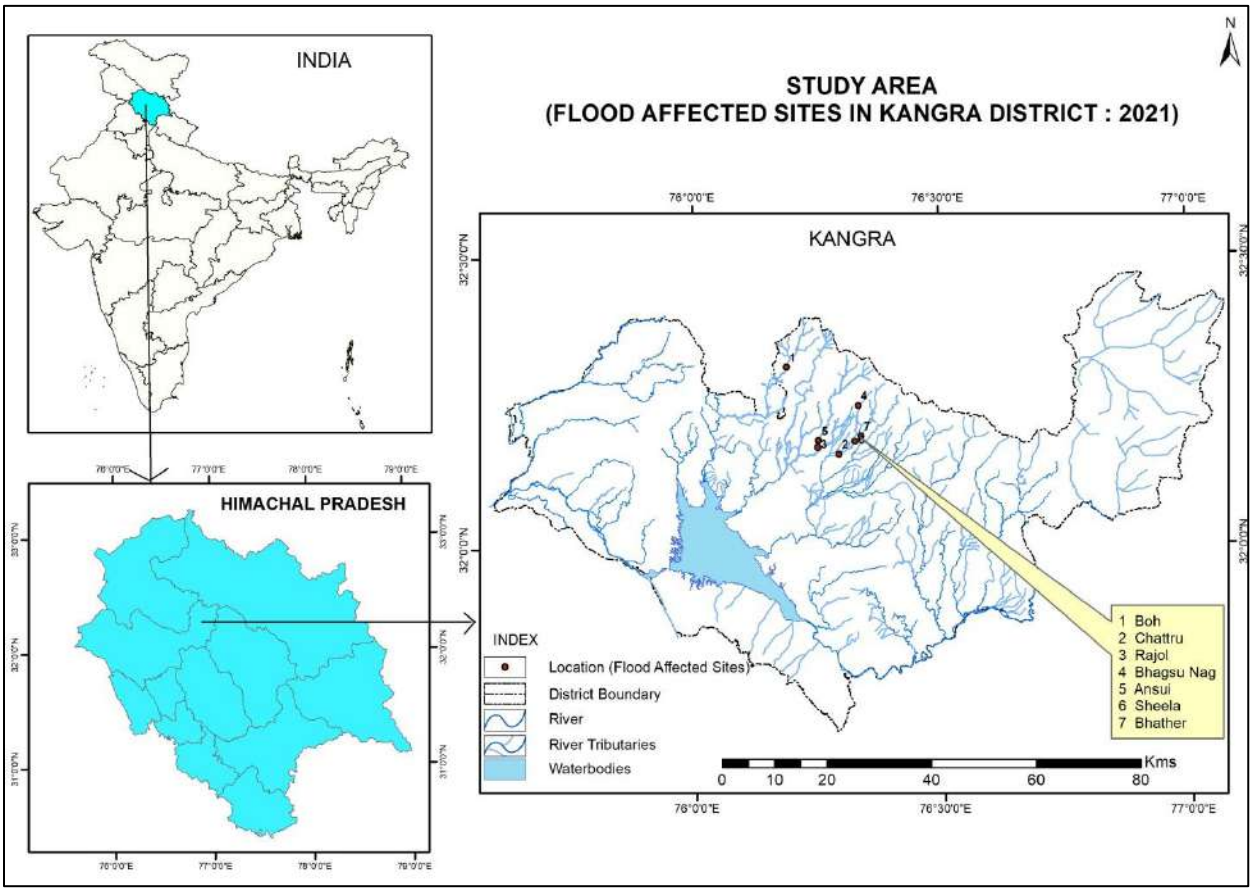


Fig.2: Study Area (Flood affected Sites in Kangra District).

The study area mainly comprises of the Kangra district **i**n the western part of Himachal Pradesh and located between latitudes 31°41' 00" and 32° 28' 05"; and longitudes 75° 35' 34" and 77° 04' 46" mainly in the foothills of the Himalayas and is bounded by the Dhauladhar range on the northern side and the Shiwalik group of rocks on the southern side. The Beas is one of the major rivers that passes all along the district. The district shares its boundary with Chamba on the north, Mandi to the southeast, and Hamirpur and Una to the south. The district shares its border with the States of Punjab on the southwest, and Jammu and Kashmir on the northwest.

During the monsoon period of 2021, in the month of July, the Kangra district witnessed widespread impact of heavy rains in the form of flash floods, erosion, landslides etc. throughout the district. On 12th July 2021, there was widespread damage in the district predominantly along the foothills of the Dhauladhars at several locations at Mcleaodganj, Shilla, Chetru, Rajol and Boh-Drini areas of the Kangra district.

2.1.**Bhagsunag:** At Bhagsunag near Mcleaodganj, the damage could be seen along the nala located at 32014' 37.55''N, 76^0 19'59.17''E and falls in the Survey of India toposheet No. 52D/08. The damage was mainly due to the heavy discharge along the nala that originated from the Dharamkot area in the upper catchment.

2.2.Along Manjhi Khad: Extensive damage could be seen along the left bank of the Manjhi khad mainly at Bhater (32^0 11' 28.09'' N, 76^0 20' 19.32'' E), Shilla (32^0 10' 55.86'' N,76^0 19' 34.45'' E,), Chetru (32^0 09' 37.77'' N,76^0 17' 38.85'' E) and falls in the Survey of India toposheet No. 52D/08. The damage was mainly due to the heavy discharge in the Manjhi khad causing toe cutting damaging infrastructure like road, water distribution pipes and houses etc.

2.3. Along Gaj khad: Further travelling in the westward direction on the Mandi –Pathankot National Highway near village Rajol (32^0 10' 20.68'' N, 760 15' 02.32'' E,) damage could be seen on the right bank of Gajkhad. Further upstream along the Gajkhad at village Ansui (32^0 11' 02.14'' N,76^0 17' 21.26'' E) and falls in the Survey of India toposheets No. 52 D/04 and 52D/08 where the effects of the flash floods were also visible along the right bank of Gajkhad.

2.4. At Boh: Further upstream in the North West direction at village, extensive damage could be seen due to a landslide from the upper catchment. The Boh village is situated at (32^0 18' 39.50'' N, 76^0 11' 18.21'' E) and falls in the Survey of India toposheet No. 52D/03 along the left bank of the Brahl khad, which is a tributary of Dehar khad and joins it at village Changleta near Trilokpur.

3. General Geology:

Himachal Himalaya is broadly divided into two major tectogens viz. Lesser Himalayan Tectogen in the South and the Tethyan Himalayan Tectogen in the North. The major tectonic feature between these tectogens is the Main Central Thrust (MCT) that separates the two tectogens. In Himachal Pradesh, the Tethyan Himalayan tectogen mainly includes the proteorozoic crystalline nappes and sequences of phenorozoic sediments covering the main Lahaul –Spiti and Kinnaur basin and other sub basins of Chamba and Tandi. The dominating stratigraphic domains of Lesser Himalayan tectogen are the Shalis, the Larji and the Deoban formation. The Lesser Himalayan tectogen comprises proteorozoic rocks and short span of early Cambrian rocks with advent of tertiary transgression. This tectogen mainly lies on the southern part of Himachal Pradesh and is bounded between Main Central thrust (MCT) and Main Boundary Thrust (MBT). As is evident, the lesser Himalayan tectogen is seismo-tectonically active and wedged between the collision boundaries and is linked with intense continental convergence on the northward moving Indian Plate. To the southern part of the Lesser Himalayan tectogen and bounded in the North by Main Boundary Thrust is the Shiwalik Group of rocks. In Himachal Pradesh, this runs along the southern margins of Palaeogene - Sirmour Belt from Ravi to the Yamuna Rivers and forms a parallel foothill belt in the Sub-Himalayan zone.

The Kangra valley shows striking features with diverse geology, landforms and river systems. This valley is a vast inter-mountain basin covering an area of about 5700 km². The Dhauladhar Range (6200m) forms the northern boundary whereas the Siwalik Sequences (1050m) are exposed in the southern part. There are three geological units namely Pre-tertiary, Tertiary and Post-tertiary Formations. The Pre-tertiary Formations are exposed to the north of Dharamshala. The MBT separates the Pre-tertiary with the Tertiary to the south. The Tertiaries comprise of Shali, Sundernagar and Chail Formations comprising of limestone, quartzite and Schist respectively. The limestone bands are sandwiched between the Tertiary in the south and Dharamshala and Chandpur Formation in the north. The age of this limestone is said to be Late Permian-Triassic (Gupta and Thakur, 1974). The Tertiary Formations covered a large area of the Kangra valley and lie in a comparatively lower topography. The Subathu Formation lies to the north of Dharamshala and consists of shale and limestone. This is believed to be of Eocene age. The Lower, Middle and Upper Siwaliks lie conformably with each other. Granite is the principle component of the Dhauladhar Range.

Quaternary deposits forming about 90-150 m sequences are exposed in the Kangra valley. These sediments represent Glacial, Fluvio-galacial, Fluvial, Lacustrine and by deposition due to mass

flows, landslides and rains. In most cases the Quaternary deposits rest uncomfortably over the Siwalik units. Apart from this, the area is characterized by a series of synteconic alluvial fan that have developed due to strong relief resulting from the reactivation of the MBT and its imbricates. This reactivation along with the incipient transverse faults in the region caused subsidence, uplift and segmentation of the otherwise contiguous fans situated on the southern flanks of the Dhauladhar range in the Kangra region.

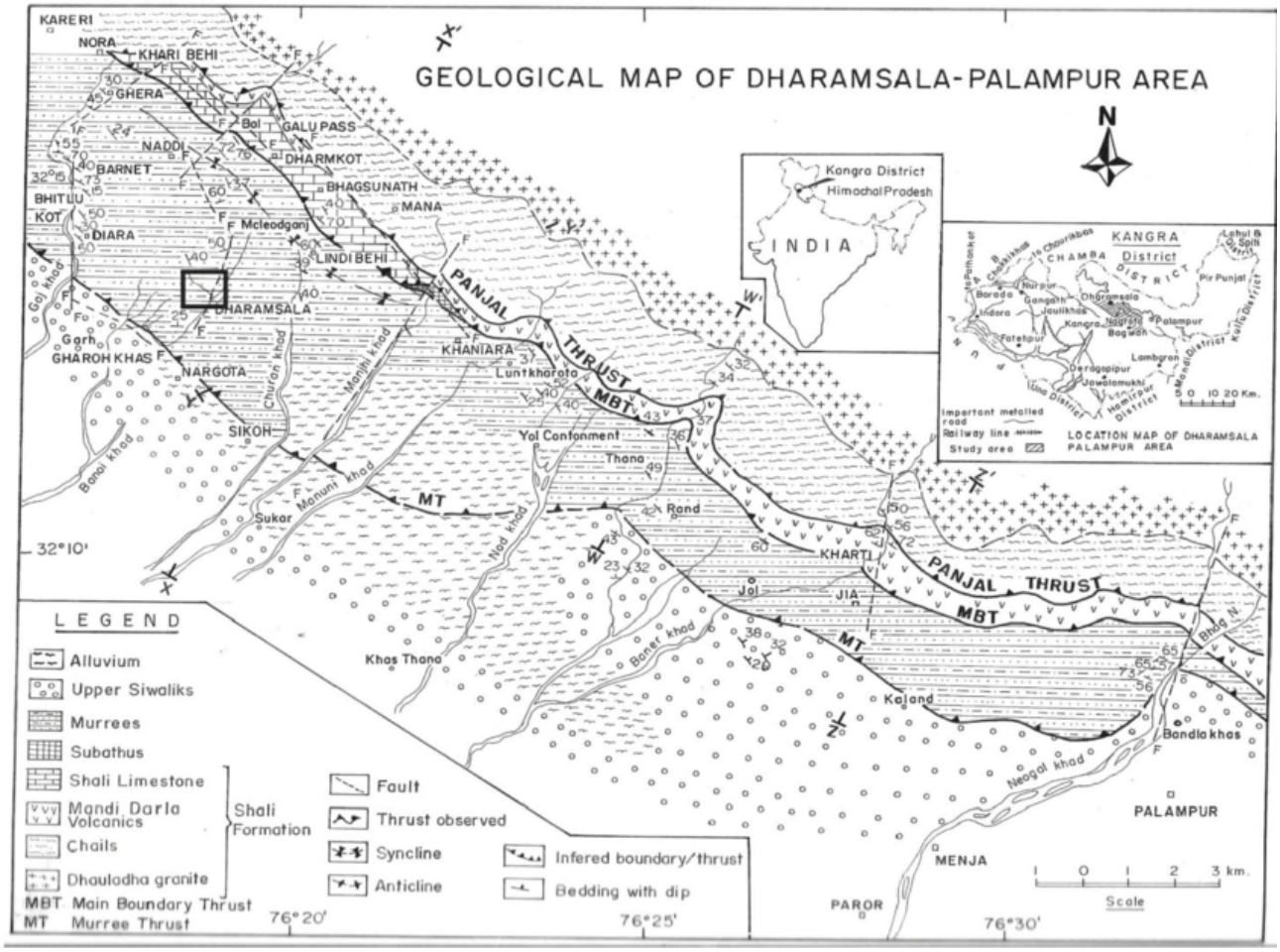


Fig.3.1: Geology Map of Dharmshala-Palampur Area ((after Kumar and Mahajan, 1991)

3.1Geology of the Area

Rock formations of study area consist of Siwalik Group, comprising sedimentary sequences of mudstone, shale, clay, coarsely bedded conglomerate and sandstones of Middle Miocene to Upper Pleistocene times) and the Lesser Himalayan zone, comprising lower tertiary Dharamshala sand stones and Sabathu shales, early Precambrian slates, phyllites, schists limestones and basic lava flows followed by late Precambrian Dhauladhar granities and gneisses dominate the study area. Lesser Himalayan zone rocks are overthrusted over the Siwalik formation along a series of major thrust planes, the Main Central thrust (MCT), the Main Boundary thrust (MBT) and the Himalayan frontal thrust (HFT) which came into existence during the collision of the Indian and Eurasian converging plates. Further the region is traversed

by numerous faults and lineaments that cross cut the litho-units of the region transversely controlling the main structural pattern and high seismicity and related geological attributes viz development of significant amount of secondary structurally controlled porosity and permeability along fractured joints, fault zones and formation contacts.

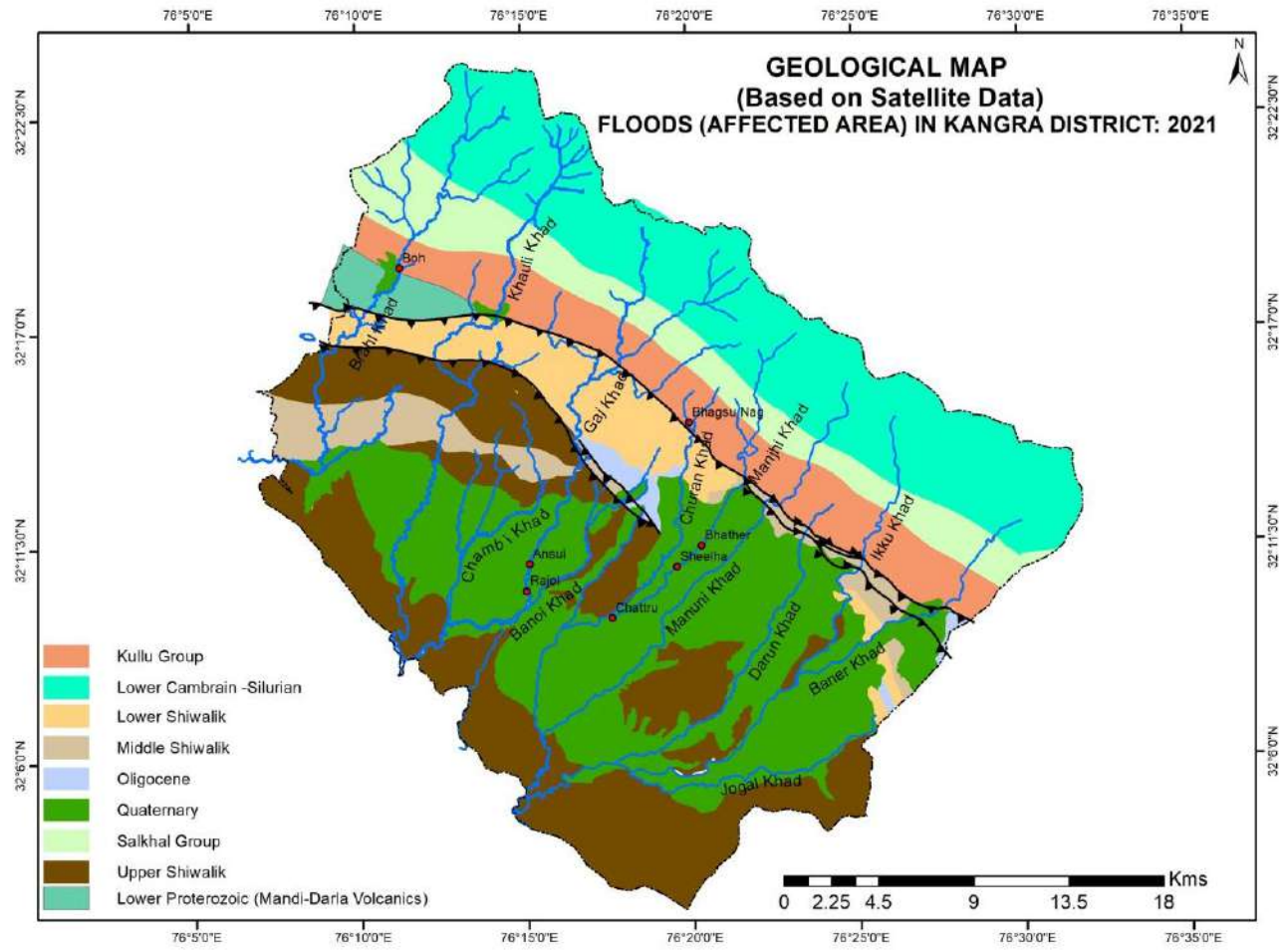


Fig. 3.2: Geological Map of Floods (Affected area) in Kangra District, 2021

3.2 Geology of the area under investigation

Location 1: Bhagsunag area is mainly characterised by the Dhauladhar Granite on the top running in NW-SE direction underlain by the phyllites, schists and slates belonging to the Chail Group which are further underlain by the Shali Limestone locally known as Dharamkot Limestone mainly on the north western side and the Mandi Darla volcanics popularly known as the Panjal Trap on the north eastern side running in NW-SE direction. The location lies very close to the Main Boundary Thursts (MBT) that separates the Tertiary group of rocks from the Pre -Tertiary. Close to it is famous town of Dharamshala which is located on the Dharamshala group of rocks comprising mainly of sandstone with the intercalation of clays, siltstones and shales. The major part of the Dharamshala town and its northern hill slopes are covered with overburden material of glacial and debris deposit and consist of clay with small

rock fragments of silt stone. The Dharamshala town is sandwiched between two major NW-SE trending tectonic features i.e. Drini thrust to the south (passes from Garoh Khas-Sukoh to the east) and MBT (passes just below Bhagsunag) (Fig.3.2).

Location 2: The Manjhi kahd section, geologically comprises of Dharmshala group of rocks on the upper reaches underlain by the thick succession of alluvium mainly comprising of the fluvio- glacial deposits all along the valley extending towards the southern parts before it confluences with the Manauni Khad and traverses the Upper Shivaliks formation down south.

Location 3: Gaj khad section towards west cross cuts the lower Shivaliks and the all the thrusts towards the north and in the southern part it traverses the Upper Shiwaliks and further southwards the unconsolidated boulder conglomerates and clays etc.

Location 4: The local geology along Brahl khad catchment which is a part of the Dehar watershed consists of the rocks of the Shiwalik Group and the Lesser Himalayan Zone with pre-tertiaries rocks towards the northern part of the catchment and towards the south the tertiaries rock exposures are visible. Mainly the catchment comprises of the rocks of Pre Cambrian gneisses and granites of Dhauladhar Group. Slate, phyllite, schist of Chails (Salooni formation), older rocks comprising slate, quartzite, schists, basic lava flows, marl and dolomites of Sundernagar Group, Jutogh and Shali formation are the major rock types of the Lesser Himalayan Zone. The Cenozoic rocks belonging to the outer Himalayan zone are mainly the green shales, sandstone of Subtahu/Dharamshala Group, and sandstone, shales, clays, and conglomerates of Shiwalik Group. Significantly Quaternary exposures are scarce in this section however some enclaves are significantly seen towards the north which are the remnants of unconsolidated glacio-fluvial sediments occurring in the area. The area also assumes significance on account of its seism-tectonic peculiarities. Numerous significant thrust consisting of MBT, Chail Thrust and Darini Thrusts are present in the area.

4. General Geomorphology of the Area:

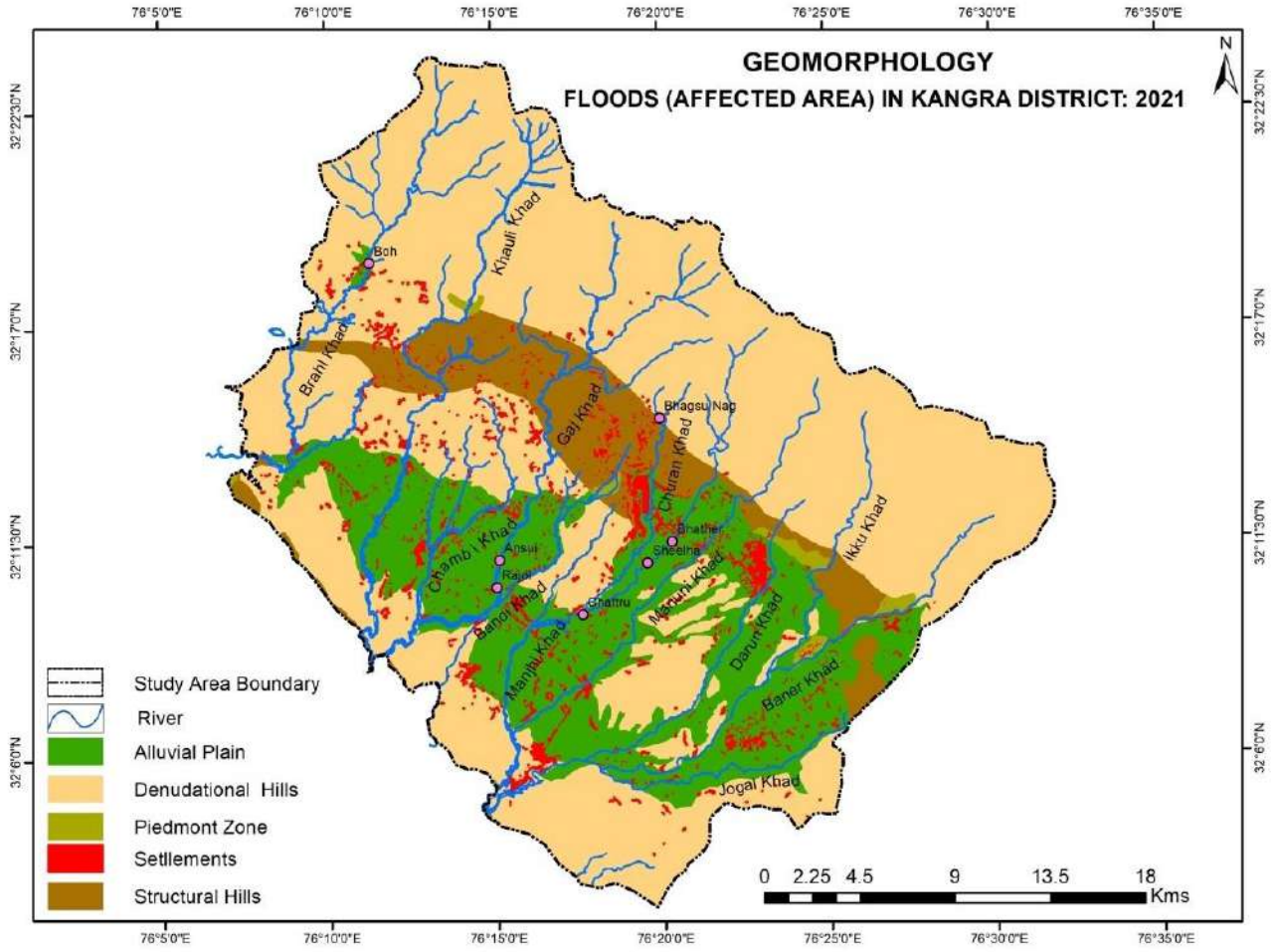
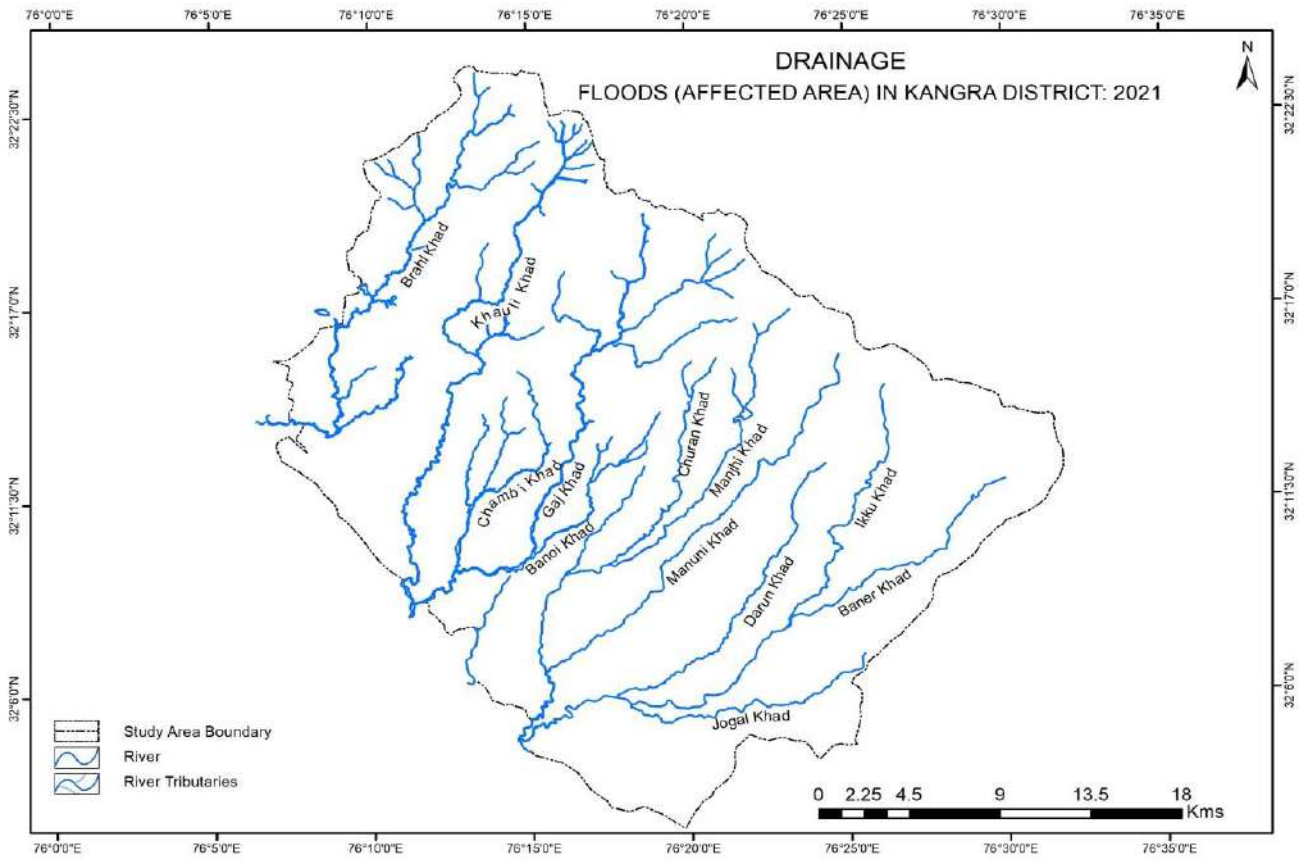


Fig .4: Geomorphology of Floods (Affected area) in Kangra District, 2021

Geomorphologically the study area is characterised by valley fills comprising of fluvio glacial and recent alluvial deposits in the Kangra valley which is a major intermountain valley in the western Himalaya extending in NW-SE direction. It is bounded between the snow clad denudational hills along the Dhauladhar Range and structural hills on the north and the denudation hills comprising of Shiwalik Group of rocks in the south. The Shiwalik Group exhibits prominent structural hills in the NW-SE direction with linear inter-hill depressions. The inter-hill depressions are structural in its character and mainly lie along the study area i.e. Kangra district. Besides this, the upper Shiwalik boulder conglomerates forming a thick sequence of linear ridges extending in NW-SE direction is another predominant unit in the study area. Apart from this the area is characterized by a series of syntectonic alluvial fan that have developed due to strong relief resulting from the reactivation of the MBT and its imbricates. This reactivation along with the incipient transverse faults in the region caused subsidence,

uplift and segmentation of the otherwise contiguous fans situated on the southern flanks of the Dhauladhar range in the Kangra region.

5. Drainage System:



The drainage system developed in the region is the part of the Indus River system with Beas, as the major river basins. There are a number of perennial streams joining the three major rivers in the study area. Prominent streams that emerge from the snow clad Dhauladhar ranges are the Dehar, Brahl, Khauli, Chambi, Gaj, Banoi, Churan, Manjhi, Manuni, Baner khad etc. The characteristic features of these streams is that they are all parallel to each other and are oriented in a trend i.e. a trend which is transverse to the strike of the Shiwalik ranges and the upper Dhauladhar range. On analysing the satellite data, it is observed that they are characterised by a linear trend in NE-SW direction reflecting strong structural control on the drainage development. Some of these streams show sticking bends resulting due to the off-set caused whiling crossing the major thrusts especially the MBT. All these streams merge into the Beas River in the Pong Reservoir on the southern side of the district.

6. Site wise Analysis and causative factors:

Based on the field visit, the following observations were made at each site.

1. **Bhagsunag:**

- At Bhagsunag (32^0 14’ 37.55’’N, 76^0 19’59.17’’ E), the major damage was occurred mainly due to very heavy flow/ discharge from a seasonal nala which originates from the upper catchment near Dharamkot.
- Based on the field observations, it was found that this is a small nala the original course of which has been obliterated because of the change in the landuse of the area and subsequent conversing of the channel into a pathway in the upper part and the encroachment by the hoteliers in downstream areas.
- Due to heavy downpour on 12th July 2021, a heavy discharge followed by a temporary blockade for some time in the upper catchment near the over bridge and the sudden release of the debris of material stalked because of road cutting work that is taking place on this channel.
- The field observations further reveal that, when the impounded water was released, there would have been a sudden increase in the flow with a very high velocity because of the gradient of the nala.


A
Catchment area above the bridge
Bridge
B
Water Channel below the bridge
Broad Channel
Bridge

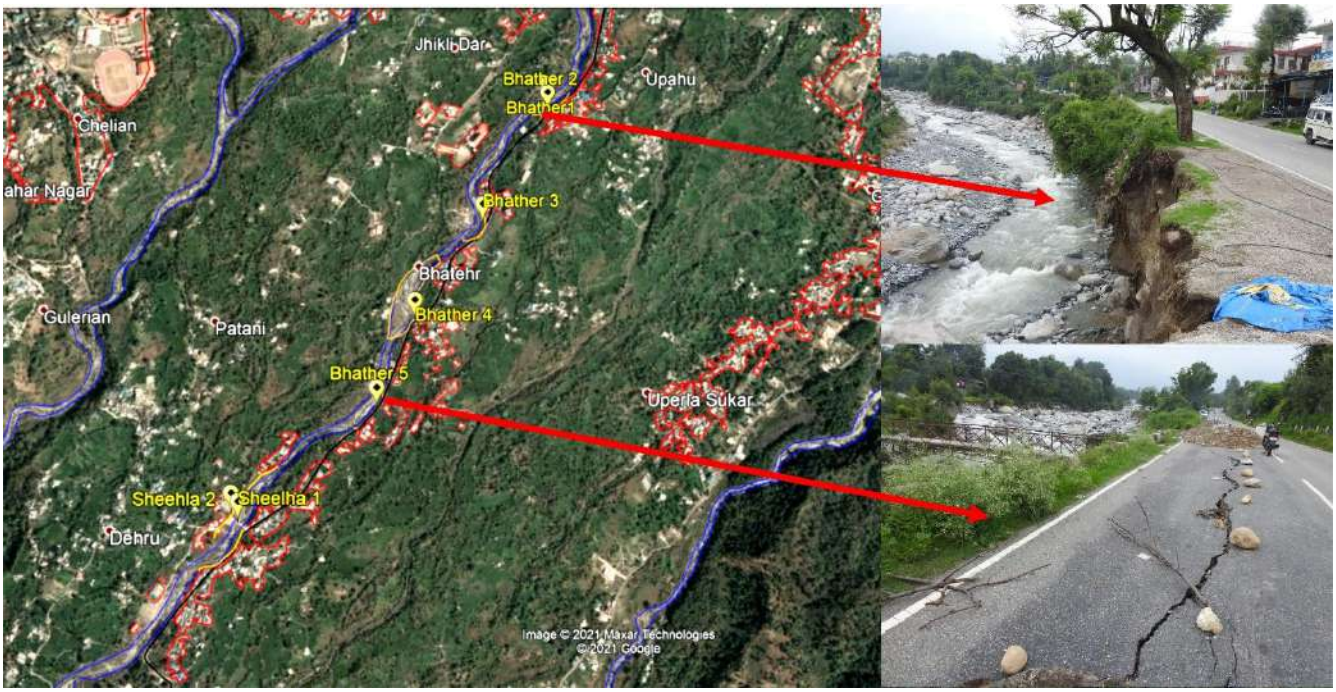
Fig. 6.1: Bhagsunag,Floods (Affected area)in Kangra District, 2021

2. Along Manjhikhad

Manjhikhad is one of major khad in the group of few khad like Churan, Manuni, Darun, Ikku, Baner&Jogalkhad that originates from the upper catchments along the Dhauldhar range and are parallel to each other and flows in NE-SW direction before they merge and form the major Banerkhad. Although there was a widespread damage within the catchments of these khads as they all flowed with very heavy discharge on the 12th of July 2021, but the pronounced effects resulting into considerable damage and loss on the public and private property is reported in following locations:

(a) Bhater

At Bhater (32^{0}11’28.09’’ N, 76^{0}20’19.32’’ E), the Manjhi khad caused heavy damage mainly along the left bank caused due toe cutting by heavily loaded the over flow (Fig.6.2 (a)).


Jhikli Dar
Bhather 2
Upahu
Bhather 1
Chelian
Bhather 3
Bhatehr
Gulerian
Patani
Bhather 4
Bhather 5
Uperla Sukar
Sheehla 2
Sheelha 1
Dehru
Image © 2021 Maxar Technologies
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A
B
C
D

Fig. 6.2 (a): Bhater, Floods (Affected area)in Kangra District, 2021

(b) Shilla

At Shilla (32^0 10' 55.86'' N,76^0 19' 34.45'' E,) again the damage was mainly along the left bank by the heavy discharge and overflow leading to toe erosion and down cutting of the banks and subsequent collapse (Fig.6.2 (b))

Fig. 6.2(b): Shilla, Floods (Affected area) in Kangra District, 2021

(c) Chetru

At Chetru (32^0 09’ 37.77’’ N,76^0 17’ 38.85’’ E), the major damage was on houses along the left bank of the Manjhi khad to the temporary course change of the flow from right to left side attributed to toe cutting. This resulted in good number of residential houses built on the terrace deposits of the channel be washed away. (Fig.6.2(c)).

Fig. 6.2(c): Chetru, Floods (Affected area)in Kangra District, 2021

3. Along Gaj khad

Gaj is another major khad further westwards that originates form the upper catchments along the Dhauladhar range and is joined by Chambi and Khauli khads on its west at different locations having a general NE-SW flow direction. Along the Gaj khad, the damage was reported from Ansui, Upper Rajol and Rajol on the Mandi-Pathankot National Highway.

At Ansui (32^0 11' 02.14'' N,76^0 17' 21.26'' E), the damage was mainly due to the change in the river course from the right bank leading to damage in the houses which are quite far away from the present right bank. Further based on the field observation, this course also appears to be an old course of the Gaj khad depicting it's over flows during the previous events of flooding occurring in this location.

Fig. 6.3(a): Upper Rajol, Floods (Affected area)in Kangra District, 2021

At Upper Rajol (32^0 10’ 40.66’’ N, 76^0 15’ 0.41’’ E) damage was mainly again on the right bank causing toe cutting and erosion of the agriculture land (Fig .6.3(a)).

At Rajol on the main National Highway ($32^0$10’ 20.68’’N, 76^0 15’ 02.32’’E), the damage observed was mainly due to the change in the river course from the point (32^0 09’ 37.90’’ N, 76^0 17’ 36.59’’ E,). At this point from the right bank, the river has diverted towards right side leaving the main course and damaged the entire area which including a playground, and other infrastructure and after crossing through the highway the diverted overflow has caused heavy damage to the houses coming under the fury of the turbulent wayward waters of the Khad. (Fig. 6.3 (b) &(c)).

Fig. 6.3(b): Rajol, Floods (Affected area) in Kangra District, 2021

Fig. 6.3(c): Rajol,Floods (Affected area)in Kangra District, 2021

4. Boh -Drini

On travelling further westwards towards Shahpur on the Mandi –Pathankot National Highway and then towards north on Shahpur-Drini-Boh state road, a massive landslide occurred on the 12th July 2021 killing 10 people, 5 injured and damaging 11 houses. The total damage estimated by the DDMA Kangra District was to the tune of about Rs13.50 Crores. This event has been the most gruesome as along with the property, precious lives were lost due to the horrific activity of debris flow that took place due to heavy downpour.


Morachh
Boh-3
Boh 4
Boh
Boh-2
Boh 1
Rulehr
Har
Dadru
Image © 2021 CNES / Airbus
© 2021 Google
Image © 2021 Maxar Technologies
Destruction Level
Google Earth

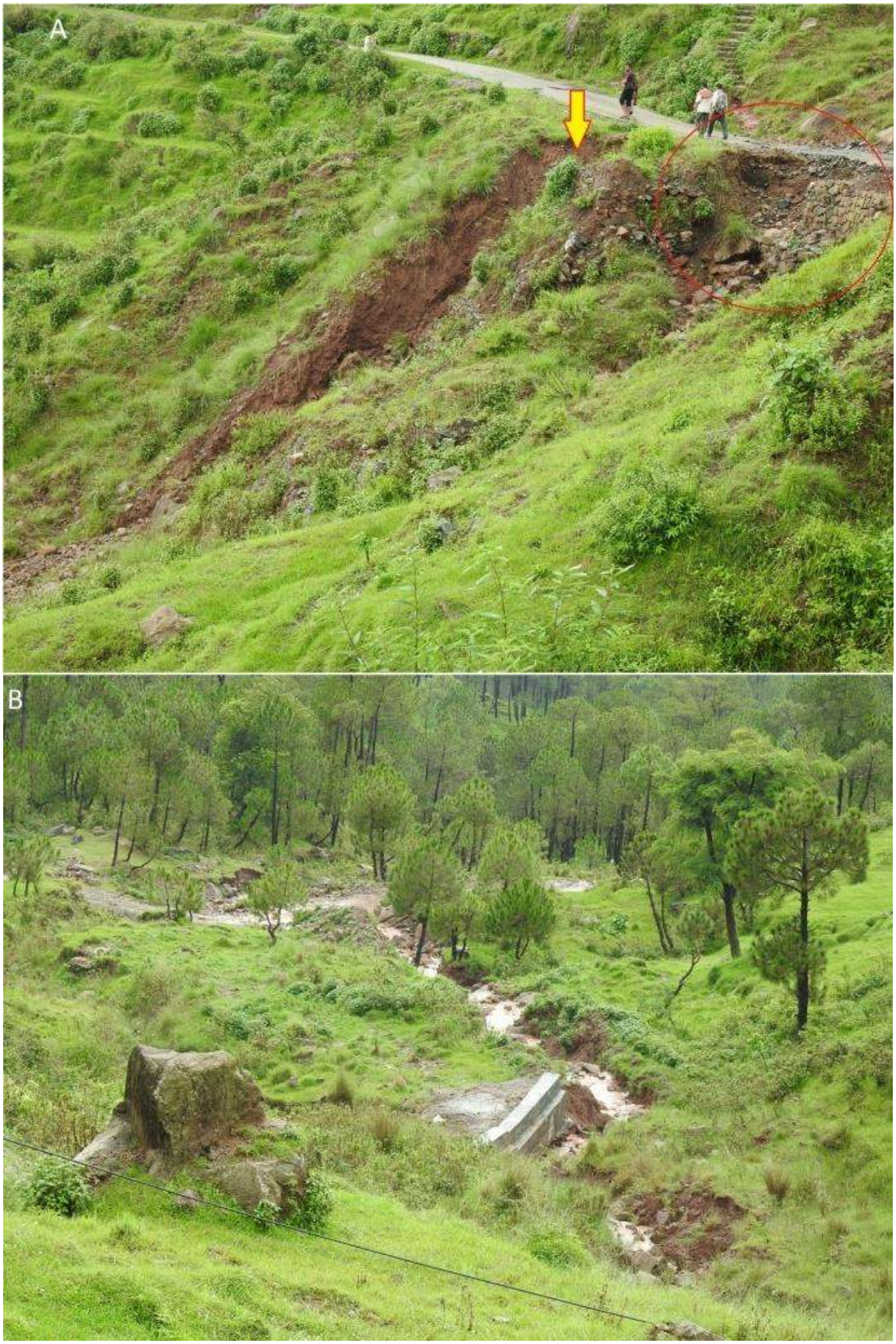
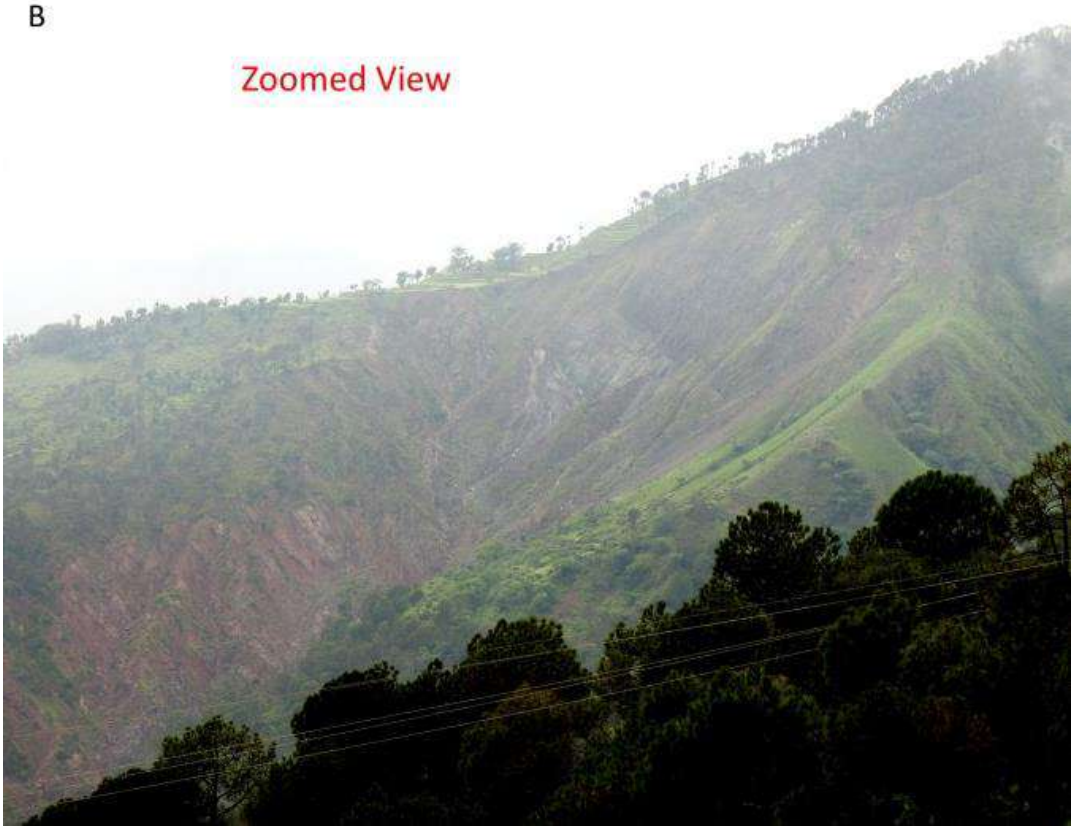


Fig. 6.4(a): Boh, Floods (Affected area) in Kangra District, 2021

A

B



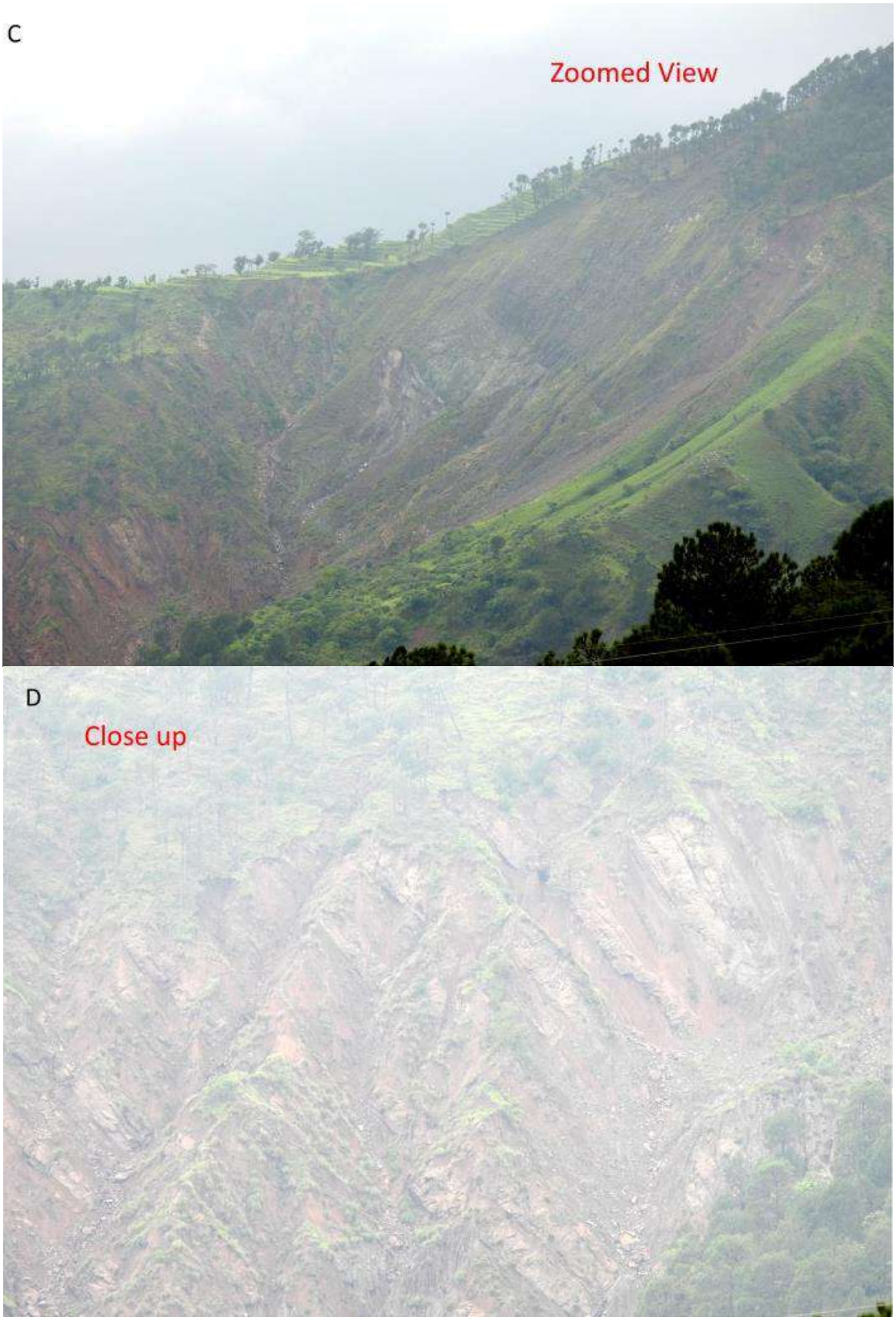


Fig. 6.4(b): Boh, Floods (Affected area) in Kangra District, 2021


A
Slope
B
Zoomed View

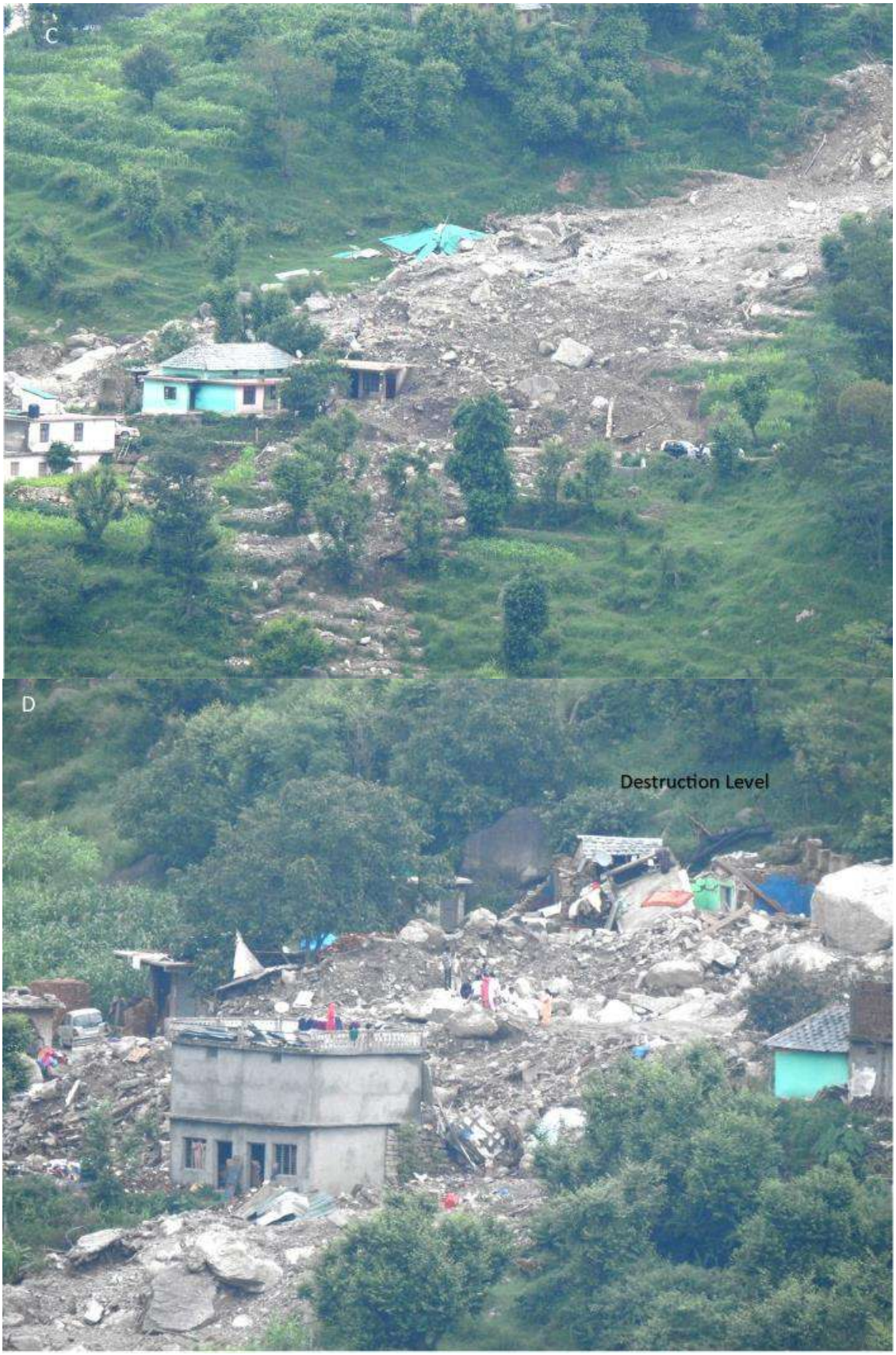
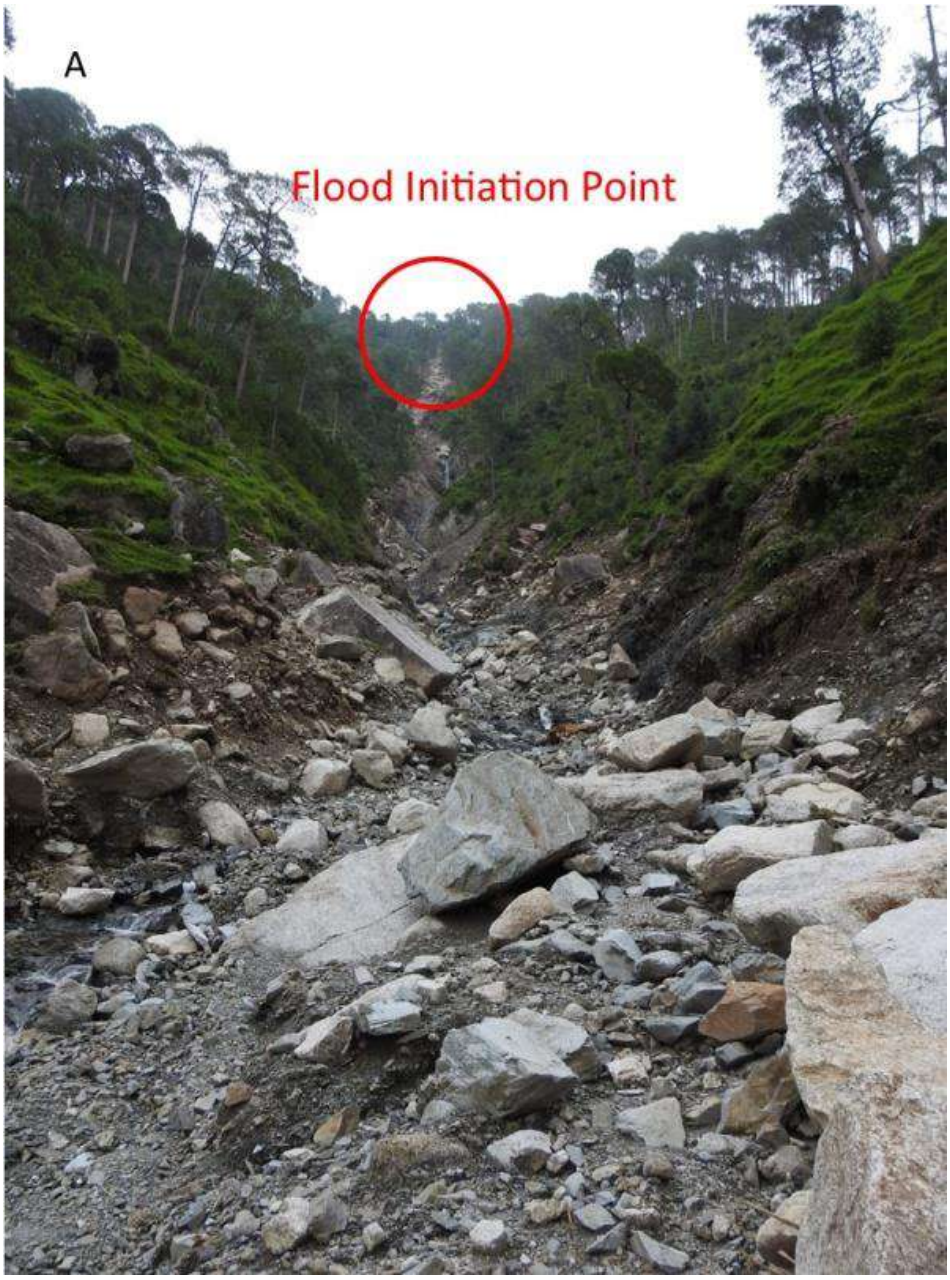


Fig. 6.4(c): Shilla, Floods (Affected area) in Kangra District, 2021

The village Boh is situated (32^0 18' 39.50'' N, 76^0 11' 18.21'' E) on the left bank of the Brahl khad which is one of the major tributary of the Dehar khad that culminates in the Pong Dam, further southwards. The landslide affected area of the village is within a small micro watershed having a total area of about 0.16 Sq. Km. Geomorpholgically the Boh village is situated within the unconsolidated alluvial sediments comprising sand, gravel, boulders eroded from the upper catchments of the Dhauladhar granites and the Kullu group. The alluvial is mainly confined along either banks of the Brahl khad, whereas the upper catchments show the presence of the denudation hills supported by the rocks of the Kullu Group and the Dhauladhar Granite. Geologically the upper catchment in the region is characterised by the rocks of Kullu Group mainly the phyllites, schist etc. and the unconsolidated alluvial sediments along the Brahl khad and the Boh village.




B
Flood Targeted Point


C

Fig. 6.4(d): Boh, Floods (Affected area) in Kangra District, 2021

The landslide that occurred on 12th July2021 between 10.30- 11.00AM originated mainly from the over burden of metamorphites which is the in situ rock visible now in the scar area of the landslide. Along with the landslide, overburden of huge erratic granitic boulders of Dhauladhar Granites were washed away due to the heavy rains causing heavy damage in the cluster of houses situated on both flanks of the road connecting the Boh village situated on gentle hill slope which supports a thick veneer of unconsolidated material. In the scar zone, the main reason of the landslide seems to be the detachment of rock mass along with the overburden comprising loose and unconsolidated material of Dhauladhar Granite developed along the weak zone that must have detached along the failure plane between the in situ county rock and the thick blanket of unconsolidated material. The debris flow comprising the detached overburden material and the erratic got impounded in the narrow upstream region and the heavy quantum of rains must have forced a sudden release of the debris and large erratic load alongwith high velocity causing devastation of the houses on the both side of the Boh road as it buckled down along the slope bulldozing the habitats of the unaware residents.

Fig. 6.4(e): Floods Impact and destruction (Affected area) in Kangra District, 2021

Inferences:

Slope failures and flash floods are commonly encountered in the hilly terrain of Himachal Himalayas. These hazards not only threaten various aspects of civilization i.e. buildings, roads and agricultural activities but also imbalance the natural equilibrium of the ecosystem. The frequent natural hazards accentuated by human interventions cause great loss of life and property every year in the hilly region of Himachal Pradesh. Scientific preparedness and mitigation measures are needed to timely safeguard the vulnerable areas against impending destruction.

High annual precipitation, complex lithological attributes and tectonic setting has sculpted the area vulnerable to mass failure. Natural drainage outlets are obliterated by unscientific change of land use. The destruction due to flash floods in Bhagsu Nag area of Dharamsala region is a combination of impairment of natural drainage due to construction activity and encroachment. Slope failure due to the heavy precipitation, hydrological factors such as infiltration, seepage, impoundment and overdose of water coupled with the thick pile of unconsolidated sediment cover has formed an ideal recipe for the slope failure that unleashed havoc in the form of debris flow in the Boh area.

Floods and associated devastation in the Manji Khad segment is attributed to the heavy precipitation causing the abnormal flow of water and eroded material in the channel and resulting in the lateral toe erosion of the river terraces regions which are occupied by either constructed area or a road.

Impact of floods in the Gaj Khad segment has mainly resulted due to the temporary course change of the channel and its tendency to follow its old course due to overflow and off shooting of the banks. Under such circumstance when the catchment receives a heavy dose of precipitation the enormous compressed volume of water from the narrow valleys tend to spread out in the region of gentle slopes and wider valley system. In this process the high velocity water heavily loaded with sediments and boulders leaves its present trajectory and tends to flows into its old/Paleo course for some time till the water in the main channel recedes. During the intervening period the disgruntled channel washed away the portion of the Mandi-Pathankot Highway and numerous houses and establishments on the both side of the state highway.

Concluding remarks

Rock falls, slope failures and flash floods are some of the common hazards during the monsoon season that are being experienced in the recent past throughout the entire Himalayan belt including Himachal Himalaya. These hazards have become a major issue of concern not only to the

common man, but also the Governments of these Himalayan States, as these incur huge infrastructural as well as the human loss. The recent floods in the Kangra district caused huge loss to the Govt. exchequer besides the loss of 10 precious human lives including 5 injured in this catastrophe. Moreover, 7 people died due to a flash flood in the Tozing nallah in Lahaul & Spiti district in August this year and 09 human loss and 3 injuries were reported in Kinnaur district due to rock fall at Batseri village in Sangla valley of Kinnaur district in July 2021. Again there was huge loss due to massive rock fall at Nigulseri in Kinnaur district in August where in precious 28 human lives were lost besides 13 being injured.

Considering the vulnerability of Himalayan States towards such hazards particularly during the monsoon season, it is suggested that a detailed micro level district wise multi-hazard geomorphological mapping be carried out for the identification of potential sites for rock falls, landslides and its other associated hazards. Apart from this vulnerable areas in the foothills regions and the major and minor river valleys including the paleo-channels should also be investigated using latest technological tools such as remote sensing and its correlation with the geological characteristics of the local area. This will help in making an assessment of the region which are prone for such kind of events during the monsoon period and accordingly the activities for the sensitisation of the local masses and awareness of other stake holders should be undertaken. Such initiatives of scientific preparedness and mitigation are important keeping in mind in the sensitivities of present era of climatic variations and its impact over the fragile mountainous regions.

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