

**भारत सरकार/Government of India**  
**खान मंत्रालय/Ministry of Mines**  
**भारतीय भूवैज्ञानिक सर्वेक्षण/ Geological Survey of India**



हिमाचल प्रदेश के कुलु जनपद में कुलु, बंजार, मनाली तथा अन्नी क्षेत्र में  
हुए भूस्खलन के प्रारम्भिक आकलन पर प्रतिवेदन

**REPORT ON THE PRELIMINARY ASSESSMENT OF LANDSLIDE AT  
KULLU, BANJAR, MANALI AND ANNI SUB-DIVISION OF KULU  
DISTRICT HIMACHAL PRADESH**

टोपोशीट सं: 53E/1,5 तथा 52H/4, 8/Toposheet No.: 53E/1,5 & 52H/4,8

मद संख्या: एम.4 ईजीजी/सी/एन.आर./एस.यू.पी. एच. पी. 2023/46620

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कार्यसत्र 2023-24  
Field Season 2023-24

द्वारा  
तृप्ति बाबा, वरिष्ठ भूवैज्ञानिक  
वेनेइख्रो क्रोमे, भूवैज्ञानिक

By  
Tripti Baba, Senior Geologist  
Weneikhro Krome, Geologist

**मिशन-IV**  
**MISSION-IV**

राज्य इकाईपंजाब :, हरियाणा एवं हिमाचल प्रदेश / State Unit: Punjab, Haryana and Himachal pradesh  
उत्तरी क्षेत्र / Northern Region  
चंडीगढ़ / Chandigarh

अक्टूबर, 2023  
October, 2023

**A PRELIMINARY REPORT ON LANDSLIDE STUDIES IN KULLU, BANJAR,  
MANALI AND ANNI SUB-DIVISION, KULLU DISTRICT, HIMACHAL PRADESH**

**Item no. M4EGG/C/NR/SU-PHP/2023/46620**

**(FS: 2023-24)**

**by**

**Tripti Baba, Sr. Geologist & WeneikhroKrome, Geologist**

**1. INTRODUCTION:**

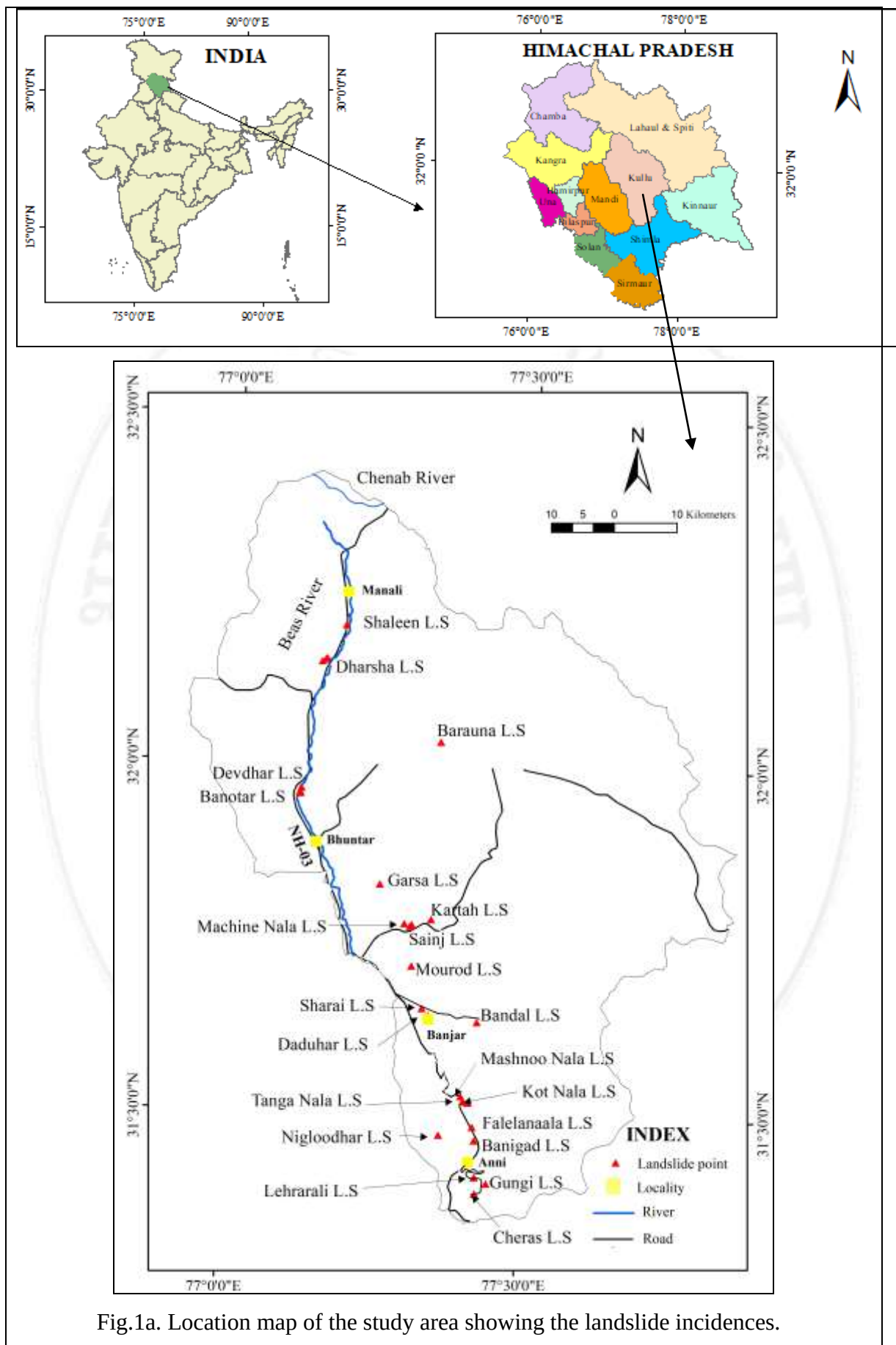
Landslides are rapid downward and outward movement of slope-forming materials, they displace material having well defined boundaries. Movement may take place by falling, sliding or flowing, or some combination of these factors (Bell 2007). The vulnerability in the geologically young and unstable steep slopes has increased due to anthropogenic activities such as road construction and widening, communication facilities, expansion of settlements and other allied developmental activities, deforestation and changes in agriculture pattern (Kahlon et. al., 2014).

Due to tectonically active region, the Geology of the Himachal Pradesh is generally fragile, Increase in population and rapid urbanization has led to the expansion of construction activities also the Himachal state particularly the Kullu district have witnesses a long spell of rain during the month of June and August 2023, which causes the slope forming material to be oversaturated and lack of proper drainage management are the major contributing factors of the landslide.

An incessant rainfall event during the month of July - August 2023 in and around the area of Kullu, Banjar, Anni and Manali Sub-Division, of Kullu district resulted in a series of slope failures/stability issues. In this regard the Deputy commissioner, Kullu District, Himachal Pradesh requested GSI, Chandigarh to carry out landslide studies vide letter no. 7142/SK(DM) dated 29<sup>th</sup> Aug. 2023. Accordingly, the authors of this report have carried out landslide studies in Kullu, Banjar, Manali and Anni Sub-Division from 30-08-2023 to 09-09-2023.

**2. a) LOCATION AND ACCESSABILITY:**

The study area falls in Kullu, Manali, Bandal, and Anni Sub division of Kullu District, Himachal Pradesh. The important road corridors are passing through the area include NH-3. Most of the villages in the area are well connected by metalled and non-metalled roads. The nearest broad gauge railway station is at Jogindar Nagar railway station and Bhuntar Airport in Kullu district is the nearest airport.

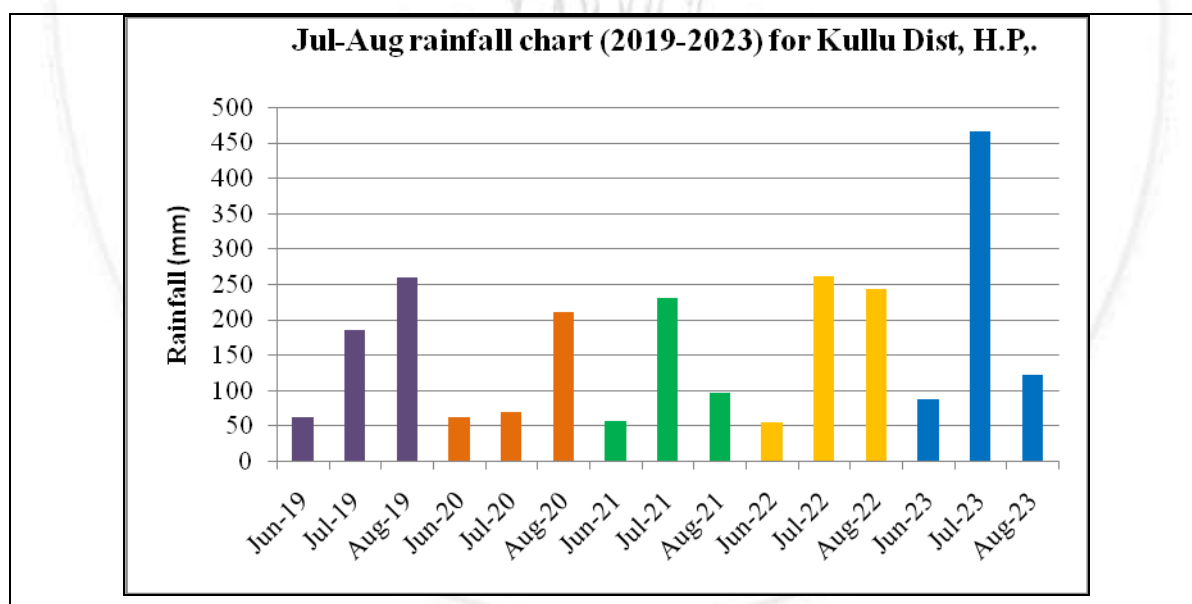


## 2.b)Rainfall;

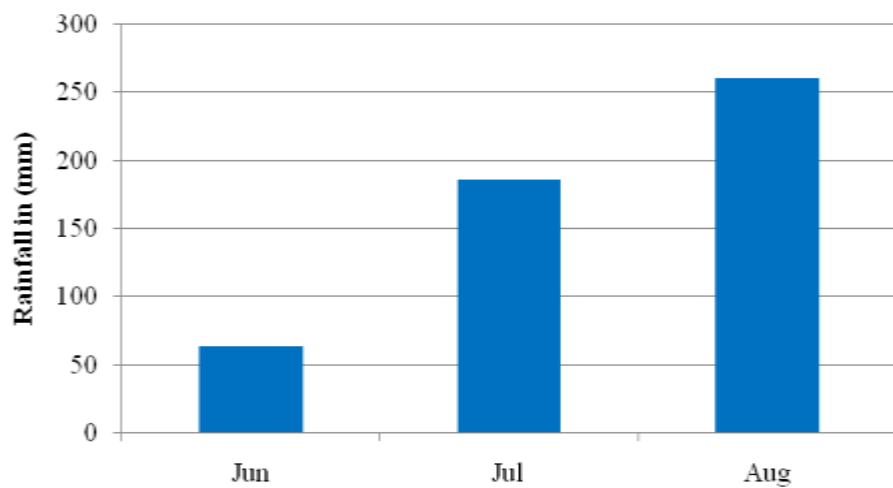
The rainfall data for the month of June-Aug from the year 2019-2023 is given in the Table.1, and Chart for rainfall data for the month of Jun-Aug from the year 2019- 2023. (Fig.1 b). From the table it can be inferred that during the past 5 years, the marginally positive departure of rainfall data was observed for the month of June 2023 and rainfall data for the month of July has drastically increased which reaches up to 467.2 mm. comparing to past 4 years data. This drastic increased of rainfall especially during the month of July -23 could be the major contribution/ triggering factors to the landslide incidences in Kullu district.

Table 1: Rainfall data for the month of Jun-Aug (2019-2023). Source <https://indiawaris.gov.in>.

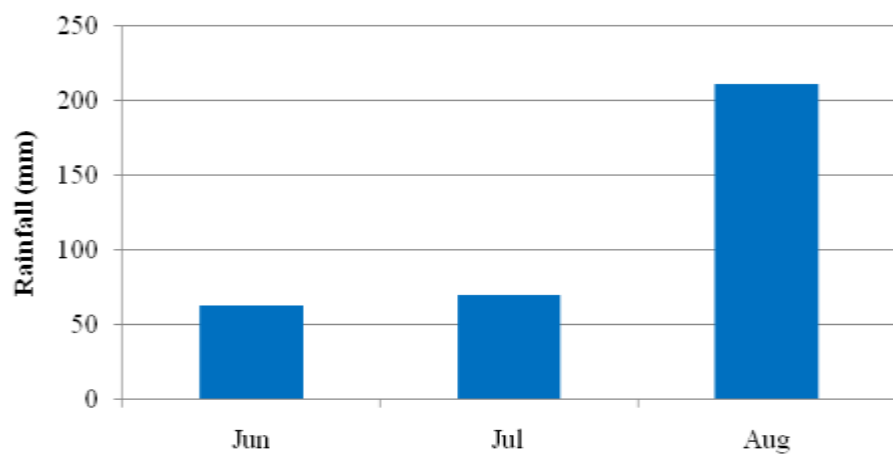
| Year | Rainfall data (mm) |        |        |
|------|--------------------|--------|--------|
|      | June               | July   | Aug    |
| 2019 | 62.98              | 185.76 | 259.43 |
| 2020 | 62.09              | 69.35  | 210.2  |
| 2021 | 57.57              | 231.27 | 97.04  |
| 2022 | 56.06              | 262.14 | 243.6  |
| 2023 | 87.87              | 467.2  | 122.46 |



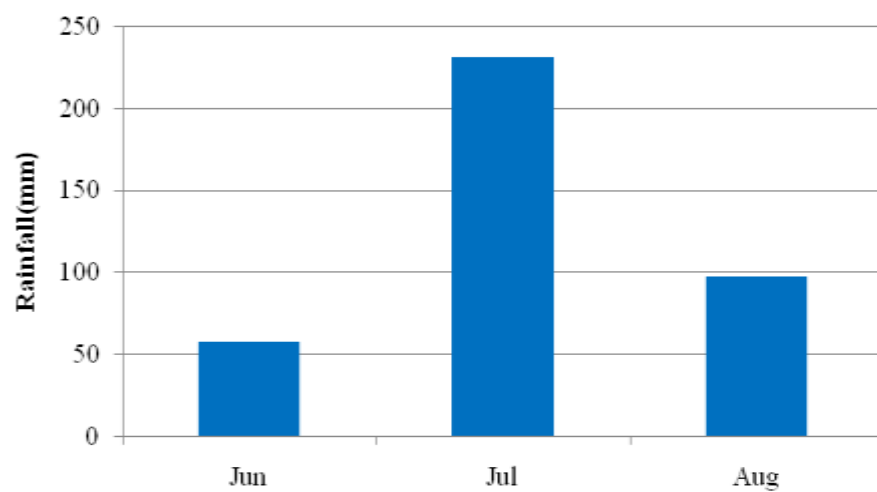
**2019- Jun-Aug Rainfall chart for Kullu Dist, H.P.,**

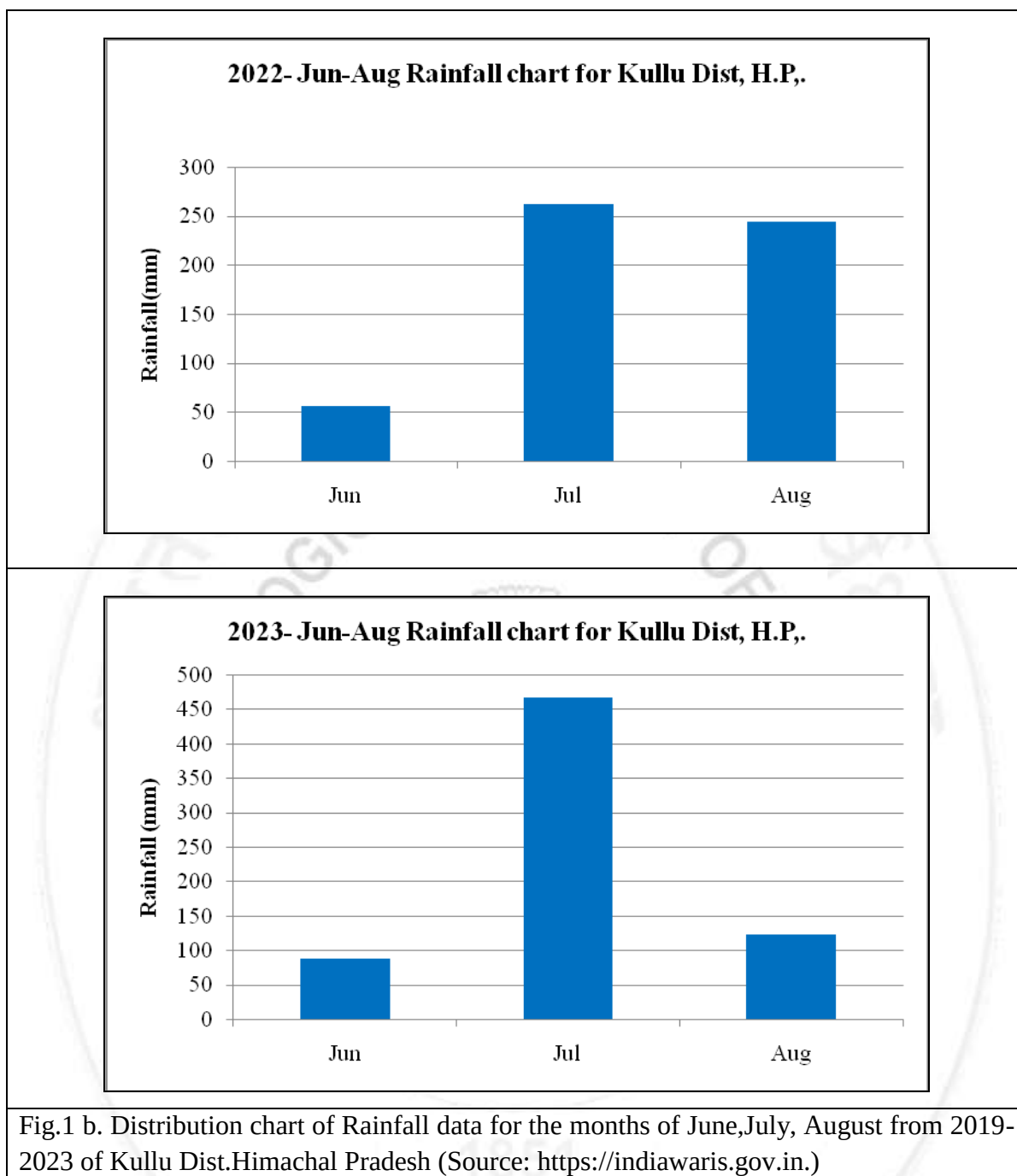


**2020- Jun-Aug Rainfall chart for Kullu Dist, H.P.,**



**2021- Jun-Aug Rainfall chart for Kullu Dist, H.P.,**





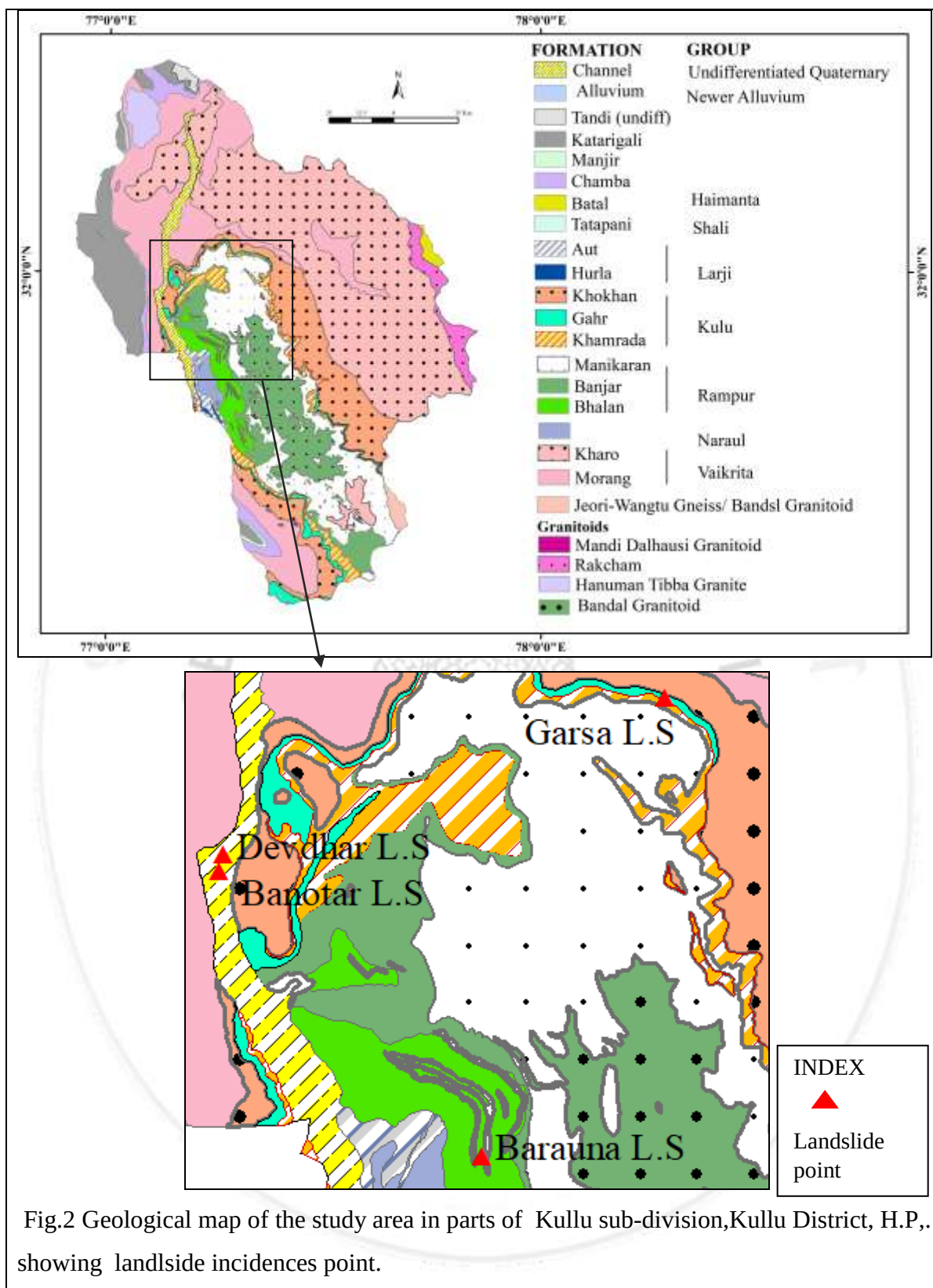
### 3. GEOLOGICAL SET UP OF THE STUDY AREA IN PARTS OF KULLU SUB-DIVISION, KULLU DISTRICT, H.P:

The study area falls in parts of SOI Toposheet nos. No. 53E/1, 53E/5 52H/04 and 52H/8, forming parts of lesser Himalayas. Geologically, the area exposes the rocks ranging in age from undifferentiated Proterozoic to Holocene represented by Vaikrita, Rampur, Kulu, Naural Larji Group, Bandal Granitoid and Quaternary deposit. (Fig.2)

Table-2 Generalized lithostratigraphy set up of the study area in parts of Kullu Sub-Div, Kullu Dist. H.P., (Geoinformatics Division, SU-PHHP, GSI (NR), Chandigarh.)

| Age                          | Group              | Formation        | Lithology                                                                                     |
|------------------------------|--------------------|------------------|-----------------------------------------------------------------------------------------------|
| Holocene                     | Undiff. Quaternary |                  | Grey fine to coarse sand with pebble and clay                                                 |
| Neo Proterozoic              |                    | Bandal Granitoid | Granitoid, gneiss, migmatite                                                                  |
| Meso-Proterozoic             | Larji              | Aut              | Grey dolomite, grey-purple limestone                                                          |
| Palaeo - Proterozoic         | Naural             |                  | Quartzite, phyllite                                                                           |
| Palaeo - Proterozoic         | Kulu               | Khokan           | Schist, quartzite.                                                                            |
|                              |                    | Gahr             | Streaky and banded gneiss                                                                     |
|                              |                    | Kharmada         | Carbonaceous slate, phyllite, limestone, quartzite                                            |
| Palaeo - Proterozoic         | Rampur             | Manikaram        | White-green quartzite, phyllite, basic flows                                                  |
|                              |                    | Banjar           | Schist, phyllite, quartzite                                                                   |
|                              |                    | Bhallan          | Phyllite, quartzite with basic flows                                                          |
| Undifferentiated Proterozoic | Vaikrita           | Morang           | Sillimanite - kyanie bearing schist, quartzite Sillimanite - kyanie bearing schist, quartzite |

The oldest rock unit is represented by Sillimanite - kyanie bearing schist, quartzite Sillimanite - kyanie bearing schist, quartzite of Morang Formation belonging to Vaikrita Group of Undifferentiated Proterozoic age. The Rampur Group is represented by Bhallan Formation ( Litho unit; Phyllite, quartzite with basic flows), Banjar Formation (Litho unit; Schist, phyllite, quartzite) and Manikaram Formation (Litho unit; White-green quartzite, phyllite, basic flows) of Paleo Proterozoic in age. The Kulu Group is represented by Kharmada Formation (Litho unit; Carbonaceous slate, phyllite, limestone, quartzite), Gahr Formation (Litho unit; Streaky and banded gneiss) and Khokan Formation (Litho unit; Schist, quartzite). The Naural Group of Paleo-Proterozoic in age is represented by litho units of Quartzite, phyllite. The Larji Group is represented by Aut Formation consisting of Grey dolomite, grey-purple limestone. The Bandal Granitoid of Neo Proterozoic in age is represented by Granitoid, gneiss and migmatite and Undiff. Quaternary deposit of Holocene in age is represented by Grey fine to coarse sand with pebble and clay.



### 3.1: LANDSLIDE INCIDENCES IN KULLU SUB-DIVISION, KULLU DISTRICT, H.P.

In Kullu Tehsil, the highly affected villages/area are Devdhar, Banontar, Garsa and Baraiuna-Patwar Circle Manikaran Jari. These villages/area are located on transportational mid slopes and colluvial foot slopes mainly consists of unconsolidated material having overburden thickness of ~5-8m. The hydrological conditions of the slope are damp.

#### 3.1.1: Devdhar Kharahal Village area:

The Devdhar Kharahal is located on hill slope at the left bank of Beas River. The village is nestled on the transportational mid slope with moderate vegetation cover having thick debris as over burden material. Several locations along this slope faces were affected with varying dimension of landslide for about ~1.5 km stretches along NH-3 and are witnesses as damaged in retention structures/walls, road caving and cracks on ground.(Fig 1)

##### 3.1.a: Devdhar subsidence:

- The Devdhar subsidence is located ( $31^{\circ}57'48.08''\text{N}$ ,  $77^{\circ}7'6.01''\text{E}$ ) on transportational mid slopes with moderately steep slope with 2-5m thick debris material as overburden. The debris are semi-consolidated to unconsolidated.
- Damaged on civil structures in the form of cracks on wall, retaining wall collapse, ground subsidence etc were observed. (Fig.3 and 4).
- Seasonal *nala* is observed on the right flank of the affected slope. Due to the side erosion of loose material by the *Nala* during incessant rainfall, instability signatures such as ground subsidence and tilting of trees is observed along the left flank/slope of the Nala/Khad. (Fig.5).
- The landslide is active and poses serious threat to civil structures present on the affected slope in case of further activating by extreme weather events.(Fig.5)
- No proper drainage management in the affected slope/area.



Fig.3; Damaged retaining walls towards the hill side along NH-3



Fig.4; Damaged house at Devdhar village.



Fig.5; Ground subsidence observed along the left flank/ slope of seasonal *Nala*



Fig.6; House at risk located upslope of NH-03 at Devdhar village.

**Causative factors:**

- Saturation of slope forming material from surface runoff water during incessant rainfall. (Ref. Table 2 and fig 1.b).
- Toe erosion by local *nala* present on the right flank of settlement.
- Natural slope disturbance by road cutting down slope.
- Disturbance in slope geometry by toe cutting for the road construction
- Lack of proper drainage management.

**Suggestions:**

- The unchannelized *nalas* and house hold sewage domestic water should be channelized systematically.
- Construct contour parallel drainage system in the upslope of the settlement.
- The damaged retaining wall along the hill side of NH-3 located down slope of the village should be repair/replaced with a provision of weep holes.
- Construction of appropriately designed guide walls is required along both the bank of *nala* located on the right flank of the affected area in consultation with design engineers to prevent further toe erosion and damage to civil structures present vicinity to it.
- Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone in consultation with Botanist/Forest dept.

**3.1.b: Indian oil Petrol Pump along NH-3:**

- It is a reactivated debris slide located on the left bank of Beas River ( $31^{\circ}57'28.81''$  N and  $77^{\circ}6'59.57''$  E) along moderately inclined hill slope with a general slope direction of  $\sim 38^{\circ}/N290^{\circ}$  (Fig.7).

- At the failure affected site, the slope forming material consists mainly of fine to coarse grained loose unconsolidated soil and no *in-situ* rock were exposed.
- The crown of the slide was observed along the local footpath connecting Devdhar to Banontar.(Fig.8). The dimension of the landslide is  $\pm 55\text{m}$  length and  $\pm 50\text{ m}$  width and are retrogressive in nature, dripping to flowing hydrological conditions (Fig.9).
- No drainage system was observed to be present in and around the distressed zone.
- A set of retaining walls constructed on the hill side of petrol pump were observed tilted and displaced due to retrogressive in nature and few ground cracks were also observed near the crown of the slide, which poses more risk to petrol pump/ downslope structures in case of uneven/extreme weather conditions.



Fig.7; Debris slide on upslope of Indian oil petrol pump.



Fig.8; Crown of the landslide.



Fig.9; Seepage zone in flowing water conditions along ground cracks in the distressed slope.

**Causative factors:**

- Concentration of pore water pressure in slope forming material due to damp and dripping hydrology condition coupled with further water saturation from surface runoff during incessant rainfall (Ref. Table 2 and fig 1.b).
- Disturbance of natural slope by road cutting and construction of petrol pump towards hill side leaving the slope steeper.
- Absence of proper drainage system on the upslope.

**Suggestions:**

- It is suggested to construct an appropriately designed lined drainage parallel to contour above the crown of the slide to avoid surface water discharge on the distressed slope.
- The source area responsible for dripping water along the distressed slope need to be identified and pipes should be installed at the seepage/source zone for proper drainage management on the slope.
- Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone in consultation with Botanist/Forest dept.
- Immediate filling of ground cracks with appropriate impervious material immediately.
- Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass in consultation with design Engineers.

**3.1.c: ~120 m south of Indian oil Petrol Pump:**

- It is a debris slide located ( $31^{\circ}57'24.56''\text{N}$ ,  $77^{\circ}6'58.79''\text{E}$ ) along moderately inclined hill slope with a general slope direction of  $\sim 40^{\circ}/\text{N}290^{\circ}$  on the left bank slope of Beas River (Fig.10).
- It was observed that the slope failure has taken place from a moderately inclined hill slope. The slope forming material consist of fined to coarse grained loose unconsolidated soil.
- At the time of field observations, the main scarp of the landslide is well exposed for about  $\sim 1\text{m}$ . The hydrology conditions of the slope is wet to flowing. (Fig.11).
- The affected slide has a dimension of  $\pm 35\text{m}$  length and  $\pm 40\text{m}$  width exhibiting retrogressive and widening in distribution.
- Retaining walls that were placed on the hill side of the NH-3 were observed to be damaged, partly tilted at places and the local foot path was completely wash out.

Apart from this traverse ground crack on the road was also observed (Fig.11 and 12)



Fig.10; Debris slide as discernable from the left bank of Beas River.



Fig.11; Main body of the landslide.



Fig.12; Damaged retention structures along the hill side of NH-3

#### **Causative factors:**

- In the present incidence, prima facie the slope failure does appear to be due to both anthropogenic and natural causes.
- Natural slope disturbances by way of steep excavation for road construction within unconsolidated debris material.
- Absence of proper drainage network in upslope and slope saturation due to excessive/ incessant rainfall spells in the area during June 2023 have drastically worsened the slope situation (Ref. Table 2 and fig 1.b)..

#### **Suggestions:**

- It is suggested to construct an appropriately designed lined drainage parallel to contour above the crown of the slide to avoid surface water discharge on the distressed slope.

- The source area responsible for dripping water along the distressed slope need to be identified and pipes should be installed at the seepage/source zone for proper drainage management on the slope.
- Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone in consultation with Botanist/Forest dept.
- Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass in consultation with design Engineers.

### 3.1.d: Banontar Kharahal.

- Banontar Kharahal subsidence is located ( $31^{\circ}57'20.23''\text{N}$ ,  $77^{\circ}6'59.42''\text{E}$ .) on the upslope of NH-3 along transported mid slope of loose unconsolidated debris material with a slope inclination and direction of  $35^{\circ}\text{N}280^{\circ}$ .
- A subsidence that has affected 2 Houses in the form of wall cracks, ground subsidence, tilting and sinking of retaining walls.(Fig.13 and 14)
- Other instability signatures such as tilting of trees (Fig.15), ground cracks ( $\text{N}020^{\circ}$ ) (Fig.14), damaged and tilted retaining walls were also observed (16).
- This subsidence is active and poses risk to the slope in case of extreme weather events.

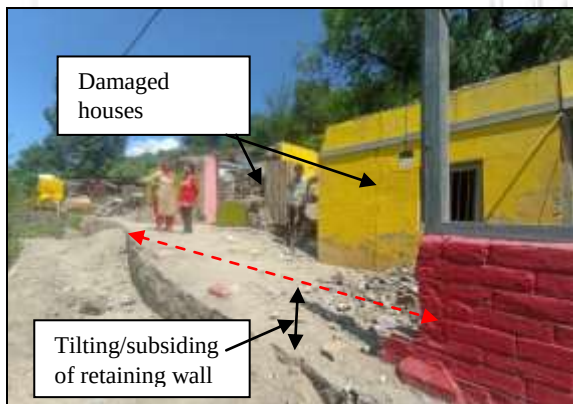


Fig.13; Damaged civil structures at Banontar Kharahal .



Fig.14; Ground cracks observed at Banontar Kharahal



Fig.15; Tilting of trees along the valley side of foot path.



Fig.16; Damage retaining structures along NH-3 downslope of Banontar Kharahal .

**Causative factors:**

- In the present incidence, prima facie the slope failure does appear to be both anthropogenic and natural causes. Natural slope disturbances by way of steep excavation for road construction within unconsolidated debris material, absence of proper drainage network in upslope and slope saturation due to excessive/incessant rainfall spells in the area have drastically worsened the slope situation (Ref. Table 2 and fig 1.b)..

**Suggestions:**

- It is suggested to construct an appropriately designed lined drainage parallel to contours upslope to avoid surface water discharge on the distressed slope.
- Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass in consultation with site and design Engineers.
- Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately.

**3.1.e: Garsa Landslide:**

- Garsa village landslide is located (31°49'42.82"N, 77°15'20.12"E) on a slope wash material of unconsolidated loose debris material along steeply inclined hill slope with a general slope direction of ~50°/N250° and presence of flowing *Nala* on the right flank of the affected slope (Fig.17).
- *In-situ* rock of Phyllite belonging to Kharmada Formation of Kulu Group is well exposed towards the right flank of *Nala* and down slope of distressed zone (Fig.17).
- The subsidence is active, retrogressive, widening in distribution with development of multiple crowns and damp to wet hydrological conditions.
- As per field observation, the main affected zone appears to be a part of landslide main body.
- During field visit/inspection it was observed that several houses were partially to fully damage in the form of cracks on walls and roof, lateral displacement of structures, ground cracks, tilting of houses and tilting of electric pole (Fig.18,19 and 20). A total nos. of 16 houses was damaged (as informed by local residence).
- The presence of seasonal *Nala* on the right flank of the slope have a huge impact on slope instability and civil structures present vicinity to it by means of excessive toe erosion.

- During field study no instability signatures were observed along and down slope of the link road that passes through the distressed slope.



Fig.17; Right flank of Garsa village affected slope.



Fig.18; Damaged house at Garsa village.



Fig.19; Ground cracks at Garsa village.



Fig.20; Tilting of electric pole located near seasonal *Nala* on the right flank of Garsa village.

#### Causative factors:

- The village is nestled on unconsolidated steep slope material. The incessant rainfall spells during the month of Jun-Aug 2023 lead to oversaturation of slope material (Ref. Table 2 and fig 1.b)..
- The hill slope is damp to wet due to presence of streamlets, Further infiltration during heavy rainfall induce the slope instability by increasing pore water pressure of the slope material and activating the streamlets and *nalas* trigger subsidence.
- Toe erosion by flowing *Nala* on the right flank of slope.
- Lack of drainage management on the slope.

#### Suggestions:

- It is suggested to construct an appropriately designed lined drainage parallel to contours on the distressed slope at multi level to avoid slope saturation.

- Appropriately designed retention structures at suitably identified locations at lower levels (in consultation with site Engineers) as support to failing mass.
- Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately.
- Avoid further loading, tampering of slope with heavy civil structures in/adjoining failure affected zone and in immediate vicinity of *nala* courses.
- Appropriately designed guide walls in consultation with design Engineers along the *nala* courses present on the right flank of the slope, to prevent further erosion and damage to civil structures present vicinity to it.

### **3.1.f: Barauna landslide:**

- Barauna village is located about 1.4 km North of Manikaram (32°2'4.73"N, 77°21'0.50"E) on transportation mid slope on the thick debris material. The debris is of semi-consolidated to unconsolidated.
- It is a debris slide that developed on 26 and 27 July 2023 after heavy and continuous precipitation.
- Morphometrically the Barauna landslide is located on steep slope 45°/N045° on the right bank of perennial Barauna *Nala*, a tributary of Parvati River. After landslide incidences, the slope becomes steeper during present field study (Fig.27).
- The local slope of Barauna village is characterised by steep slope on upper part exposing *in-situ* rock, gentle to moderate in mid slope where settlement exist and steeper in down slope where major slide took place. (Fig.28).
- It is a debris slide which is active in nature, widening and retrogressive in distribution, multiple style and the hydrological condition of the slope is damp.
- Prior to landslide incidences based on satellite imageries the land cover and land use pattern depict mostly sparse vegetation, plantation and orchard with scattered settlement. No sign of past landslide activities were observed.
- During field visit/inspection it was observed that several houses including Mandir were damaged and developed cracks on walls and roof, lateral displacement of structures, ground cracks, tilting of houses and foundation damaged. (Fig 21,22,23 and 25).
- Towards the right flank of the main slide area, several minor landslide incidences were also observed which has damaged the footpath completely that connect Manikaram- Barauna village and put several houses at risk (Fig.25 and 26).

- The slide is active and poses severe risk to life and properties that were present in immediate vicinity in the upslope near the crown of the landslide.



Fig.21; Crown of the slide along steep slope at Barauna village.



Fig.22; Mandir at risk located on the crown of the slide at Barauna village



Fig.23; Crack on civil structures at Barauna village



Fig.24; Tilting of houses at Barauna village.



Fig.25; Landslide on right flank slope of the Barauna village.



Fig.26 Footpath completely wash out/damaged due to landslide on right flank slope of Barauna village.

## Causative factors:

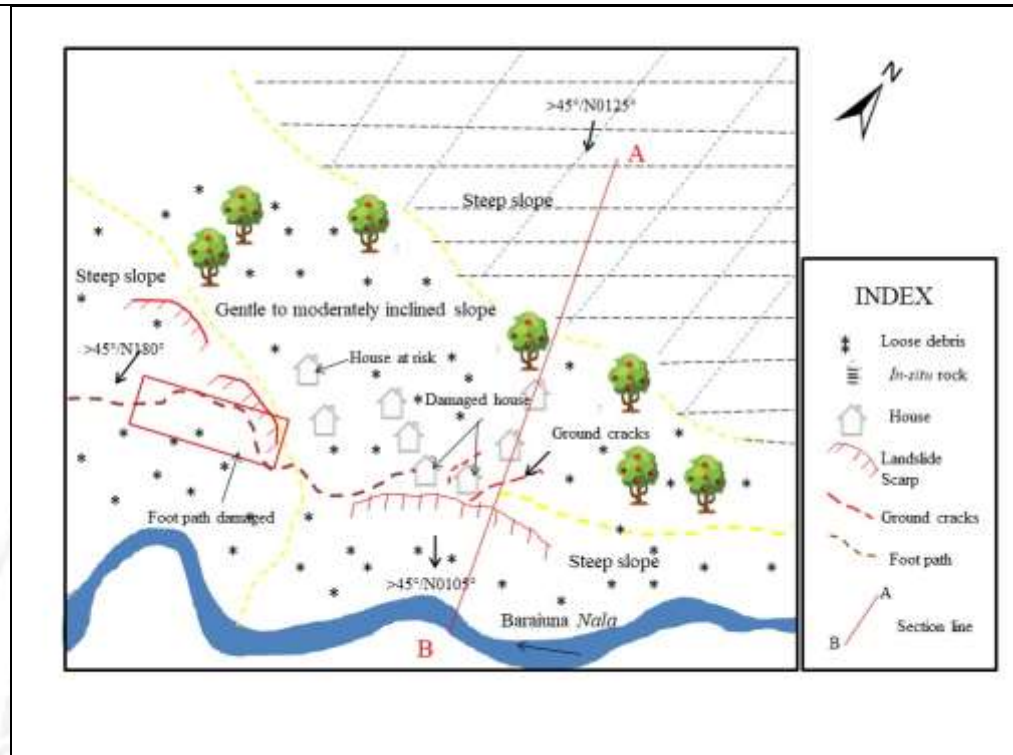


Fig. 27; Schematic diagram of the Baraiuna landslide

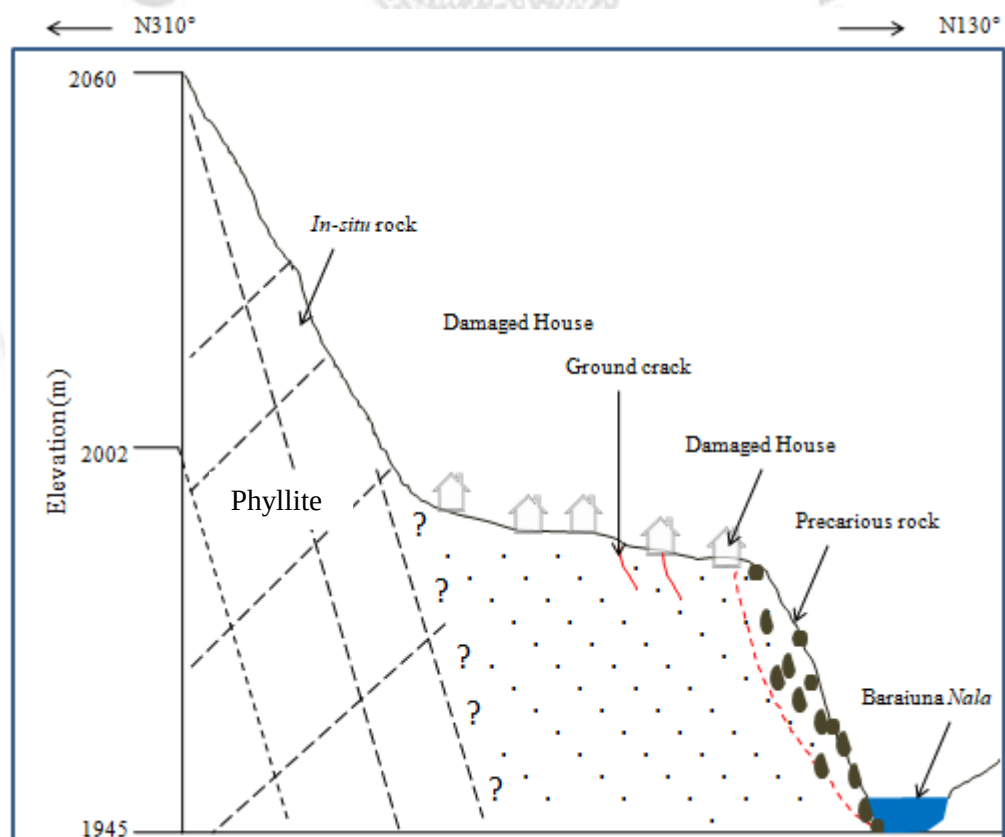


Fig.27 a. Cross section of Baraiuna landslide

- Absence of proper drainage network in the upslope part and slope saturation due to excessive/ incessant rainfall spells in the area during June-Aug 2023. (Ref. Table 2 and fig 1.b). along steep have drastically worsened the slope situation coupled with toe erosion by the Baraiuna *Nala*.

**Suggestions:**

- It is suggested to construct an appropriately designed lined drainage upslope to avoid surface water discharge on the distressed slope.
- Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass.
- The affected house located at the crown of the landslide need to vacate immediately.
- Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately.
- Avoid further loading, tampering of slope with heavy civil structures in adjoining failure affected zone.
- Appropriately designed guide walls along the bank of Baraiuna *nala* to prevent further toe erosion of slope.

#### 4. GEOLOGICAL SET UP OF THE STUDY AREA IN PARTS OF BANJAR SUB-DIVISION, KULLU DISTRICT, H.P:

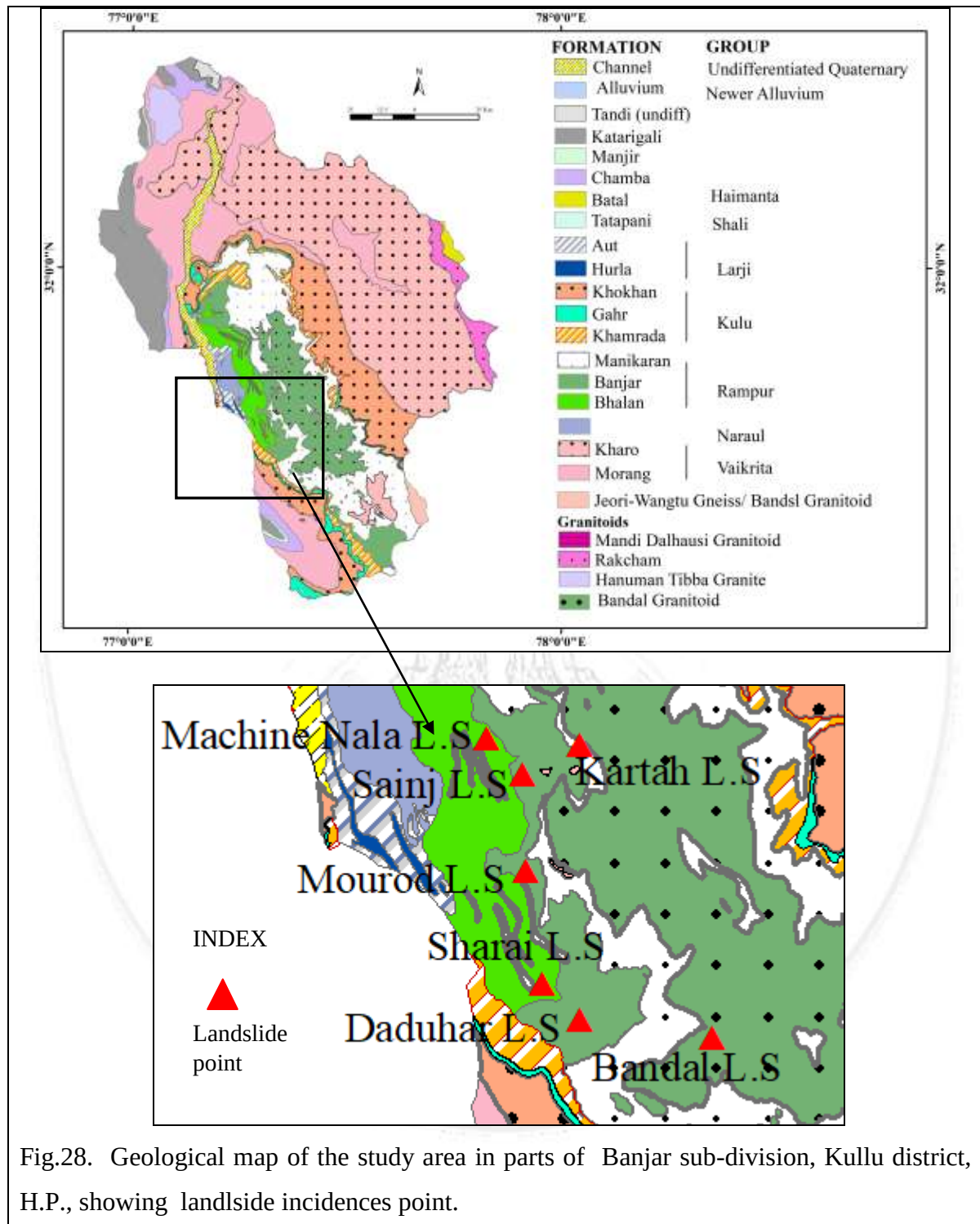
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Table-3. Generalized lithostratigraphy set up of the study area in parts of Kullu Sub-Div, Kullu Dist. H.P., (Geoinformatics Division, SU-PHHP, GSI (NR), Chandigarh.)

| Age                          | Group              | Formation        | Lithology                                                                                     |
|------------------------------|--------------------|------------------|-----------------------------------------------------------------------------------------------|
| Holocene                     | Undiff. Quaternary |                  | Grey fine to coarse sand with pebble and clay                                                 |
| Neo Proterozoic              |                    | Bandal Granitoid | Granitoid, gneiss, migmatite                                                                  |
| Meso-Proterozoic             | Larji              | Aut              | Grey dolomite, grey-purple limestone                                                          |
|                              |                    | Hurla            | Quartzite, shale, slate, limestone                                                            |
| Palaeo - Proterozoic         | Naural             |                  | Quartzite, phyllite                                                                           |
| Palaeo - Proterozoic         | Kulu               | Khokan           | Schist, quartzite.                                                                            |
|                              |                    | Gahr             | Streaky and banded gneiss                                                                     |
|                              |                    | Kharmada         | Carbonaceous slate, phyllite, limestone, quartzite                                            |
| Palaeo - Proterozoic         | Rampur             | Manikaram        | White-green quartzite, phyllite, basic flows                                                  |
|                              |                    | Banjar           | Schist, phyllite, quartzite                                                                   |
|                              |                    | Bhallan          | Phyllite, quartzite with basic flows                                                          |
| Undifferentiated Proterozoic | Vaikrita           | Morang           | Sillimanite - kyanie bearing schist, quartzite Sillimanite - kyanie bearing schist, quartzite |

The oldest rock unit is represented by Sillimanite - kyanie bearing schist, quartzite Sillimanite - kyanie bearing schist, quartzite of Morang Formation belonging to Vaikrita Group of Undifferentiated Proterozoic age. The Rampur Group is represented by Bhallan Formation ( Litho unit; Phyllite, quartzite with basic flows), Banjar Formation (Litho unit; Schist, phyllite, quartzite) and Manikaram Formation (Litho unit; White-green quartzite, phyllite, basic flows) of Paleo Proterozoic in age. The Kulu Group is represented by Kharmada Formation (Litho unit; Carbonaceous slate, phyllite, limestone, quartzite), Gahr Formation (Litho unit; Streaky and banded gneiss) and Khokan Formation (Litho unit; Schist, quartzite). The Naural Group of Paleo-Proterozoic in age is represented by litho units of Quartzite, phyllite. The Larji Group is represented by Hurla Formation consisting of Quartzite,

shale, slate, limestone and Aut Formation consisting of Grey dolomite, grey-purple limestone. The Bandal Granitoid of Neo Proterozoic in age is represented by Granitoid, gneiss and migmatite and Undiff. Quaternary deposit of Holocene in age is represented by Grey fine to coarse sand with pebble and clay.



#### **4.1: LANDSLIDE INCIDENCES IN BANJAR SUB-DIVISION, KULLU DISTRICT, H.P.**

In Banjar Tehsil, the main landslide villages/area are Bandal landslide, Machine *Nala* slide, road stretch from Thana Sainj to Taxi Stand, Sainj Landslide, Mourod subsidence, Daduhar slide, Kartah and Sharai subdidence. The slide is mostly located on slope wash material on moderate to steeply inclined hill slope.

##### **4.1.a: Bandal landslide:**

- Bandal landslide is located ( $31^{\circ}38'3.49''\text{N}$ ,  $77^{\circ}25'31.81''\text{E}$ ) to the left bank slope of Tirthan River along moderate to steeply inclined hill slope with a general slope direction of 45 to  $65^{\circ}/\text{N}030$ .
- It is a large debris slide with a dimension of  $\pm 350\text{m}$  length and  $\pm 250\text{ m}$  width. It is an active slide, deep translational failure, retrogressive in distribution and multiple and successive in nature.
- The slope forming material of the distressed zone/area consists mostly of loose unconsolidated debris material.
- *In-situ* rock of Gneiss belonging to Bandal Granitoid is exposed to the left flank of the distressed slope and no any major instability signatures were observed on the exposed *in-situ* rock at the site.
- The Hydrological conditions of the distressed slope are damp, wet and dripping at sporadic locations.
- At least three level of link road were passes along the distressed slope. Several severe instability signatures were observed along all the road level in the main distressed slope such as damages of retention structures (Fig.35), crack on civil structures, lateral ground displacement (Fig.30 and 32), damage houses, ground cracks (Fig.29), tilting of trees (Fig.34), uprooting and road subsidence for about 2-5 m mainly on topmost and middle road level (Fig.31).
- The instability signatures of landslide such as tilting of trees, minor landslides, has reach down to Tirthan River which poses risk to life and property present down the slope and especially to the school that was located to the left bank of the Tirthan River.



Fig.29; Ground cracks along the lower most road level at Bandal.



Fig.30 ; Damaged retaining wall towards valley side of lowermost road level.



Fig.31; Road subsidence observed along the middle road level at Bandal



Fig.32; Lateral displacement of civil structure located at the valley side of middle road level at Bandal.

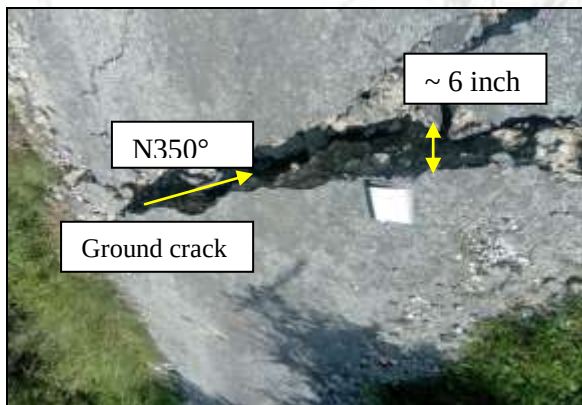


Fig.33; Ground cracks along middle road level



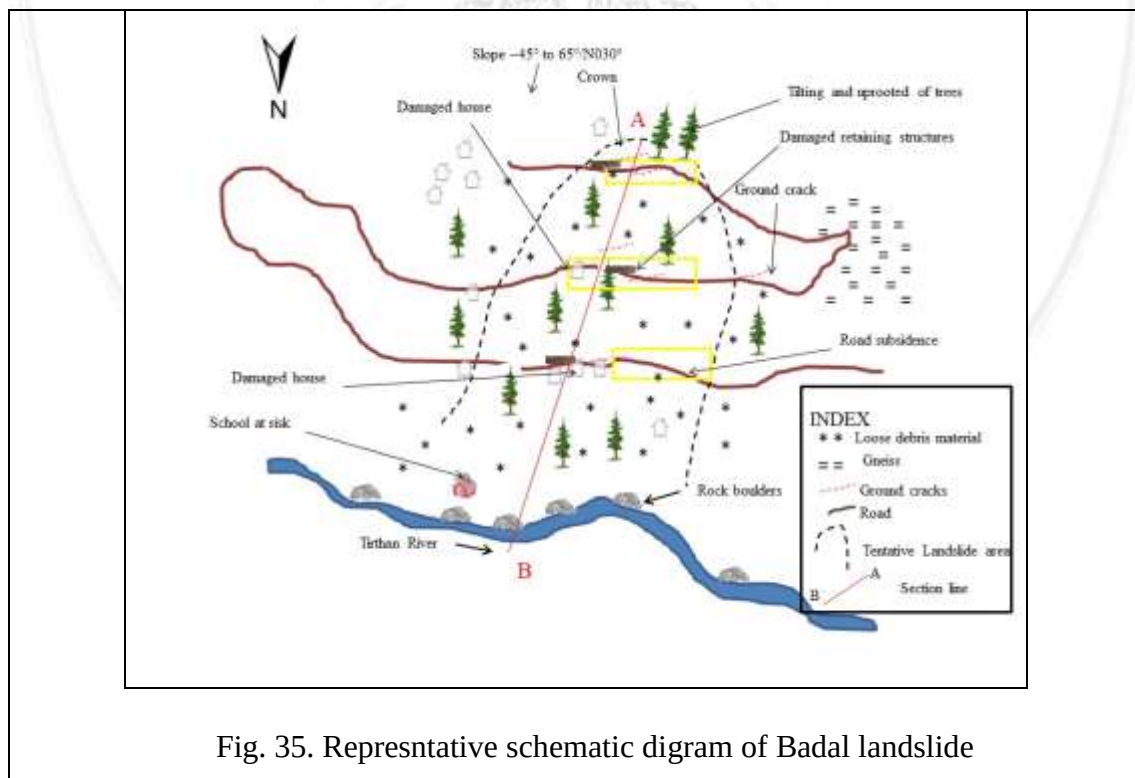
Fig.34; Tilting and uprooting of trees observed near the Scarp of the slide

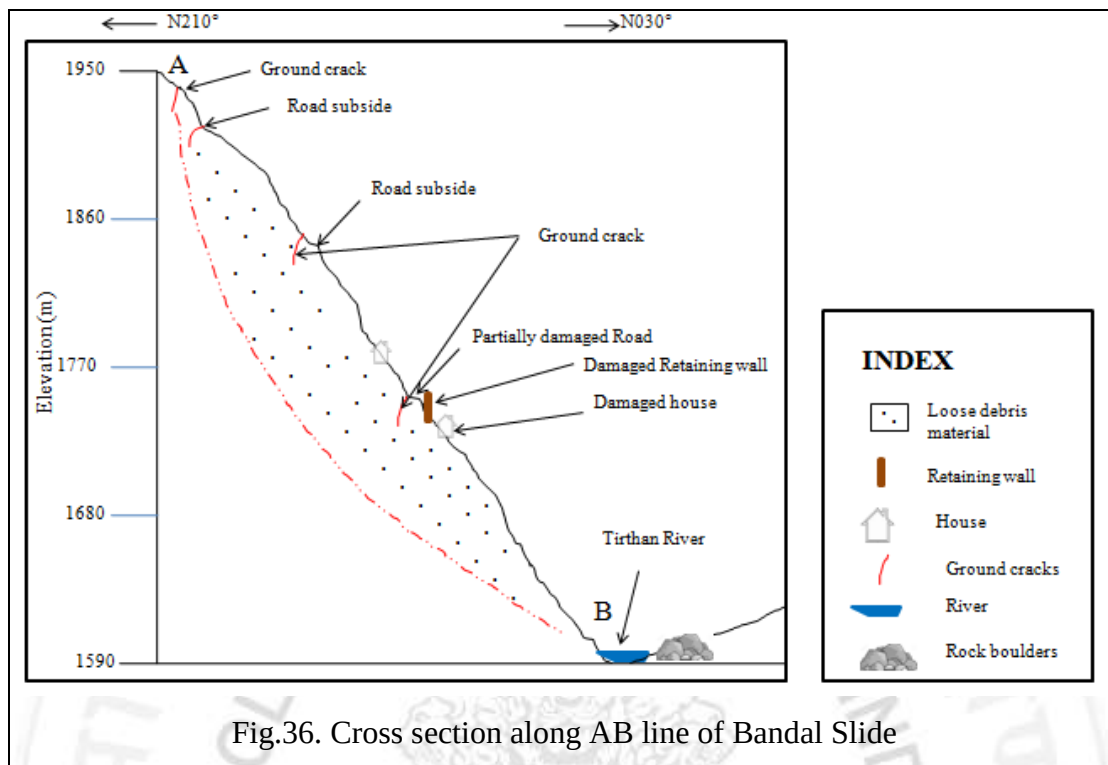
### Causative factor:

- Concentration of pore water pressure in debris due to damp and dripping hydrology condition of the slope.
- Saturation of slope forming material from surface runoff water during incessant rainfall along moderate to steeply inclined hill slope. (Ref. Table 2 and fig 1.b).
- Lack of proper drainage system in upslope.

### Suggestions:

- It is suggested to construct an appropriately designed channelized lined drainage to avoid surface water discharge on the distressed slope.
- Appropriately designed retention structures in consultation with design Engineers along the hill and valley side of road with a provision of weep holes and hill side drainage.
- Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately.
- Avoid further loading, tampering of slope with heavy civil structures in/adjoining failure affected zone.
- Based on the dimension of the slide, the importance of the affected road and houses located at the slide zone a detailed site specific study is recommended.





#### 4.1.b: Machine *Nala* slide:

- Machine *nala* slide is located ( $31^{\circ}46'21.80''N$ ,  $77^{\circ}17'54.82''E$ ) to the right bank slope of Parvati river along moderate to steeply inclined hill slope with a general slope inclination and direction of  $60^{\circ}/N160$ . (Fig.37)
- It is a shallow translation debris slide with a dimension of  $\pm 130m$  length and  $\pm 100m$  width. It is an active slide, retrogressive in distribution and single style.
- The Hydrological conditions of the distressed slope are damp and wet. Seasonal *nala* was observed just to the right flank of the slide and Parvati River is flowing down the slope/toe of the slide.
- No major casualties were reported from the affected site during field visit except road damaged (Fig.38) (informed by local residence and Tehsildar). However few houses are observed to be present on upslope/near the crown of the slide where traverse ground cracks (Fig.39) were present which may pose risk to settlement in case of extreme weather conditions.
- Construction of retaining wall towards hill side along road level is in progress.



Fig.37; Machine *Nala* slide as discernable from the opposite slope of Parvati River.



Fig.38; Road subsidence along Machine *Nala* landslide.



Fig.39; Traverse ground crack on the right flank of landslide.

**Causative factor:**

- Saturation of slope forming material from surface runoff water during incessant rainfall along moderate to steeply inclined hill slope. (Ref. Table 2 and fig 1.b).
- Toe erosion by Parvati River/Sainj River.
- Lack of proper drainage system in upslope.

**Suggestions:**

- It is suggested to construct an appropriately designed contour parallel channelized lined drainage above crown of the slide to avoid ingress of surface water in the distressed slope.
- Appropriately designed retention structures along the hill and valley side of road with a provision of weep holes and hill side drainage.
- Immediate filling of ground cracks/tension cracks (Fig.39) with appropriate impervious material.
- Avoid further loading, tampering of slope in the adjoining failure affected zone.

- Appropriately designed guide walls along the bank of Parvati River to prevent further toe erosion of the slope.

#### 4.1.c: Thana Sainj to Taxi Stand road stretch:

- The road of about ~1km stretch from Thana Sainj to Taxi Stand was adversely affected, which is located along the left bank of Parvati River ( $31^{\circ}46'18.55''\text{N}$ ,  $77^{\circ}18'46.78''\text{E}$ )
- The affected road stretch was observed to be constructed on loose unconsolidated debris and river bone material along steep slope on left bank of River.
- Several portion of the said road stretch was observed to be subsiding, cave out and development of ground cracks (Fig.40 and 41) due to excessive toe erosion on loose material located on the left bank of the river. However, the right /opposite bank of the river was observed to be least affected due to presence sound and *in-situ* rock exposure.
- Few houses that are constructed on valley side of affected road/very close to the river bank along steep slope ( $45^{\circ}/\text{N}005^{\circ}$ ) were found to be damaged and also poses risk to further damaged in case of uneven/extreme weather conditions (Fig.41).
- The entire affected stretch is observed to be damp, having dripping and flowing hydrological conditions (Fig.42).



Fig.40; Severe road damaged near Thana Sainj.



Fig.41; Ground cracks and House at risk located towards valley side of the road along Thana Sainj to Taxi stand road stretch.



Fig.42 Flowing hydrological conditions along the hill side of the road stretch.

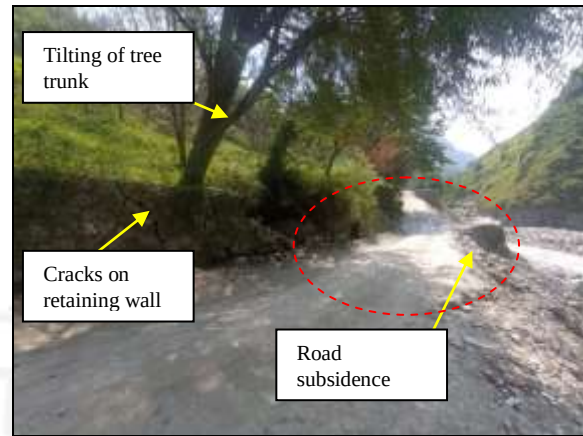


Fig.43; Main subsidence zone at (31°46'18.34"N, 77°18'39.95"E) along Thana Sainj to Taxi stand road stretch.

- At location (31°46'18.34"N, 77°18'39.95"E) a major subsidence zone of about  $\pm 80$  m length and  $\pm 75$  m width was observed on the said affected road stretch (Fig.43). The entire distressed zone at this location is characterised by moderate vegetation cover with a hydrological conditions of damp to dripping.
- The road stretch of about 75m in this zone is observed to be subsiding for about 5-10m. The hill side and valley side retention wall are found to be bulged and damaged along with tilting of trees were observed (Fig.43).
- Few settlements were nestled upslope of the affected zone along moderately inclined hill slope with a general slope direction of  $\sim 40^\circ/\text{N}340^\circ$  poses risk to further damaged to the existing structures if left untreated with suitable remedial measures.

#### **Causative factor:**

- Saturation of slope forming material from surface runoff water during incessant rainfall along steeply inclined hill slope. (Ref. Table 2 and fig 1.b).
- Toe erosion by Parvati River.
- Lack of proper drainage system.

#### **Suggestions:**

- It is suggested to construct an appropriately designed drainage network to avoid surface water discharge on the distressed slope.
- Immediate filling of ground cracks/tension cracks with appropriate impervious material.
- Appropriately designed guide structures for toe support along Parvati River.
- Identified the seepage point and channelized the flowing water nearest to natural *Nala/ Khad* to avoid further slope saturation.

- Avoid further loading/construction of any heavy structures towards valley side of the road along this affected stretch.
- Appropriately designed retention structures along the hill and valley side of the major road subsidence zone with a provision of weep holes and hill side drainage.

#### 4.1.d: Sainj Landslide:

- Sainj landslide ( $31^{\circ}46'8.77''\text{N}$ ,  $77^{\circ}18'29.22''\text{E}$ ) is located on the left bank of Sainj River along moderately inclined hill slope with a general slope direction of  $\sim 35^{\circ}/\text{N}350^{\circ}$  of loose unconsolidated to semi consolidated material (Fig.44).
- It is a shallow rotational debris slide, active, retrogressive and enlarging in distribution and single crown with an approximate dimension of  $\pm 70$  m length and  $\pm 85$  m width.
- A total 49 houses were damaged (informed by local residences) and most severely affected area was observed at the main market.
- Due to excess water discharge/flow the houses that were constructed on low lying area along both the bank of river are found to be damaged due to excessive side ward erosion.(Fig.45 and 46) Also several houses located downstream of the landslide are observed to be damaged.
- It is observed that the dumping site (Fig.47) was present (approximately 1.2 km) upstream to the landslide point. During incessant rainfall, the rise of river water level coupled with higher flow velocity eroded the dump material leading more damaged to the civil structures and river bank downstream in the form of attrition and abrasion.



Fig.44; Main landslide affected area at Sainj market,

Fig.45; Houses at risk located at the right bank of the river opposite to Sainj Market



Fig.46; House at risk at Sainj (left bank of the river)



Fig.47; Dumping site (located upstream of Sainj town)

#### **Causative factors:**

- Saturation of slope forming material from upslope surface runoff water during incessant rainfall along moderately inclined hill slope. (Ref. Table 2 and fig 1.b).
- Toe erosion by Parvati River.

#### **Suggestions:**

- It is suggested to construct an appropriately designed contour parallel drainage above the crown of the main slide to avoid surface water discharge on the distressed slope.
- Appropriately designed guide wall for toe support along both the bank of Parvati River in consultation with Engineers for design and dimension.
- Avoid further construction of any civil structures vicinity to both the banks the river.
- It is best to vacate the houses whose pillar foundation are affected as it poses risk to life and property in case of uneven/extreme weather conditions.

#### **4.1.e: Mourod subsidence:**

- Mourod subsidence ( $31^{\circ}42'44.05''\text{N}$ ,  $77^{\circ}18'46.49''\text{E}$ ) is located along moderately inclined hill slope of slope wash material of loose unconsolidated to semi consolidated debris material.
- The general slope of Mourod subsidence valley side face is moderate to steep i.e.  $35^{\circ}$  to  $60^{\circ}$  towards  $\text{N}110^{\circ}$ .
- The land use land cover of the subsidence zone is characterised by moderately vegetation cover and plantation.
- Hydrologically the distressed zone is damp to flowing.

- Instability signatures such as minor ground cracks, partially damaged foot path, partially damaged house, ground subsidence on plantation land were observed (Fig.48,49 and 50).
- The subsidence is active and poses serious threat to some houses (Fig.51) if further activating in the event of external trigger by rainfall/earthquake unless adequate slope protection measure is given.



Fig.48; Ground cracks and partially damaged retaining wall.



Fig.49; Ground subsidence.



Fig.50: Houses at risk.



Fig.51; partially damaged houses Mourod

#### **Causative factors:**

- Saturation of slope forming material from upslope surface runoff water during incessant rainfall. (Ref. Table 2 and fig 1.b).
- Toe erosion by *nala* and lack of drainage network.

#### **Suggestions:**

- It is suggested to construct an appropriately designed drainage network where ever applicable to avoid excess surface water/domestic water discharge on the distressed slope.

- Appropriately designed guide structures for toe support and toe erosion prevention along the bank of flowing *nala*.
- Avoid construction of any heavy civil structures on the distressed slope.
- Immediate filling of ground cracks/tension cracks with appropriate impervious material.

#### 4.1.f: Daduhar ward No.1:

- Daduhar landside is located ( $31^{\circ}38'31.20''\text{N}$ ,  $77^{\circ}20'35.88''\text{E}$ ) to the right bank slope of Rabhi *Khad* along moderately inclined hill slope with a general slope direction of  $30^{\circ}/\text{N}290^{\circ}$ . (Fig.52)
- It is an active debris slide with a dimension of  $\pm 100\text{m}$  length and  $\pm 150\text{ m}$  width, Shallow translational failure, retrogressive in distribution and single crown.
- The slope forming material of the distressed zone/area consists mostly of loose to semi loose unconsolidated debris material.
- The Hydrological conditions of the distressed slope are damp, wet and dripping at sporadic locations (Fig.54) and no proper channelized drainage system were present in and around the affected area.
- It is observed that due to debris slide down the slope, the NH-305 road stretch of around  $\sim 40\text{ m}$  present just above the upslope of landslide has been subside for about  $\sim 5\text{m}$  (Fig.55).
- As per information (received from local residence , SDM Banjar and field observation) a total 5 nos. of houses were damaged including Sarswati Vidya Mandir Sr.Sec, School located on the affected zone/slope. (Fig.53)



Fig.52; Daduhar slide as discernable from the opposite slope.



Fig.53; Damaged Sarswati Vidya Mandir Sr.Sec, School at Daduhar.



Fig.54; Dripping hydrological conditions on the distressed slope. Fig.55; Damaged road stretch at Daduhar.

**Causative factors:**

- Increase of pore water pressure in debris due damp and dripping hydrology condition of the slope.
- Saturation of slope forming material from surface runoff water during incessant rainfall along moderate inclined hill slope. (Ref. Table 2 and fig 1.b).
- Lack of proper drainage system in upslope and Toe erosion by Rabhi *Khad* down slope.

**Suggestions:**

- It is suggested to construct an appropriately designed contour parallel drainage along hill ward side of road level to avoid excess surface water/domestic water discharge on the distressed slope.
- Construction of adequate retaining walls towards the valley side of the road with a provision of weep holes and installation of culvert at suitable location.
- Appropriately designed guide structures for toe support and toe erosion prevention along the bank of flowing *nala*.
- Avoid any further construction of civil structures on the distressed slope.
- Immediately vacate the affected houses/school present on the distressed slope as the slide is still active and poses threat to live and properties in case of any extreme weather conditions.

**4.1.g: Kartah subsidence:**

- Kartah subsidence is located ( $31^{\circ}46'47.28''N$ ,  $77^{\circ}20'35.20''E$ ) to the left bank slope of Sainj River along gentle-moderately inclined hill slope with a general slope direction of  $15^{\circ}$  to  $40^{\circ}/N065^{\circ}$ .

- The affected area/settlement is located very close to the river bank on a slope wash material of unconsolidated loose debris material (Fig.56).
- The hydrological conditions of the distressed slope are damp, wet, dripping and flowing at sporadic locations and no proper channelized drainage system were present in and around the affected area.(Fig.58)
- Instability signatures such as ground cracks along road (N300°), cracks on wall lateral displacement on wall, road subsidence for about 0.5 m were observed (Fig.59).
- During field study it is observed that, the affected civil structures are mostly located towards the valley side of Siund-Neuli road (Fig.58) and upslope are least affected. However, the upslope also poses risk to life and property if the adequate remedial measure is not given.



Fig.56; Damaged houses towards the valley side of the slide at Kartah.



Fig.57; Damaged houses located near the bank of River at Kartah.



Fig.58; Road subsidence at Kartah



Fig.59; Cracks on walls at Kartah.

**Causative factors:**

- Increase of pore water pressure in debris due damp and dripping hydrology condition of the slope
- Excessive Toe erosion by Sainj River during incessant rainfall (Ref. Table 2 and fig 1.b).and lack of proper drainage system is found to be the main triggering factors.

**Suggestions:**

- Construction of appropriately designed guide structures for toe support and toe erosion prevention along the bank of the river.
- Construction of adequate retaining walls towards the hill side of the road with a provision of weep holes, hill side drainage and installation of culvert at suitable location.
- Identification of seepages/dripping point and channelized the water away from distresses slope to prevent further slope saturation.
- Immediate filling of ground cracks/tension cracks with appropriate impervious material.
- Avoid any further construction of civil structures towards the valley side of the road.

**4.1.h: Sharai subsidence:**

- Sharai subsidence (31°39'7.20"N 77°19'56.64"E) is located to the right bank of Tirthan River along steeply inclined hill slope with a general slope direction of 55 °/N245°.
- The affected area has a dimension of ±55 m length and ±35 m width having damp hydrological conditions.
- The slope forming material of the affected area composed mainly of unconsolidated-semi consolidated loose debris material.
- The road subside for about ~5m (Fig.60) and ground subsidence below road level were observed.(Fig 61) on the distresses slope. Also few houses were badly affected located along the affected slope (Fig.62).



Fig.60; Road subsidence at Sharai



Fig.61; Ground subsidence below road at Sharai



Fig.62; Damaged house present on the affected slope at Sharai.

#### **Causative factors:**

- Increase of pore water pressure due to saturation of slope forming material along steep slope from upslope surface runoff water during incessant rainfall and toe erosion by Tirthan River. (Ref. Table 2 and fig 1.b).

#### **Suggestions:**

- Construction of appropriately designed guide structures for toe support and toe erosion prevention along the bank of the river.
- Construction of adequate retaining walls towards the hill side of the road with a provision of weep holes, hill side drainage and installation of culvert at suitable location.
- Immediate filling of ground cracks/tension cracks with appropriate impervious material.
- Avoid further slope saturation on distressed slope by constructing adequate drainage network on the upslope.

- The pillar foundation of one house is observed to be cave out completely , located on the valley side of road need to be vacate immediately (Fig.62).

## 5. GEOLOGICAL SET UP OF THE STUDY AREA IN PARTS OF ANNI SUB-DIVISION, KULLU DISTRICT, H.P:

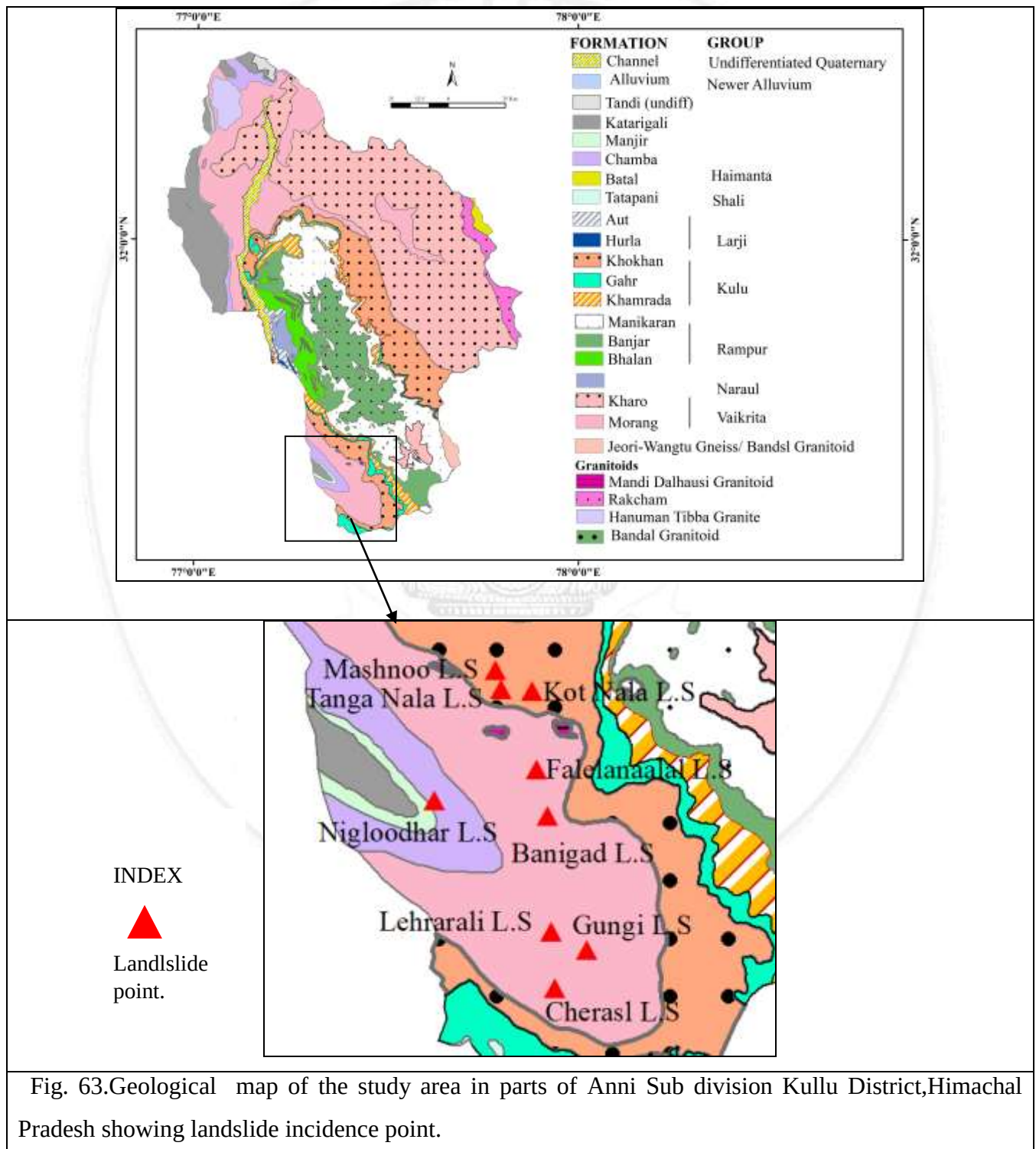
The study area falls in parts of SOI Toposheet nos. No. 53E/6, 53E/7, 53E/10 and 53E/11, forming parts of lesser Himalayas. Geologically, the area exposes the rocks ranging in age from undifferentiated Proterozoic to Paleozoic represented by Vaikrita, Rampur, Kulu, Shali Group, Katarigali, Manjir Formation and Mandi Dalhausi Granitoid. (Fig.63)

Table-4. Generalized lithostratigraphy set up of the study area in parts of Anni Sub-Div, Kullu Dist. H.P., (Geoinformatics Division, SU-PHHP, GSI (NR), Chandigarh.)

| Age                          | Group    | Formation                | Lithology                                                                                     |
|------------------------------|----------|--------------------------|-----------------------------------------------------------------------------------------------|
| Paleozoic                    |          | Mandi Dalhausi Granitoid | Leucocratic granite, aplite, quartz veins.                                                    |
| Neo- Proterozoic             |          | Katarigali               | Slate, Phyllite, Quartzarenitr, limestone, metabasics.                                        |
|                              |          | Manjir                   | Diamictite, shale, slate, sandstone, limestone                                                |
| Meso-Proterozoic             | Shali    | Tattapani                | Pink, grey dolomite, phyllite, shale.                                                         |
| Palaeo - Proterozoic         | Kulu     | Khokan                   | Schist, quartzite.                                                                            |
|                              |          | Gahr                     | Streaky and banded gneiss                                                                     |
|                              |          | Kharmada                 | Carbonaceous slate, phyllite, limestone, quartzite                                            |
| Palaeo - Proterozoic         | Rampur   | Manikaram                | White-green quartzite, phyllite, basic flows                                                  |
|                              |          | Banjar                   | Schist, phyllite, quartzite                                                                   |
| Undifferentiated Proterozoic | Vaikrita | Chamba                   | Carbonaceous slate, phyllite, quartzite.                                                      |
|                              |          | Morang                   | Sillimanite - kyanie bearing schist, quartzite Sillimanite - kyanie bearing schist, quartzite |

The oldest rock unit is represented by Morang Formation consisting of Sillimanite - kyanie bearing schist, quartzite Sillimanite - kyanie bearing schist, quartzite and Chamba Formation consisting of Carbonaceous slate, phyllite, quartzite belonging to Vaikrita Group of Undifferentiated Proterozoic age. The Rampur Group is represented by Banjar Formation (Litho unit; Schist, phyllite, quartzite) and Manikaram Formation (Litho unit; White-green quartzite, phyllite, basic flows) of Paleo Proterozoic in age. The Kulu Group is represented by Kharmada Formation (Litho unit; Carbonaceous slate, phyllite,

limestone, quartzite), Gahr Formation(Litho unit; Streaky and banded gneiss) and Khokan Formation (Lithounit; Schist, quartzite). The Shali Group is represented by Tattapani Formation of Meso-Proterozoic in age is represented by litho units of Pink, grey dolomite, phyllite, shale. The Manjir Formation consist of Diamictite, shale, slate, sandstone, limestone and Kataragali Formation consists of Slate, Phyllite, Quartzarenitr, limestone,metabasics represent Neo Proterozoic in Age. The Mandi Dalhausi Granitoid of Paleozoic in age consists essentially of Leucocratic granite, aplite, quartz veins.



## 5.1. LANDSLIDE INCIDENCES IN ANNI SUB DIVISION, KULLU DISTRICT, H.P.

In Anni Tehsil, the most vulnerable and hazardous sites are Nigloodhar, Gungi, and Chehva. These villages are situated on steep slopes having 5-8m thick semi-consolidated, damp colluvium and 2-5m thick slope wash material. Besides these slides, other slides like Lehrarali, Mashnoo nala, Kot nala, Falela nala, and Bainagarh slides are also major debris slides observed in this sub-division.

### 5.1.1. Nigloodhar Village landslide:

- Nigloodhar Village ( $31^{\circ}28'16.16''\text{N}$ ,  $77^{\circ}22'1.63''\text{E}$ ) is located on semi consolidated debris of slope wash material along steeply inclined hill slope ( $65^{\circ}$ - $70^{\circ}$ /N $270^{\circ}$ ).
- It is observed that 3 houses were completely damaged by run out material from upslope debris slide leading to loss of life to 3 persons. (Fig.64.a)
- The side was triggered by incessant rainfall during the early morning of 14<sup>th</sup> August 2023.
- The hydrological conditions of the affected slope is characterised by damp to dripping.



Fig. 64.a; Google image showing the Nigloodhar slide located along steep slope.

- Addition to this, No. of debris slides were observed to be occurred in the adjoining areas. Most of the slide are taken place along the course of seasonal nala that has partially affected houses.
- The debris slide in Rageli ( $31^{\circ}28'11.10''\text{N}$ ,  $77^{\circ}22'00.1''\text{E}$ ) at elevation EL 1727m with approximate dimension of 145m in length, 80m width with 180m run out zone which touches the river portion (Fig.64).
- A flowing river is observed on the toe portion of the slide.
- Seasonal nalas, rills and crop lands are present along the distressed slope.
- A debris slide has also been observed on the same date 14th August, 2023 in Dharta village ( $31^{\circ}28'22.8''\text{N}$ ,  $77^{\circ}22'03.8''\text{E}$ ) at elevation EL 1706m comes in Nigloodhar Panchayat (Fig.65).
- The slide is 100m in length, 25m in width with 45m height.
- Multiple tension cracks of 1-3m deep, 5-6m long are developed at sporadic location along the affected zone.
- The buildings/houses located near the nalas/bounded by nalas are mostly affected by the debris slide material and rill erosion.
- The whole hill slope comprises a thick semi-consolidated debris materials dissected by small rills. The hydrological conditions of the affected zone is wet and damp.
- All of these slides are subjected to ground subsidence due to deep rotational failure.

**Causative Factors: -**

- Main cause for these landslides appear to be due to saturation of slope forming material along steep slope during heavy rainfall/ precipitation (Ref. Table 2 and fig 1.b)
- Presence of several dry Nalas along the slope was reactivated during heavy rainfall and erode the loose material present along the Nala course.
- Lack of drainage management in the entire slope.



Fig. 64. Flowing nala observed near the Rageli slide



Fig.65. Crown portion observed in the Dharta village slide

#### Suggestions:-

- Scaling of loose debris in the upslope (Unloading of the crown portion).
- Channelization of nala/ domestic waste water. They shall be aligned with lining and taken away from the slid affected zone.
- Slope dressing: Benches/berms of suitable heights and width shall be provided at intermediate levels with gabions support and toe drains/ditches away from the main slope to collect, carry and drain the seepage water away from the slide area.
- The wide-open tension cracks shall be treated / sealed/filled with impervious material.

#### 5.1.2. Gungi Slide:-

- Gungi village ( $31^{\circ}24'12.8''\text{N}$ ,  $77^{\circ}26'51.0''\text{E}$ ) is 0.1sq.km from the MDR Dalash-Shahidar Gungi link road situated on the transportational mid slope at  $\text{EL}\pm 1929\text{m}$ . This debris slide is activated during heavy rainfall period from 08/07/2023 to 10/07/2023. It is reactivated again on 18/07/2023 on 3.30pm.
- From the field work it is identified as an active, shallow translational failure, retrogressive, widening in nature.
- The slide with an approximate dimension of 170m in length, 65 in width and 60m run out zone.

- The distressed slope is composed of loose debris material with an overburden thickness of 2-7m.
- A flowing nala is channelised on the left flank of the slide. The affected zone shows the signatures of dripping and damp hydrological conditions.
- The village is situated at the toe portion of the slide. The crown portion is unstable (Fig.66).
- Ground cracks (N045°) with a depth vary from 2-5m are observed on the slide area (Fig.68).
- During field work no damaged in civil structures were observed and reported, However houses located above crown and toe portion of the slide poses risk to damaged in extreme events. (Fig.67).
- Small rills and channels flowing through the crown portion which looses the strata of slide.
- Few seepages points were observed in the main body of the slide.

#### **Casuative Factor:-**

- Saturation of water along debris material during incessant rainfall induces the slope instability by increasing the pore pressure of the slope material. (Ref. Table 2 and fig 1.b).
- Reactivation of small unchannelized rills/drainage during incessant rainfall triggered the slide area.



Fig.66. Construction of retaining wall carried out to protect the crown.



Fig.67. Houses in high risk zone observed on the crown portion.

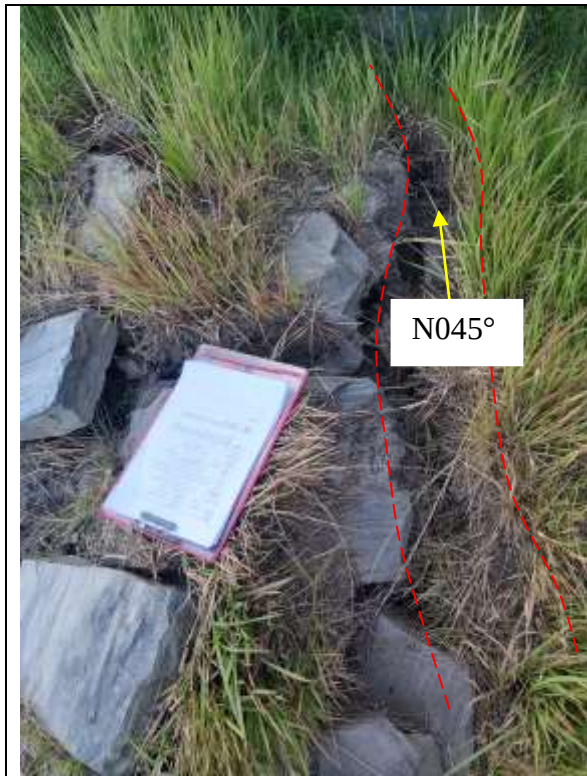


Fig.68. Longitudinal cracks with depth vary from 2-4m observed in the slide area.



Fig.69. Ground water seepage within the ground crack in the slide area

#### Suggestions:-

- Scaling of loose debris in the upslope (Unloading of the crown portion) along the nala flow path.
- Channelization of nala/ domestic waste water. They shall be aligned with lining and taken away from the slide affected zone Adequate toe support in the form of retaining wall to protect it further mass movement.
- The wide-open tension cracks shall be treated / sealed / filled with locally available clay if possible. This shall help in preventing further water percolation through this inside the weak sliding plane.
- The source area responsible for dripping water along the distressed slope need to be identified and pipes should be installed at the seepage/source zone for proper drainage management on the slope.

### **Cheras Slide:-**

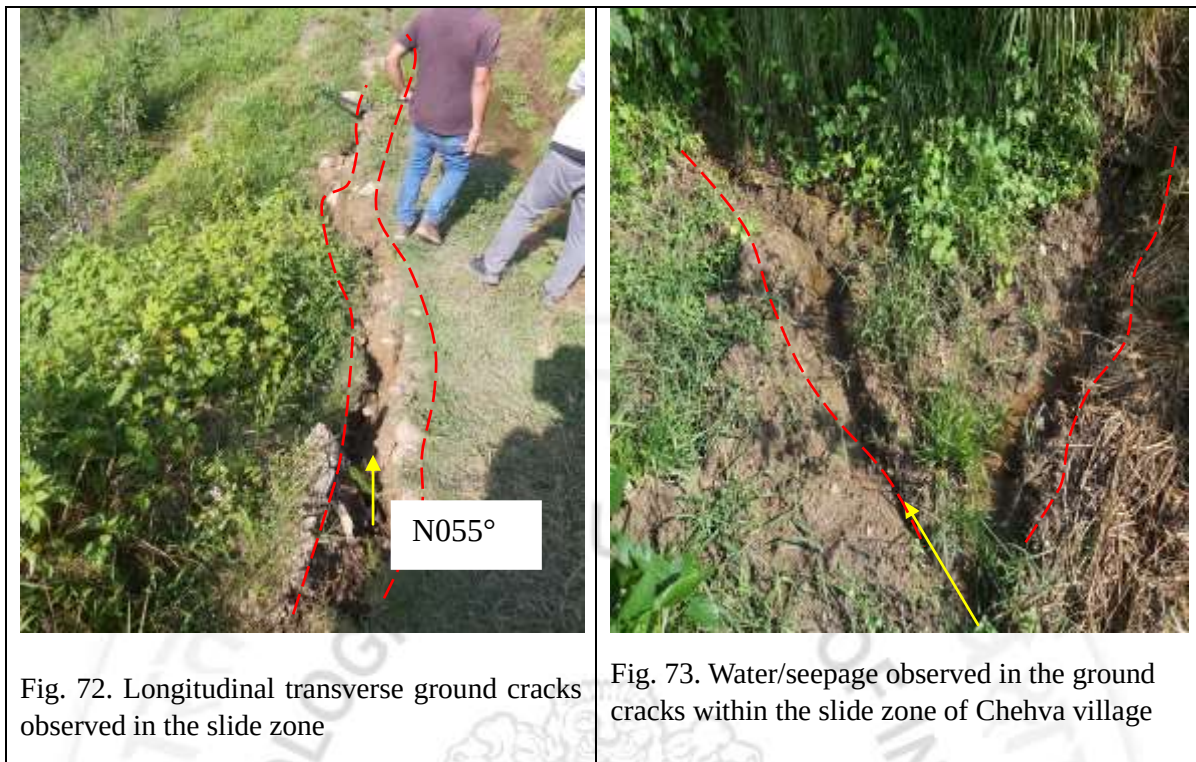
- In Cheras village (31°24'12.8"N, 77°26'51.0"E) a subsidence was observed which was initiated due to heavy rainfall between 8/07/2023 to 10/07/2023 damaging three houses severely. The slide is located on the upslope of the road NH 305 (Fig.70).
- The subsidence zone have an approximately dimension of 47m in length, and 15m in width exhibiting widening, retrogressive and active in nature.
- The debris material has an overburden thickness of <5m, composed mostly of sandy silt to clay with the wet and dripping hydrological conditions.
- Ground cracks with depth vary from 1-5m observed in the slide area. Seepage along the cracks are also observed (Fig.73).
- Longitudinal cracks as a sign of tension cracks indicate the slide is active and widening in nature (Fig.72).
- It is observed that the upslope of the slide-affected zone has few agricultural lands, orchards, and settlements in the downslope.
- The subsidence/sink zone was observed at the road level and adjoining areas of the main slide zone (Fig.71)



Fig. 70. Debris slide observed in Chehva village on the road side of NH 305



Fig.71. Subsidence/ sink zone in road observed on NH-305.



**Causative Factors: -**

- Percolation of rainwater within loose debris material during heavy precipitation and over-saturation of prolonged water from agricultural land and domestic sewage appears to be the major triggering factor of the slide. (Ref. Table 2 and fig 1.b).

**Suggestions:-**

- Proper drainage management.
- Construction of retaining /gabion wall to stabilized the slope forming material.
- The wide-open tension/ ground cracks shall be treated quickly.
- Well dug at suitable location along the distressed slope where seepages point were present coupled with line channelized drainage to drain the water away from affected zone.

**Lehrarali Slide:-**

- In the heavy precipitation period, from 08/07/2023 to 10/07/2023 a debris landslide occurs in the village of Laharili (31°24'42.7"N,77°25'44.5"E). It is reactivated again 17<sup>th</sup> August,2023.
- The slide with 25m in length, 20m width with 22 m run out zone till the upslope of the settlements.
- This slide is active, retrogressive, widening and single crown which shows the shallow translational failure.

- The debris material is loose and wet due to precipitation of surface runoff water from the crown side (Fig.74).
- Footpath track is damaged fully due to the slide.
- The debris/overburden material moves downward direction towards the settlements in the village.
- Parts of orchards located down slope the slide were damaged due to run off slide material.

**Causative Factors: -**

- Slope saturation by excess surface runoff along steep slope during heavy precipitation coupled with prolong slope saturation from domestic usage of water triggered the distressed slope for slide activity. (Ref. Table 2 and fig 1.b).
- Lack of drainage management in and around the affected slope.



**Suggestions:-**

- Construct contour parallel drainage above the crown of the slide to avoid surface water discharge to the distressed slope.
- Construct adequate retaining wall for atleast level, preferably one at the toe part and other at the main body of the slide in consultation with site Engineers.

**Mashnoo Nala slide:-**

- Mashnoo Nala (31°31'41.3"N,77°24'04.5"E ) is a paleo slide with a steep gradient having potential slide material. The slope gets retriggered frequently by external causative factors in the form of rain leading to slope failures. The slides initiated prior

to 2018 (source: Multi-temporal Google Earth Image) and has history of recurrent activation (Fig.75 ).

- The slide is 560m in length, 200m width, 83m height, and the runout zone varies till 560m.
- Approximately 230m road stretch of NH 305 is badly affected by the slide.
- The slide is deep seated forming multiple crowns which shows the deep translational failure along the slide (Fig.76).
- Presence of dripping nalas were observed along the slide zone.
- During active rainy seasons, these nalas have heavy discharge and erode the nala side slopes further widening the slide zone.
- The run-out extend below road level and also observed having further side slope erosion along run-out path.

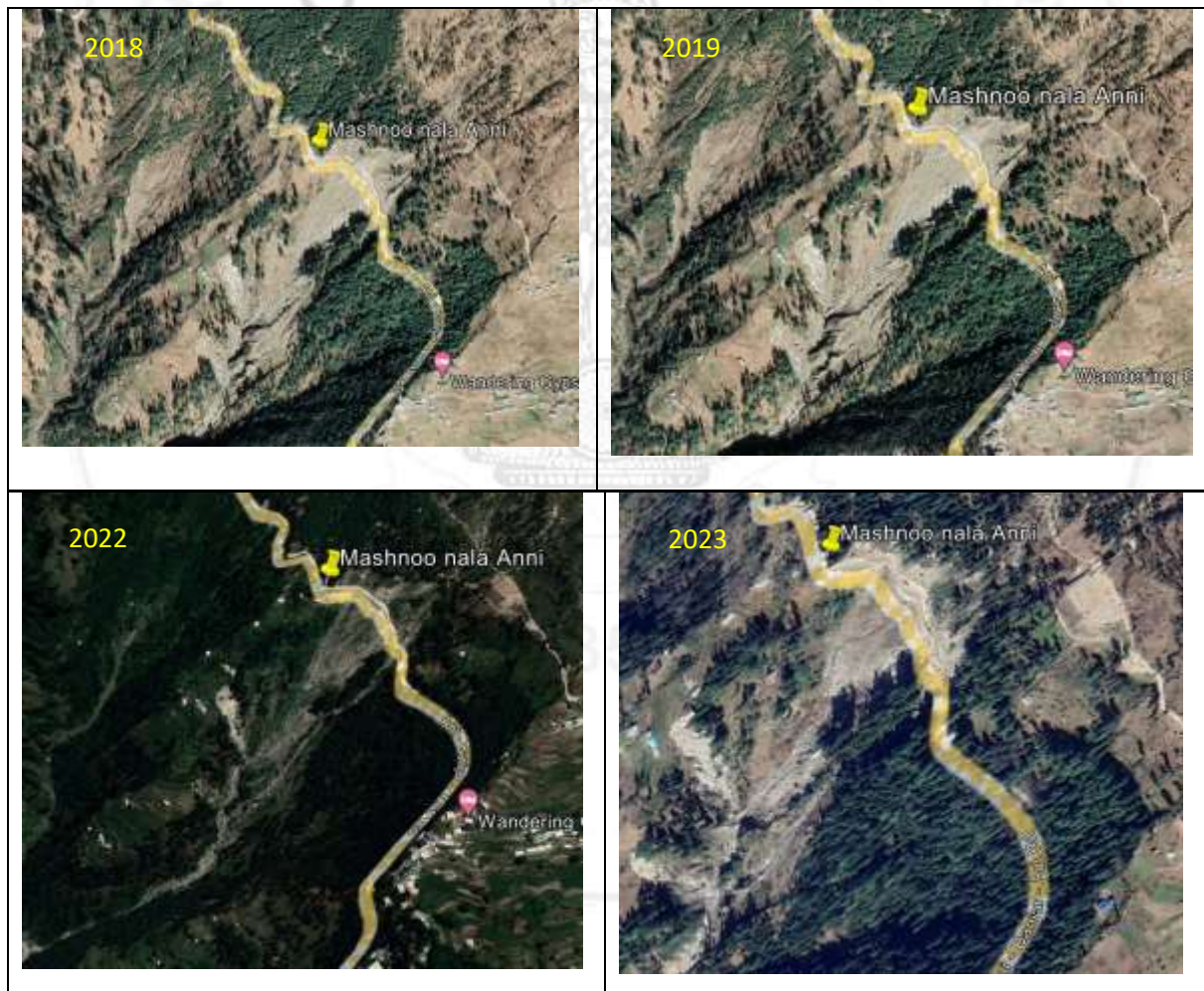
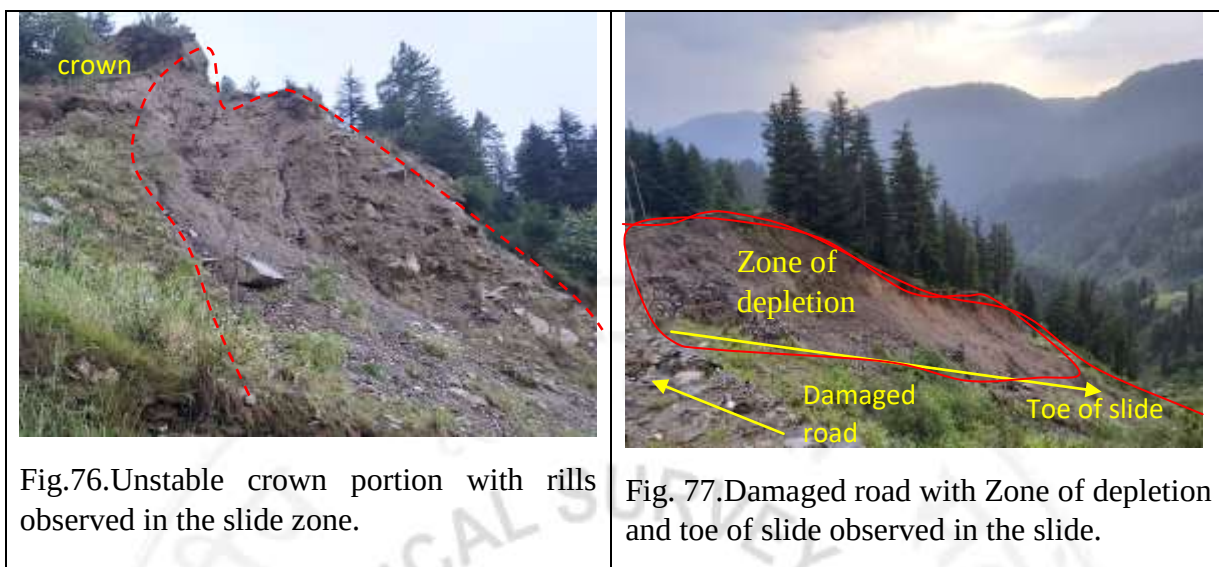


Fig. 75. Multi temporal Google earth image from 2018 to 2023



#### Causative factors:

- Saturation of slope forming material from surface runoff water during incessant rainfall. (Ref. Table 2 and fig 1.b).
- Toe erosion by Mashnoo Nala.
- Discharge of upslope surface water directly to the distressed slope.
- Seepage points present along the slope could lead to piping out of finer sand, silt and clay material of the slope are also likely to contribute to slope failure.
- Lack of drainage network.

#### Suggestions:-

- Scaling of loose slope wash/debris/dislodged rock boulders (Unloading of the crown).
- Provide benches /berms at suitable distance in consultation with design Engineers.
- Channelize the nala course with suitable width cascade structures.
- Install boulder catch fence/wire mesh at required places below the potential rock fall zones.
- Provide toe protection by RCC wall along with weep holes in consultation with the civil designers as per IS code.
- Construction of retaining wall with weep holes for proper drainage circulation.

#### Kot Nala Slide:-

- Kot Nala ( $31^{\circ}31'5.76''\text{N}$ ,  $77^{\circ}25'0.24''\text{E}$ ) is a prominent old debris slide situated on Jibhi-Anni road NH-305 which is reactivated during the heavy rainy period of 8-10<sup>th</sup> July, 2023. The slide is appearing to be initiated in the year of 2008 (Fig.78).

- About 100m stretch road has been badly damaged due to sliding in every monsoon which creates inconvenience in transportation due to road blocking for local peoples.
- The slide is active, retrogressive, widening in nature.
- The distressed slope exposes the debris material of schist and quartzite in the slide.
- Settlement located along the right flank of the slide is observed to be at risk in case of extreme events (Fig.78.a).
- Two major nala namely, i.e.; *Kot Nala* and *Tanga Nala* merged at the downside of the slide named *Dwara Nala* flowing near the slide area.
- Several flowing small rills drained within the distressed slope.
- The presence of two major *Nala* flowing along with excess surface runoff through the unchannelized drainage in the upslope of the slide makes the distressed zones wet and damp which vivacious the slope stability of the slide.

**Causative Factors: -**

- Saturation of slope forming material from surface runoff water during incessant rainfall. (Ref. Table 2 and fig 1.b).
- During the heavy monsoon season, it is possible that the flowing nala near the slide area and the unchannelized *Nala* could erode the fragile slope forming material from the upslope and accumulating on the road level leading to the blockage of roads and damaged the existing supports.
- Toe erosion by *Kot Nala*.



Fig.78.a; Field photograph showing Kot Nala landslide.

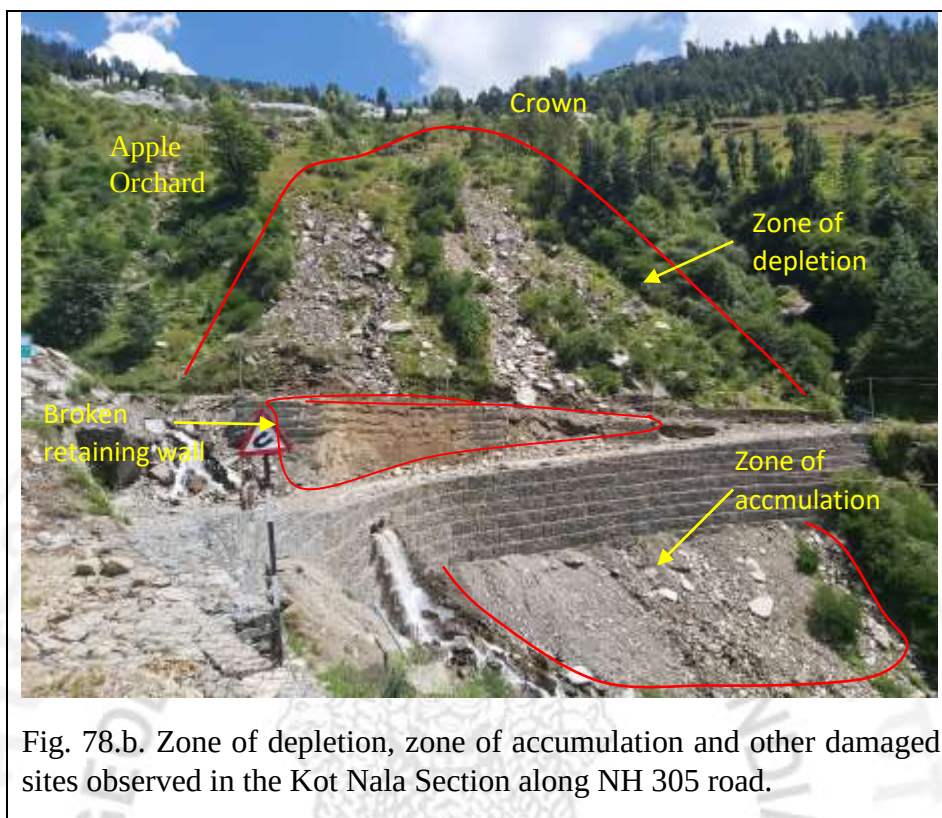


Fig. 78.b. Zone of depletion, zone of accumulation and other damaged sites observed in the Kot Nala Section along NH 305 road.

#### **Suggestions: -**

- All the flowing *nalas* along the distressed zone need to be properly lined and channelized to the main *nala* to avoid further surface water discharge on the distressed slope.
- Installation of underground drainage pipe below the present road level along the major depression of the affected zone.
- Construction of proper lined drainage along the hillside connecting it to the main adjoining *nala*.
- Adequate retaining wall along the Kot Nala for toe support.

#### **Falela Nala slide:-**

- Falela nala slide ( $31^{\circ}29'01.6''N, 77^{\circ}25'23.1''E$ ) is an old debris slide located along the nala section on Banjar-Jalori Pass- Anni (NH 305) road. Initially, the slide occurs in the year of 2022 and gets reactivated during the period of 8<sup>th</sup>-10<sup>th</sup> July 2023 by heavy rainfall. The area is densely vegetated and agricultural lands/apple orchards.
- This is an active multiple deep rotational failure debris slide with the dimensions of 65m in length and 20m in width.
- The crown portion of the slide is in unstable condition.

- The debris material comprises boulders of phyllite and granite gneiss with dry conditions.
- The slide affected the orchards present in the main body of the slide.
- The slide area is located in the close vicinity of flowing nala with unchanneled seasonal nalas.
- No culvert system was observed in the affected/ slide area.
- The pre-existing slope protective measures in the form of a retaining wall of 5m height and 10m length in the valley side of the road are partially failed with cracks due to ground sinking and subsidence.
- The preliminary study unveils that, the semi-consolidated, very steep slopes ( $70^{\circ}$ - $75^{\circ}$ ) meta-stable slope was modified during road cut with partial slope protective measures. The slope was already in semi-saturated condition due to surface runoff, and cultivated land/ orchards in the upslope area. The unchanneled drainage/ small rills were observed flowing along the seasonal nala path in the downslope direction.

**Casulative Factors:-**

- Main causative factor for this slide is the oversaturation of slope forming material from surface run off along steep slope. After the slope failure, it is observed that, the affected slope is subjected to excessive erosion from upslope runoff water leading to development of rills and gully along the distressed zone. The upper part of slide is defined by the ridge with agricultural land and orchards.



Fig.79. Unstable crown portion of slide



Fig.80.Run out materail of the slide as descereenable from the road

**Suggestions:-**

- Construct channelized contour parallel lined drainage above the crown of the slide and divert its channel to the main *Nala* present left flank of the slope to arrest excess water discharge to the affected slope/area.
- Proper lined channelized drainage need to be constructed along the hill side of the road.
- Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone in consultation with Botanist/Forest dept.
- Construct adequate retaining wall along the main body of the slide/ above the road level at suitable interval in consultation with site Engineers.

**Shailubhan Slide:-**

- It is a major slide observed on the NH 305, which is initiated during the heavy rainfall period of 8<sup>th</sup>-10<sup>th</sup> July,2023. The slide has affected the road for about ~1km causing problematic to commuters during monsoon season.
- The major slide (~22H / 25L /60m & 150m) observed on NH305.
- It is an active, retrogressive, widening and enlarging in nature with development of multiple crowns with an overburden thickness of 5-6m.
- Topographically the area is characterised by moderate to highly dissected landforms.
- The affected slide area/slope is incised by flowing *Nala*.
- The slope material is damp and wet due to flowing of small rills and drainage within the slide material.
- The right flank exposed the mountains whereas the left bank exposes debris material.
- In the crown portion, 1-2mt depth of ground cracks were observed which covered with plastic sheets to prevent it from excess seepage of ground water (Fig.81).
- Due to the debris slide, orchards and roads were destroyed.

**Casuative Factors:-**

- Unchannelized drainage on hill side of the road.
- Presence of loose and fragile rock/ debris material in the upslope and along the side slopes of the nala.

- Flowing water action during heavy precipitation cause extensive rill erosions and nala bank erosion.
- The loose and fragile rock/ debris material resting along slopes and nala side slopes gets eroded and trigger debris flows with surface run-off.
- Toe portion of the slide gets eroded by the flowing nala and weaken the lower portion (Fig.82).



Fig.81. Crown is covered with plastic sheets of the slide



Fig.82. Run off material of slide reaches up to the nala

#### **Suggestions:-**

- The loose materials confined along the major nala need to be removed manually / mechanically.
- Construction of adequate retaining wall along the Hill side of the road with a provision of weep holes.
- Construction of proper lined drainage along the hill side of the road and joined/ connect it to the main adjoining Nala to avoid excess surface water discharge on the distressed slope.
- Construction of adequate retaining wall along along the bank of River located below the road level in affected slope.

#### **6. GEOLOGICAL SET UP OF THE STUDY AREA IN PARTS OF MANALI SUB-DIVISION, KULLU DISTRICT, H.P:**

The study area falls in parts of SOI Toposheet nos. No. 52H/4, forming parts of lesser Himalayas. Geologically, the study area exposes the rock of Vaikrita Group of undiff.

Proterozoic in age represented by Kharo Formation (Litho units; Schist, gneiss, migmatite, qrtzite, marble) and Morang Formation (Litho units; Sillimanite - kyanie bearing schist, quartzite). The undifferentiated Quaternary deposit of Holocene in age is represented by Grey fine to coarse sand with pebble and clay. (Fig.83)

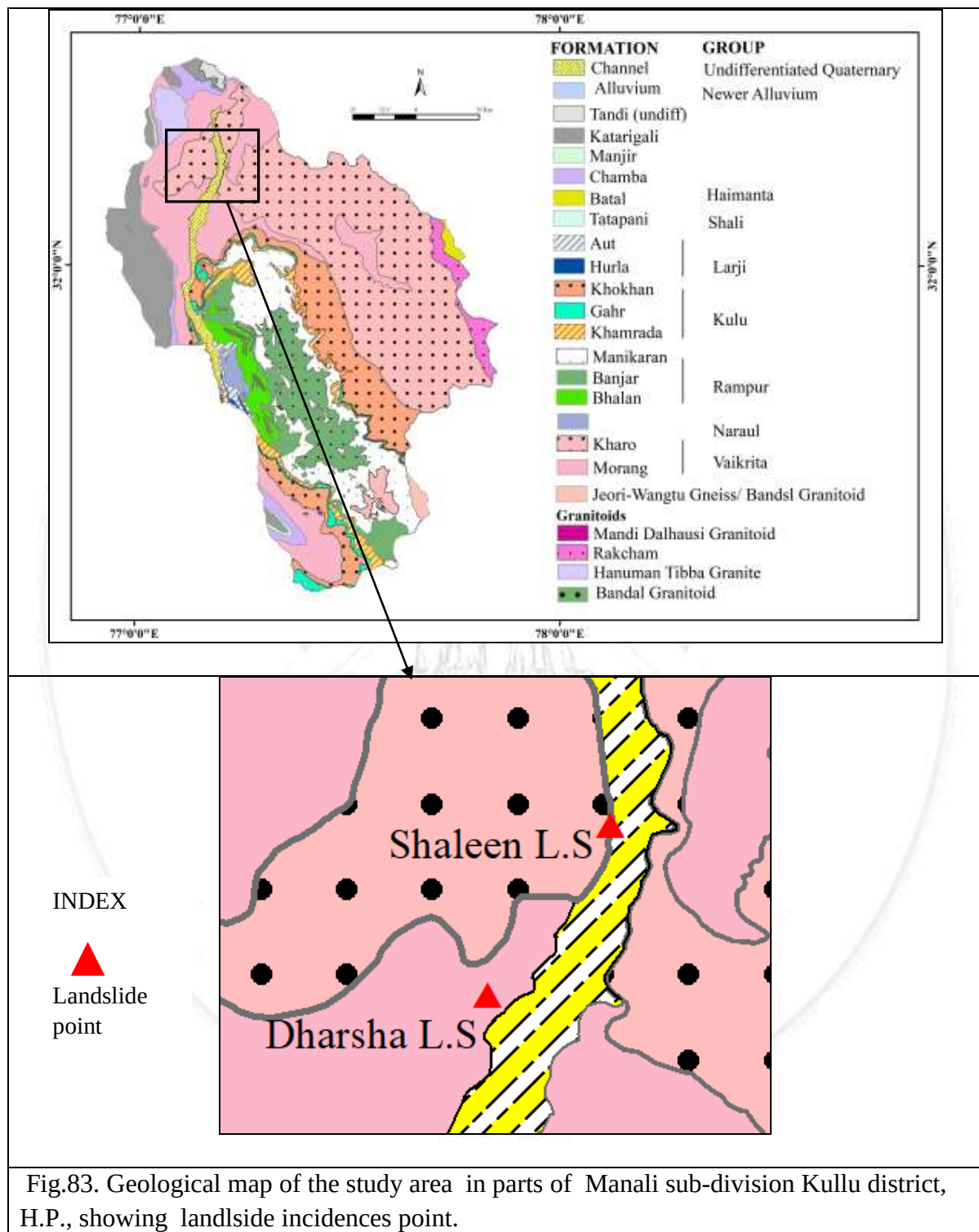


Fig.83. Geological map of the study area in parts of Manali sub-division Kullu district, H.P., showing landslide incidences point.

## **6.1. LANDSLIDE INCIDENCES IN MANALI SUB DIVISION, KULLU DISTRICT, H.P.**

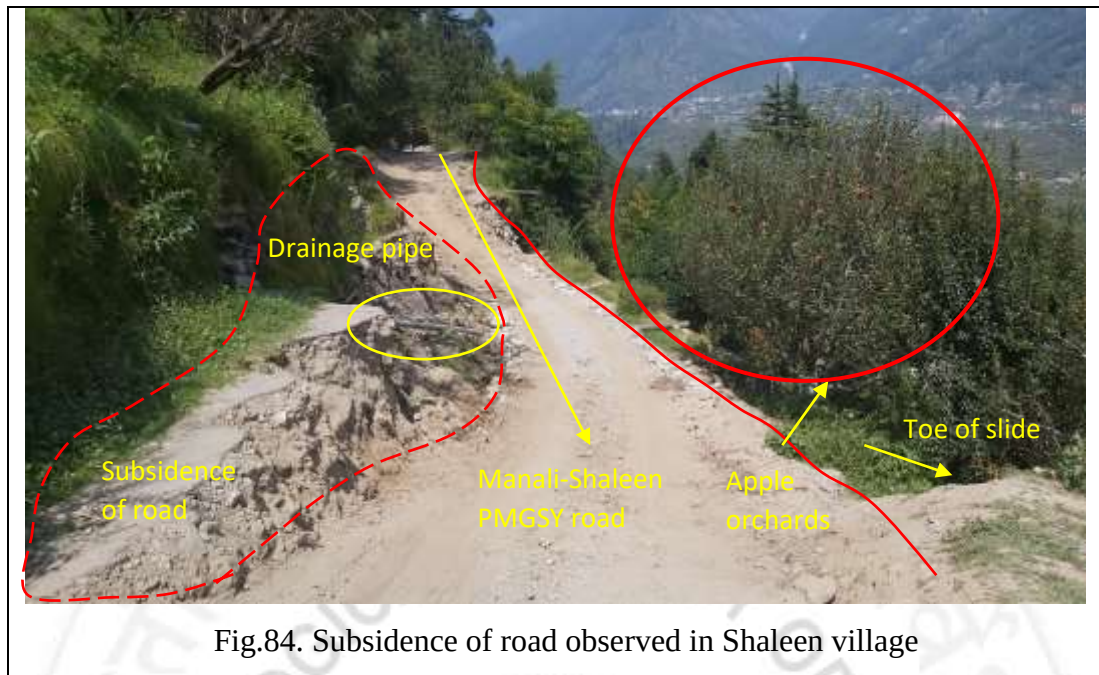
In Manali sub division, two slides zones were studied during the post disaster studies. Both the slides are debris slide situated on transportational mid slope of the study area.

### **6.1.1. Shaleen Subsidence:-**

- Shaleen subsidence ( $32^{\circ}11'55.1''\text{N}$ ,  $77^{\circ}11'05.9''\text{E}$ ) is located along Manali-Shaleen village road. The affected zone is situated along moderately inclined hill slope with a slope inclination and direction of  $35^{\circ}/\text{N}120^{\circ}$ .
- The slope forming material consist of semi consolidated loose debris.
- The subsidence was triggered from incessant rainfall during the period of 08/07/2023 to 10/07/2023 and has affected the link road stretch for about ~70m, in the form for road subside for about 10m (Fig.84).
- The Hydrological conditions of the site is dripping to flowing conditions
- The drainage on the hill side of the road has been completely choked by the debris material.
- Instability signatures such as tilting to trees, bulging gabion wall were observed towards the hill side of the road.
- At location ( $32^{\circ}11'50.5''\text{N}$ ,  $77^{\circ}11'04.5''\text{E}$ ) about 150 m SW Shaleen Subsidence a debris flow along the course of nala was observed.
- These materials are fresh, loose debris that were resting along the nala course without any toe support and affected parts of orchards located along the flow course.
- The debris flow have an approximate dimension of 160 m in length and 20 m width.

#### **Causative Factors: -**

- Oversaturation of water within the semi consolidated material during incessant rainfall leads to weaken the slope forming material and triggered the subsidence. (Ref. Table 2 and fig 1.b).
- Seepages points/spots as observed based on field conditions in this failure/subsidence affected zone could lead to piping out of finer material of the slope are also likely to contribute to subsidence.
- Lack of drainage management.



#### Suggestions:-

- Construction of adequate retaining wall with a provision of weep hole.
- Construct channelized lined contour parallel drainage above the crown of the slide and divert it to the main *Nala*.
- The dripping/flowing *Nala* present along the slide area need to be properly channelized coupled with installation of culvert across the road.
- Proper drainage management.



Fig. 85. Debris flow path along the course of seasonal Nala (about 150 m SW Shaleen Subsidence).



Fig.86. Run out debris material damaged the apple orchards located along the course of debris flow path (about 150 m SW Shaleen Subsidence)

### 6.1.2. Darsha Slide:-

- A shallow debris slide ( $32^{\circ} 8'56.51''\text{N}$  ,  $77^{\circ} 9'8.44''\text{E}$ ) occurs on the Manali-Darsha PMGSY Road. Due to the unprecedented heavy rainfall in the period of 8<sup>th</sup>-10<sup>th</sup> July, 2023 results the major debris slide (Fig.88).
- A debris slide ( $\sim 25\text{m H}$  /  $35\text{m L}$  /  $30\text{mW}$ ) was observed along the Manali-Darsha PMGSY Road.
- The debris slide is active, retrogressive, widening in nature with development of multiple crowns showing shallow translational failure mechanism.
- The material is damp to wet due to presence of dripping of flowing small rills within the slide.
- The PMGSY road is passing within the slide zone and is partially damaged.
- It was observed that the nalas were unchannelized.
- Addition to this minor slide in the form of road caving, damaged retaining wall along the Manali-Darsha PMGSY Road were observed at location ( $32^{\circ} 8'58.79''\text{N}$ ,  $77^{\circ} 9'16.50''\text{E}$ ). Fig.89.

#### Causative Factors: -

- Saturation of water on the loose debris material during incessant rainfall.
- Lack of drainage management.
- Road cutting along steep slope.

|                                                                                                                                                             |                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                          |                                                                           |
| <p>Fig.88. In Darsha debris slide (<math>32^{\circ} 8'56.51''\text{N}</math> , <math>77^{\circ} 9'8.44''\text{E}</math>) along Manali-Darsha PMGSY Road</p> | <p>Fig.89. Road caving along Manali-Darsha PMGSY Road at location (<math>32^{\circ} 8'58.79''\text{N}</math>, <math>77^{\circ} 9'16.50''\text{E}</math>).</p> |

### **Suggestions:-**

- Construct adequate retaining wall along the hill side of the slope with a provision of weep holes at location (32° 8'56.51"N , 77° 9'8.44"E) along Manali-Darsha PMGSY Road
- Repair/replaced the damaged retaining wall along the valley side of the road at location (32° 8'58.79"N, 77° 9'16.50"E). along Manali-Darsha PMGSY Road
- Construction of lined chanallized drainage along the hill side of the road.
- Channelization of seasonal nalas with construction of culverts along nala-road junctions.

### **7. CONCLUSION:**

1. On the request received from Deputy commissioner, Kullu District, Himachal Pradesh requested GSI, Chandigarh to carry out post disaster landslide studies vide letter no. 7142/SK(DM) dated 29<sup>th</sup> Aug. 2023. The authors of this report have carried out landslide studies in Kullu, Banjar, Manali and Anni Sub-Division from 30-08-2023 to 09-09-2023.
2. An incessant rainfall event during the month of July 2023 and August 2023 in and around the area of Kullu, Banjar, Anni and Manali Sub-Division, of Kullu district resulted in a series of slope failures/stability issues
3. The study area falls in parts of SOI Toposheet nos. 52E/6, 52H/6, 52H/8, 53E/1, 53E/2, 53E/6, 53E/7, 53E/10 and 53E/11. Forming parts of lesser Himalayan characterised by high relief with moderated to highly dissected hills.
4. Geologically, the area exposes the Rocks ranging in age from undifferentiated Proterozoic to Quaternary represented by Vaikrita, Rampur, Kullu, Shali, Nirmal, and undiff. Quaternary deposit and intrusion of Bandal Granitoid and Mandi Dalhausi Granitoid.
5. Most of the affected area are observed to be nestled/located along transported mid slope and slope wash material of semi unconsolidated debris.

### **8. Recommendation:**

1. The Highly affected areas are to be avoided for any planning and construction activities. However, if at all any construction is unavoidable detailed site-specific studies must be carried out.
2. Proper drainage management for surface runoff and domestic water.

3. Natural drainages, even though dry, may not be blocked/diverted as they are vital in draining out excess surface runoff water during heavy rainfall.
4. Unplanned excavation of hill slopes is to be avoided , since the settlement are mostly located on semi unconsolidated debris material without sound/in situ rock. However, where the excavation is unavoidable, suitable retaining structures/slope stabilisation measures should be provided for the excavated slope.
5. Suitable retaining structures as per site conditions and along the road may be provided with adequate filter and drainage in particular, when constructed in debris filled mass.
6. Monitoring of slope by way of installing adequate instruments in consultation with local people and administration.



## Annexure I

**42 POINT GEOPARAMETRIC DATASHEET FOR LANDSLIDE OF KULLU  
DISTRICT, HP**

|    |                                |                               |
|----|--------------------------------|-------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/01           |
| 1  | State                          | Himachal Pradesh              |
| 2  | District                       | Kullu                         |
| 3  | Toposheet No                   | 53E/1                         |
| 4  | Slide Name                     | Devdhar Kharahal landslide    |
| 5  | NH/SH Location                 | NH-03                         |
| 6  | Latitude                       | 31°57'48.08"N                 |
| 7  | Longitude                      | 77° 7'6.01"E                  |
| 8  | Landslide alert categorisation | II                            |
| 9  | Length                         | ~60 m                         |
| 10 | Width                          | ~80 m                         |
| 11 | Height                         | ~70 m                         |
| 12 | Run out distance               | --                            |
| 13 | Depth                          | 2-5m                          |
| 14 | Landslide volume               | Data not available            |
| 15 | Material type                  | Debris                        |
| 16 | Movement type                  | Subsidence                    |
| 17 | Movement rate                  | Moderate                      |
| 18 | Activity                       | Active                        |
| 19 | Distribution                   | Confined                      |
| 20 | Style                          | Single                        |
| 21 | Failure plane                  | Shallow                       |
| 22 | Failure mechanism              | Shallow translational failure |
| 23 | Initiation year                | 2023                          |
| 24 | Reactivation year 1            | --                            |
| 25 | Reactivation year 2            | --                            |
| 26 | Reactivation year 3            | --                            |
| 27 | Geomorphology                  | Lowly dissected hill          |
| 28 | Geology                        | Quaternary Deposit            |
| 29 | Structure                      | --.                           |
| 30 | Land use land cover            | Moderate vegetation           |
| 31 | Hydrological condition         | Damp                          |
| 32 | Triggering factor              | Anthropogenic and Rainfall.   |
| 33 | Persons death                  | --                            |
| 34 | People affected                | --                            |
| 35 | Livestock affected             | --                            |
| 36 | Communication affected         | ---                           |

|                                                                                                                                                                 |                             |                                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 37                                                                                                                                                              | Infrastructure affected     | Damaged to houses and retention structures.                                                                                                                                   |
| 38                                                                                                                                                              | Landuse land cover affected | --                                                                                                                                                                            |
| 39                                                                                                                                                              | Geoscientific causes        | Saturation of slope forming material from surface runoff water during incessant rainfall.                                                                                     |
|                                                                                                                                                                 |                             | Toe erosion by local <i>nala</i> present on the right flank of settlement.                                                                                                    |
|                                                                                                                                                                 |                             | Natural slope disturbance by road cutting down slope.                                                                                                                         |
| 40                                                                                                                                                              | Remedial measures, if any   | The unchannelized <i>nalas</i> , house hold sewage domestic water should be channelized systematically right from the up slope with side banks and slope protective measures. |
|                                                                                                                                                                 |                             | Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone                                                     |
|                                                                                                                                                                 |                             | The damaged retaining wall along the hill side of NH-3 located down slope of the village should be repair/replaced with a provision of weep holes.                            |
| 41                                                                                                                                                              | Remarks                     |                                                                                                                                                                               |
| 42 Photograph of the slide                                                                                                                                      |                             |                                                                                                                                                                               |
|  <p>Seasonal Nala</p> <p>Devdhar</p> <p>Image © 2023 Maxar Technologies</p> |                             |                                                                                                                                                                               |
| Fig.1. Devdhar landslide (Source: Google image)                                                                                                                 |                             |                                                                                                                                                                               |

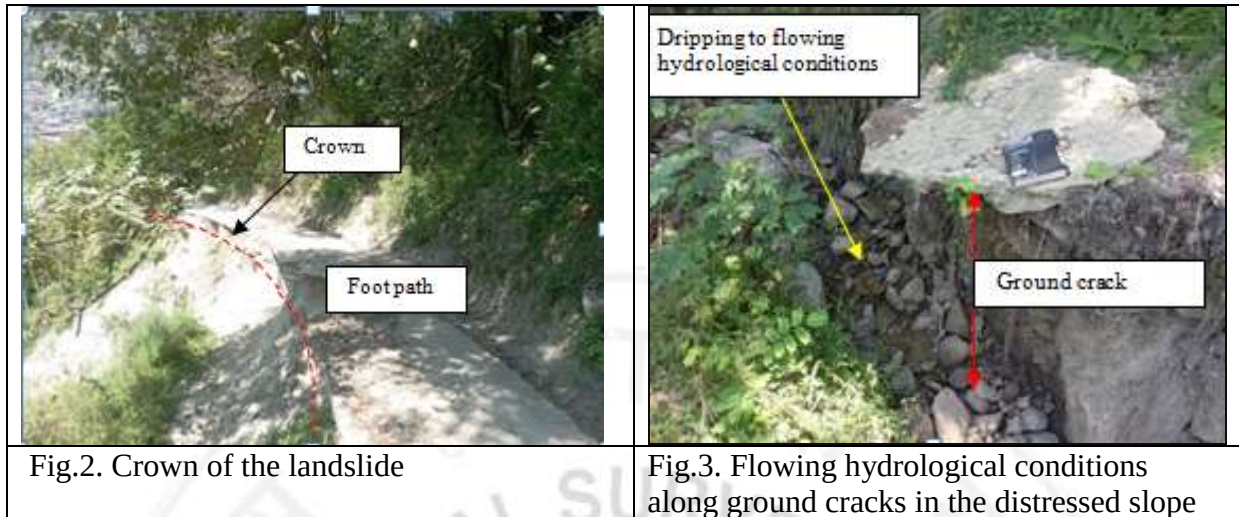


|    |                                |                                               |
|----|--------------------------------|-----------------------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/02                           |
| 1  | State                          | Himachal Pradesh                              |
| 2  | District                       | Kullu                                         |
| 3  | Toposheet No                   | 53E/1                                         |
| 4  | Slide Name                     | Up slope of Indian oil Petrol Pump along NH-3 |
| 5  | NH/SH Location                 | NH-03                                         |
| 6  | Latitude                       | 31°57'28.81" N                                |
| 7  | Longitude                      | 77° 6'59.57" E                                |
| 8  | Landslide alert categorisation | II                                            |
| 9  | Length                         | ~55 m                                         |
| 10 | Width                          | ~50 m                                         |
| 11 | Height                         | ~50 m                                         |
| 12 | Run out distance               | --                                            |
| 13 | Depth                          | 2-5m                                          |
| 14 | Landslide volume               | Data not available                            |
| 15 | Material type                  | Debris                                        |
| 16 | Movement type                  | Slide                                         |
| 17 | Movement rate                  | Moderate                                      |
| 18 | Activity                       | Active                                        |
| 19 | Distribution                   | Retrogressive                                 |
| 20 | Style                          | Single                                        |
| 21 | Failure plane                  | Shallow                                       |
| 22 | Failure mechanism              | Shallow translational failure                 |
| 23 | Initiation year                | --                                            |
| 24 | Reactivation year 1            | 2023                                          |
| 25 | Reactivation year 2            | --                                            |
| 26 | Reactivation year 3            | --                                            |
| 27 | Geomorphology                  | Lowly dissected hill                          |

|    |                              |                                                                                                                          |
|----|------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| 28 | Geology                      | Quaternary Deposit                                                                                                       |
| 29 | Structure                    | --.                                                                                                                      |
| 30 | Land use land cover          | Moderate vegetation                                                                                                      |
| 31 | Hydrological condition       | Dripping to flowing                                                                                                      |
| 32 | Triggering factor            | Anthropogenic and Rainfall.                                                                                              |
| 33 | Persons death                | --                                                                                                                       |
| 34 | People affected              | --                                                                                                                       |
| 35 | Livestock affected           | --                                                                                                                       |
| 36 | Communication affected       | ---                                                                                                                      |
| 37 | Infrastructure affected      | Retention structures and footpath                                                                                        |
| 38 | Land use land cover affected | --                                                                                                                       |
| 39 | Geoscientific causes         | Saturation of slope forming material from surface runoff water during incessant rainfall.                                |
|    |                              | Natural slope disturbance by road cutting down slope.                                                                    |
| 40 | Remedial measures, if any    | Proper channelization of drainage                                                                                        |
|    |                              | The dripping water source along distressed slope need to be identified and channelized it away from the distressed slope |
|    |                              | Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass. |
| 41 | Remarks                      |                                                                                                                          |
| 42 | Photograph of the slide      |                                                                                                                          |



Fig.1. Debris slide on upslope of Indian oil petrol pump



|    |                                |                                        |
|----|--------------------------------|----------------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/03                    |
| 1  | State                          | Himachal Pradesh                       |
| 2  | District                       | Kullu                                  |
| 3  | Toposheet No                   | 53E/1                                  |
| 4  | Slide Name                     | ~120 m south of Indian oil Petrol Pump |
| 5  | NH/SH Location                 | NH-03                                  |
| 6  | Latitude                       | 31°57'24.56"N                          |
| 7  | Longitude                      | 77° 6'58.79"E                          |
| 8  | Landslide alert categorisation | II                                     |
| 9  | Length                         | ~35 m                                  |
| 10 | Width                          | ~40 m                                  |
| 11 | Height                         | ~30 m                                  |
| 12 | Run out distance               | --                                     |
| 13 | Depth                          | 2-5m                                   |
| 14 | Landslide volume               | Data not available                     |
| 15 | Material type                  | Debris                                 |
| 16 | Movement type                  | Slide                                  |
| 17 | Movement rate                  | Moderate                               |
| 18 | Activity                       | Active                                 |
| 19 | Distribution                   | Retrogressive and widening             |
| 20 | Style                          | Single                                 |
| 21 | Failure plane                  | Shallow                                |
| 22 | Failure mechanism              | Shallow translational failure          |
| 23 | Initiation year                | 2023                                   |
| 24 | Reactivation year 1            | --                                     |
| 25 | Reactivation year 2            | --                                     |
| 26 | Reactivation year 3            | --                                     |

|    |                             |                                                                                                                                                                                  |
|----|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 27 | Geomorphology               | Lowly dissected hill                                                                                                                                                             |
| 28 | Geology                     | Quaternary Deposit                                                                                                                                                               |
| 29 | Structure                   | --.                                                                                                                                                                              |
| 30 | Land use land cover         | Moderate vegetation                                                                                                                                                              |
| 31 | Hydrological condition      | Dripping to flowing                                                                                                                                                              |
| 32 | Triggering factor           | Anthropogenic and Rainfall.                                                                                                                                                      |
| 33 | Persons death               | --                                                                                                                                                                               |
| 34 | People affected             | --                                                                                                                                                                               |
| 35 | Livestock affected          | --                                                                                                                                                                               |
| 36 | Communication affected      | ---                                                                                                                                                                              |
| 37 | Infrastructure affected     | Retention structures and footpath                                                                                                                                                |
| 38 | Landuse land cover affected | --                                                                                                                                                                               |
| 39 | Geoscientific causes        | Saturation of slope forming material from surface runoff water during incessant rainfall.                                                                                        |
|    |                             | Natural slope disturbance by road cutting down slope.                                                                                                                            |
| 40 | Remedial measures, if any   | Proper channelization of drainage                                                                                                                                                |
|    |                             | The dripping water source along distressed slope need to be identified and channelized it away from the distressed slope                                                         |
|    |                             | Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass and repair or replaced the damaged retaining structures. |
|    |                             | Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone.                                                       |
| 41 | Remarks                     |                                                                                                                                                                                  |
| 42 | Photograph of the slide     |                                                                                                                                                                                  |



Fig.1. Debris slide as discernible from the left bank of Beas River.



Fig.2. Damaged retention structures along the hill side of NH-3

|    |                                |                               |
|----|--------------------------------|-------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/04           |
| 1  | State                          | Himachal Pradesh              |
| 2  | District                       | Kullu                         |
| 3  | Toposheet No                   | 53E/1                         |
| 4  | Slide Name                     | Banontar Kharahal             |
| 5  | NH/SH Location                 | NH-03                         |
| 6  | Latitude                       | 31°57'20.23"N                 |
| 7  | Longitude                      | 77° 6'59.42"E                 |
| 8  | Landslide alert categorisation | II                            |
| 9  | Length                         | ~75 m                         |
| 10 | Width                          | ~100 m                        |
| 11 | Height                         | ~70 m                         |
| 12 | Run out distance               | --                            |
| 13 | Depth                          | 2-5m                          |
| 14 | Landslide volume               | Data not available            |
| 15 | Material type                  | Debris                        |
| 16 | Movement type                  | Subsidence                    |
| 17 | Movement rate                  | Moderate                      |
| 18 | Activity                       | Active                        |
| 19 | Distribution                   | Retrogressive and widening    |
| 20 | Style                          | Single                        |
| 21 | Failure plane                  | Shallow                       |
| 22 | Failure mechanism              | Shallow translational failure |
| 23 | Initiation year                | 2023                          |
| 24 | Reactivation year 1            | --                            |
| 25 | Reactivation year 2            | --                            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                |                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Reactivation year<br>3         | --                                                                                                                                                                                                                                                                                                                                            |
| 27                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Geomorphology                  | Lowly dissected hill                                                                                                                                                                                                                                                                                                                          |
| 28                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Geology                        | Quaternary Deposit                                                                                                                                                                                                                                                                                                                            |
| 29                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Structure                      | --.                                                                                                                                                                                                                                                                                                                                           |
| 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Land use land<br>cover         | Moderate vegetation                                                                                                                                                                                                                                                                                                                           |
| 31                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Hydrological<br>condition      | Damp                                                                                                                                                                                                                                                                                                                                          |
| 32                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Triggering factor              | Anthropogenic and Rainfall.                                                                                                                                                                                                                                                                                                                   |
| 33                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Persons death                  | --                                                                                                                                                                                                                                                                                                                                            |
| 34                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | People affected                | --                                                                                                                                                                                                                                                                                                                                            |
| 35                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Livestock<br>affected          | --                                                                                                                                                                                                                                                                                                                                            |
| 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Communication<br>affected      | ---                                                                                                                                                                                                                                                                                                                                           |
| 37                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Infrastructure<br>affected     | Houses and Retention structures.                                                                                                                                                                                                                                                                                                              |
| 38                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Landuse land<br>cover affected | --                                                                                                                                                                                                                                                                                                                                            |
| 39                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Geoscientific<br>causes        | Saturation of slope forming material from surface runoff water during incessant rainfall.<br>Natural slope disturbance by road cutting down slope.                                                                                                                                                                                            |
| 40                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Remedial<br>measures, if any   | Proper channelization of drainage<br>Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass and repair or replaced the damaged retaining structures.<br>Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately |
| 41                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Remarks                        |                                                                                                                                                                                                                                                                                                                                               |
| 42                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Photograph of the<br>slide     |                                                                                                                                                                                                                                                                                                                                               |
|  <p>The photograph shows a landslide area with damaged civil structures. A yellow house is visible on the right, and a red brick retaining wall is in the foreground. A red dashed line indicates the boundary of the slide. Two labels with arrows point to specific areas: 'Damaged houses' points to the yellow house, and 'Tilting/subsiding of retaining wall' points to the red brick wall. The ground is uneven and appears to be a mix of soil and rocks.</p> |                                |                                                                                                                                                                                                                                                                                                                                               |

Fig.1. Damaged civil structures



Fig.2. Ground cracks



Fig.3 Damage retaining structures along NH-3.

|    |                                |                            |
|----|--------------------------------|----------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/05        |
| 1  | State                          | Himachal Pradesh           |
| 2  | District                       | Kullu                      |
| 3  | Toposheet No                   | 53E/5                      |
| 4  | Slide Name                     | Garsa Slide                |
| 5  | NH/SH Location                 | --                         |
| 6  | Latitude                       | 31°49'42.82"N              |
| 7  | Longitude                      | 77°15'20.12"E              |
| 8  | Landslide alert categorisation | I                          |
| 9  | Length                         | ~190 m                     |
| 10 | Width                          | ~130 m                     |
| 11 | Height                         | ~180 m                     |
| 12 | Run out distance               | --                         |
| 13 | Depth                          | >5m                        |
| 14 | Landslide volume               | Data not available         |
| 15 | Material type                  | Debris                     |
| 16 | Movement type                  | Subsidence                 |
| 17 | Movement rate                  | Moderate                   |
| 18 | Activity                       | Active                     |
| 19 | Distribution                   | Retrogressive and widening |
| 20 | Style                          | Multiple                   |

|    |                             |                                                                                                                                                                                            |
|----|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 21 | Failure plane               | Deep seated                                                                                                                                                                                |
| 22 | Failure mechanism           | Deep translational failure                                                                                                                                                                 |
| 23 | Initiation year             | 2023                                                                                                                                                                                       |
| 24 | Reactivation year 1         | --                                                                                                                                                                                         |
| 25 | Reactivation year 2         | --                                                                                                                                                                                         |
| 26 | Reactivation year 3         | --                                                                                                                                                                                         |
| 27 | Geomorphology               | Lowly dissected hill                                                                                                                                                                       |
| 28 | Geology                     | Phyllite (Kharmada Formation)                                                                                                                                                              |
| 29 | Structure                   | J1=15°/ N030°, J2=70°/ N270° and J3=80°/ N200°                                                                                                                                             |
| 30 | Land use land cover         | Moderate to sparsely vegetation cover                                                                                                                                                      |
| 31 | Hydrological condition      | Damp and dripping                                                                                                                                                                          |
| 32 | Triggering factor           | Rainfall.                                                                                                                                                                                  |
| 33 | Persons death               | --                                                                                                                                                                                         |
| 34 | People affected             | --                                                                                                                                                                                         |
| 35 | Livestock affected          | --                                                                                                                                                                                         |
| 36 | Communication affected      | ---                                                                                                                                                                                        |
| 37 | Infrastructure affected     | Damaged 16 Houses (Informed by local residence)                                                                                                                                            |
| 38 | Landuse land cover affected | --                                                                                                                                                                                         |
| 39 | Geoscientific causes        | Saturation of slope forming material from surface runoff water during incessant rainfall.                                                                                                  |
|    |                             | Toe erosion by flowing <i>Nala</i> on the right flank of slope.                                                                                                                            |
| 40 | Remedial measures, if any   | Proper channelization of drainage                                                                                                                                                          |
|    |                             | Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass                                                                    |
|    |                             | Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately                                                                       |
|    |                             | Avoid further loading, tampering of slope with heavy civil structures in/adjoining failure affected zone and in immediate vicinity of <i>nala</i> courses.                                 |
|    |                             | Appropriately designed guide walls along the <i>nala</i> courses present on the right flank of the slope, to prevent further erosion and damage to civil structures present vicinity to it |
| 41 | Remarks                     |                                                                                                                                                                                            |
| 42 | Photograph of the slide     |                                                                                                                                                                                            |



Fig.1. Garsa Subsidence (Source: Google image)



Fig.2. Damaged house



Fig.3 Ground crack

|    |                                |                                  |
|----|--------------------------------|----------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/06              |
| 1  | State                          | Himachal Pradesh                 |
| 2  | District                       | Kullu                            |
| 3  | Toposheet No                   | 52H/8.                           |
| 4  | Slide Name                     | Baraiuna landslide               |
| 5  | NH/SH Location                 | NH-03                            |
| 6  | Latitude                       | 32° 2'4.73"N                     |
| 7  | Longitude                      | 77°21'0.50"E                     |
| 8  | Landslide alert categorisation | I                                |
| 9  | Length                         | ~130 m                           |
| 10 | Width                          | ~180 m                           |
| 11 | Height                         | ~120 m                           |
| 12 | Run out distance               | --                               |
| 13 | Depth                          | >5m                              |
| 14 | Landslide volume               | Data not available               |
| 15 | Material type                  | Debris                           |
| 16 | Movement type                  | Slide                            |
| 17 | Movement rate                  | Moderate                         |
| 18 | Activity                       | Active                           |
| 19 | Distribution                   | Retrogressive and widening       |
| 20 | Style                          | Multiple                         |
| 21 | Failure plane                  | Deep seated                      |
| 22 | Failure mechanism              | Deep rotational failure          |
| 23 | Initiation year                | 2023                             |
| 24 | Reactivation year 1            | --                               |
| 25 | Reactivation year 2            | --                               |
| 26 | Reactivation year 3            | --                               |
| 27 | Geomorphology                  | Lowly dissected hill             |
| 28 | Geology                        | Bhalan Formation of Rampur Group |
| 29 | Structure                      | --.                              |
| 30 | Land use land cover            | Sparsely vegetation              |
| 31 | Hydrological condition         | Damp                             |
| 32 | Triggering factor              | Rainfall and toe erosion         |
| 33 | Persons death                  | --                               |
| 34 | People affected                | --                               |
| 35 | Livestock affected             | --                               |
| 36 | Communication affected         | ---                              |

|                                                                                      |                             |                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 37                                                                                   | Infrastructure affected     | Damaged to houses.                                                                                                                                                                                                                                         |
| 38                                                                                   | Landuse land cover affected | --                                                                                                                                                                                                                                                         |
| 39                                                                                   | Geoscientific causes        | Absence of proper drainage network in upslope and slope saturation due to excessive/ incessant rainfall spells in the area during June 2023 along steep have drastically worsened the slope situation coupled with toe erosion by the Baraiuna <i>Nala</i> |
| 40                                                                                   | Remedial measures, if any   | It is suggested to construct an appropriately designed lined drainage upslope to avoid surface water discharge on the distressed slope                                                                                                                     |
|                                                                                      |                             | Appropriately designed retention structures at suitably identified locations at lower levels as support to failing mass.                                                                                                                                   |
|                                                                                      |                             | The affected house located at the crown of the landslide need vacate immediately.                                                                                                                                                                          |
|                                                                                      |                             | Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately                                                                                                                                       |
|                                                                                      |                             | Appropriately designed guide walls along the Baraiuna <i>nala</i> to prevent further erosion of slope.                                                                                                                                                     |
|                                                                                      |                             | Avoid further loading, tampering of slope with heavy civil structures in/adjoining failure affected zone                                                                                                                                                   |
| 41                                                                                   | Remarks                     |                                                                                                                                                                                                                                                            |
| 42 Photograph of the slide                                                           |                             |                                                                                                                                                                                                                                                            |
|  |                             |                                                                                                                                                                                                                                                            |

Fig.1. Crown of the slide along steep slope



Fig.2. Crack on civil structures



Fig.3. Landslide on right flank of the slope

|    |                                |                            |
|----|--------------------------------|----------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/07        |
| 1  | State                          | Himachal Pradesh           |
| 2  | District                       | Kullu                      |
| 3  | Toposheet No                   | 53E/6                      |
| 4  | Slide Name                     | Bandal landslide           |
| 5  | NH/SH Location                 | --                         |
| 6  | Latitude                       | 31°38'3.49"N               |
| 7  | Longitude                      | 77°25'31.81"E              |
| 8  | Landslide alert categorisation | I                          |
| 9  | Length                         | ~350 m                     |
| 10 | Width                          | ~250 m                     |
| 11 | Height                         | ~300 m                     |
| 12 | Run out distance               | --                         |
| 13 | Depth                          | >5m                        |
| 14 | Landslide volume               | Data not available         |
| 15 | Material type                  | Debris                     |
| 16 | Movement type                  | Slide                      |
| 17 | Movement rate                  | Moderate                   |
| 18 | Activity                       | Active                     |
| 19 | Distribution                   | Retrogressive and widening |
| 20 | Style                          | Multiple                   |
| 21 | Failure plane                  | Deep seated                |
| 22 | Failure mechanism              | Deep translational failure |
| 23 | Initiation year                | 2023                       |
| 24 | Reactivation year 1            | --                         |
| 25 | Reactivation year 2            | --                         |
| 26 | Reactivation year 3            | --                         |
| 27 | Geomorphology                  | Lowly dissected hill       |
| 28 | Geology                        | Gneiss of Bandal Granitoid |

|                            |                              |                                                                                                                                                                                                         |
|----------------------------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29                         | Structure                    | J1=60°/ N290°, J2=30°/ N160° and J3=75°/ N070°                                                                                                                                                          |
| 30                         | Land use land cover          | Moderately vegetation                                                                                                                                                                                   |
| 31                         | Hydrological condition       | Damp, wet and dripping                                                                                                                                                                                  |
| 32                         | Triggering factor            | Rainfall.                                                                                                                                                                                               |
| 33                         | Persons death                | --                                                                                                                                                                                                      |
| 34                         | People affected              | --                                                                                                                                                                                                      |
| 35                         | Livestock affected           | --                                                                                                                                                                                                      |
| 36                         | Communication affected       | ---                                                                                                                                                                                                     |
| 37                         | Infrastructure affected      | Damaged to civil structures and road                                                                                                                                                                    |
| 38                         | Land use land cover affected | --                                                                                                                                                                                                      |
| 39                         | Geoscientific causes         | Absence of proper drainage network in upslope and slope saturation due to excessive/ incessant rainfall spells in the area during June 2023 along unconsolidated-semi consolidated slope wash material. |
| 40                         | Remedial measures, if any    | It is suggested to construct an appropriately designed lined drainage upslope to avoid surface water discharge on the distressed slope                                                                  |
|                            |                              | Appropriately designed retention structures along the hill and valley side of road with a provision of weep holes and hill side drainage.                                                               |
|                            |                              | Avoid further loading, tampering of slope with heavy civil structures in/adjoining failure affected zone                                                                                                |
|                            |                              | Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately                                                                                    |
|                            |                              | Based on the dimension of the slide, the importance of the affected road and houses located at the slide zone a detailed site specific study is recommended.                                            |
| 41                         | Remarks                      |                                                                                                                                                                                                         |
| 42 Photograph of the slide |                              |                                                                                                                                                                                                         |



Fig.1. Bandal landslide (Source: Google image)



Fig.2. Ground cracks



Fig.3. Road subsidence

|    |                 |                           |
|----|-----------------|---------------------------|
| No | Slide No        | HP/KUL/53E1/2023/08       |
| 1  | State           | Himachal Pradesh          |
| 2  | District        | Kullu                     |
| 3  | Toposheet No    | 53E/5                     |
| 4  | Slide Name      | Machine <i>Nala</i> slide |
| 5  | NH/SH Location  | --                        |
| 6  | Latitude        | 31°46' 21.80"N            |
| 7  | Longitude       | 77°17' 54.82"E            |
| 8  | Landslide alert | II                        |

|    |                             |                                                                                                                                                                                                         |
|----|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | categorisation              |                                                                                                                                                                                                         |
| 9  | Length                      | ~130 m                                                                                                                                                                                                  |
| 10 | Width                       | ~100 m                                                                                                                                                                                                  |
| 11 | Height                      | ~110 m                                                                                                                                                                                                  |
| 12 | Run out distance            | --                                                                                                                                                                                                      |
| 13 | Depth                       | 2-5m                                                                                                                                                                                                    |
| 14 | Landslide volume            | Data not available                                                                                                                                                                                      |
| 15 | Material type               | Debris                                                                                                                                                                                                  |
| 16 | Movement type               | Slide                                                                                                                                                                                                   |
| 17 | Movement rate               | Moderate                                                                                                                                                                                                |
| 18 | Activity                    | Active                                                                                                                                                                                                  |
| 19 | Distribution                | Retrogressive                                                                                                                                                                                           |
| 20 | Style                       | Single                                                                                                                                                                                                  |
| 21 | Failure plane               | Shallow                                                                                                                                                                                                 |
| 22 | Failure mechanism           | Shallow translational failure                                                                                                                                                                           |
| 23 | Initiation year             | 2023                                                                                                                                                                                                    |
| 24 | Reactivation year 1         | --                                                                                                                                                                                                      |
| 25 | Reactivation year 2         | --                                                                                                                                                                                                      |
| 26 | Reactivation year 3         | --                                                                                                                                                                                                      |
| 27 | Geomorphology               | Lowly dissected hill                                                                                                                                                                                    |
| 28 | Geology                     | Bhalan Formation of Rampur Group                                                                                                                                                                        |
| 29 | Structure                   | --.                                                                                                                                                                                                     |
| 30 | Land use land cover         | Moderately vegetation                                                                                                                                                                                   |
| 31 | Hydrological condition      | Damp and wet                                                                                                                                                                                            |
| 32 | Triggering factor           | Rainfall and toe erosion                                                                                                                                                                                |
| 33 | Persons death               | --                                                                                                                                                                                                      |
| 34 | People affected             | --                                                                                                                                                                                                      |
| 35 | Livestock affected          | --                                                                                                                                                                                                      |
| 36 | Communication affected      | ---                                                                                                                                                                                                     |
| 37 | Infrastructure affected     | Damaged to road                                                                                                                                                                                         |
| 38 | Landuse land cover affected | --                                                                                                                                                                                                      |
| 39 | Geoscientific causes        | Absence of proper drainage network in upslope and slope saturation due to excessive/ incessant rainfall spells in the area during June 2023 along unconsolidated-semi consolidated slope wash material. |
|    |                             | Toe erosion by Parvati River                                                                                                                                                                            |

|                                                                                           |                           |                                                                                                                                           |
|-------------------------------------------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 40                                                                                        | Remedial measures, if any | It is suggested to construct an appropriately designed lined drainage upslope to avoid surface water discharge on the distressed slope    |
|                                                                                           |                           | Appropriately designed retention structures along the hill and valley side of road with a provision of weep holes and hill side drainage. |
|                                                                                           |                           | Avoid further loading, tampering of slope with heavy civil structures in/adjoining failure affected zone                                  |
|                                                                                           |                           | Immediate filling of transverse and contour parallel tension cracks with appropriate impervious material immediately                      |
|                                                                                           |                           | Appropriately designed guide walls along the Parvati River to prevent further toe erosion of slope.                                       |
| 41                                                                                        | Remarks                   | Settlement located on upslope/near the crown of the slide pose risk to life and properties in case of uneven weather conditions.          |
| 42 Photograph of the slide                                                                |                           |                                                                                                                                           |
|        |                           |                                                                                                                                           |
| Fig.1. Machine <i>Nala</i> slide as discernable from the opposite slope of Parvati River. |                           |                                                                                                                                           |
|       |                           |                                                                                                                                           |
| Fig.2. Road subsidence                                                                    |                           | Fig.3. Traverse ground crack on the right flank of landslide.                                                                             |

|    |                                |                                                     |
|----|--------------------------------|-----------------------------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/09                                 |
| 1  | State                          | Himachal Pradesh                                    |
| 2  | District                       | Kullu                                               |
| 3  | Toposheet No                   | 53E/5                                               |
| 4  | Slide Name                     | Sainj Landslide                                     |
| 5  | NH/SH Location                 | --                                                  |
| 6  | Latitude                       | 31°46' 8.77"N                                       |
| 7  | Longitude                      | 77°18'29.22"E                                       |
| 8  | Landslide alert categorisation | I                                                   |
| 9  | Length                         | ~70 m                                               |
| 10 | Width                          | ~85 m                                               |
| 11 | Height                         | ~65 m                                               |
| 12 | Run out distance               | --                                                  |
| 13 | Depth                          | 2-5m                                                |
| 14 | Landslide volume               | Data not available                                  |
| 15 | Material type                  | Debris                                              |
| 16 | Movement type                  | Slide                                               |
| 17 | Movement rate                  | Moderate                                            |
| 18 | Activity                       | Active                                              |
| 19 | Distribution                   | Retrogressive and enlarging                         |
| 20 | Style                          | Single                                              |
| 21 | Failure plane                  | Shallow                                             |
| 22 | Failure mechanism              | Shallow translational failure                       |
| 23 | Initiation year                | 2023                                                |
| 24 | Reactivation year 1            | --                                                  |
| 25 | Reactivation year 2            | --                                                  |
| 26 | Reactivation year 3            | --                                                  |
| 27 | Geomorphology                  | Lowly dissected hill                                |
| 28 | Geology                        | Bhalan Formation of Rampur Group                    |
| 29 | Structure                      | --.                                                 |
| 30 | Land use land cover            | Sparse vegetation                                   |
| 31 | Hydrological condition         | Damp and wet                                        |
| 32 | Triggering factor              | Rainfall and toe erosion                            |
| 33 | Persons death                  | --                                                  |
| 34 | People affected                | --                                                  |
| 35 | Livestock affected             | --                                                  |
| 36 | Communication affected         | ---                                                 |
| 37 | Infrastructure affected        | Damaged 49 houses (As informed by local residences) |
| 38 | Landuse land                   | --                                                  |

|    |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | cover affected            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 39 | Geoscientific causes      | <p>Saturation of slope forming material from upslope surface runoff water during incessant rainfall along moderately inclined hill slope.</p> <p>Toe erosion by Parvati River and unloading of dump site material from upstream</p>                                                                                                                                                                                                                                                                                                                       |
| 40 | Remedial measures, if any | <p>It is suggested to construct an appropriately designed contour parallel drainage above the crown of the main slide to avoid surface water discharge on the distressed slope.</p> <p>Appropriately designed guide structures for toe support along both the bank of Parvati River.</p> <p>Avoid further construction of any civil structures vicinity to both the banks the river.</p> <p>It is best to vacate the houses whose pillar foundation are affected as it possess risk to life and property in case of uneven/extreme weather conditions</p> |
| 41 | Remarks                   | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

#### 42 Photograph of the slide



Fig.1. Main landslide affected are



Fig.2. Houses at risk (Right bank of the river)

Fig.3. House at risk (left bank of the river)

|    |                                |                                   |
|----|--------------------------------|-----------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/10               |
| 1  | State                          | Himachal Pradesh                  |
| 2  | District                       | Kullu                             |
| 3  | Toposheet No                   | 53E/6                             |
| 4  | Slide Name                     | Mourod subsidence                 |
| 5  | NH/SH Location                 | --                                |
| 6  | Latitude                       | 31°42'44.05"N                     |
| 7  | Longitude                      | 77°18'46.49"E                     |
| 8  | Landslide alert categorisation | II                                |
| 9  | Length                         | ~80 m                             |
| 10 | Width                          | ~35 m                             |
| 11 | Height                         | ~70 m                             |
| 12 | Run out distance               | --                                |
| 13 | Depth                          | 2-5m                              |
| 14 | Landslide volume               | Data not available                |
| 15 | Material type                  | Debris                            |
| 16 | Movement type                  | Subsidence                        |
| 17 | Movement rate                  | Moderate                          |
| 18 | Activity                       | Active                            |
| 19 | Distribution                   | Retrogressive and enlarging       |
| 20 | Style                          | Single                            |
| 21 | Failure plane                  | Shallow                           |
| 22 | Failure mechanism              | Shallow translational failure     |
| 23 | Initiation year                | 2023                              |
| 24 | Reactivation year 1            | --                                |
| 25 | Reactivation year 2            | --                                |
| 26 | Reactivation year 3            | --                                |
| 27 | Geomorphology                  | Lowly dissected hill              |
| 28 | Geology                        | Banjar Formation of Rampur Group  |
| 29 | Structure                      | --.                               |
| 30 | Land use land cover            | Sparse vegetation                 |
| 31 | Hydrological condition         | Damp to flowing                   |
| 32 | Triggering factor              | Rainfall and toe erosion          |
| 33 | Persons death                  | --                                |
| 34 | People affected                | --                                |
| 35 | Livestock affected             | --                                |
| 36 | Communication affected         | ---                               |
| 37 | Infrastructure                 | Damaged houses and retention wall |

|                                                                                     |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                     | affected                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 38                                                                                  | Landuse land cover affected | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 39                                                                                  | Geoscientific causes        | <p>Saturation of slope forming material from upslope surface runoff water during incessant rainfall along moderately inclined hill slope.</p> <p>Toe erosion by <i>nala</i> and lack of drainage network.</p>                                                                                                                                                                                                                                                                                        |
| 40                                                                                  | Remedial measures, if any   | <p>It is suggested to construct an appropriately designed drainage network where ever applicable to avoid excess surface water/domestic water discharge on the distressed slope.</p> <p>Appropriately designed guide structures for toe support and toe erosion prevention along the bank of flowing <i>nala</i>.</p> <p>Avoid construction of any heavy civil structures on the distressed slope</p> <p>Immediate filling of ground cracks/tension cracks with appropriate impervious material.</p> |
| 41                                                                                  | Remarks                     | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 42 Photograph of the slide                                                          |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|  |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Fig.1. Mourod Subsidence zone (Source: Google image)                                |                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

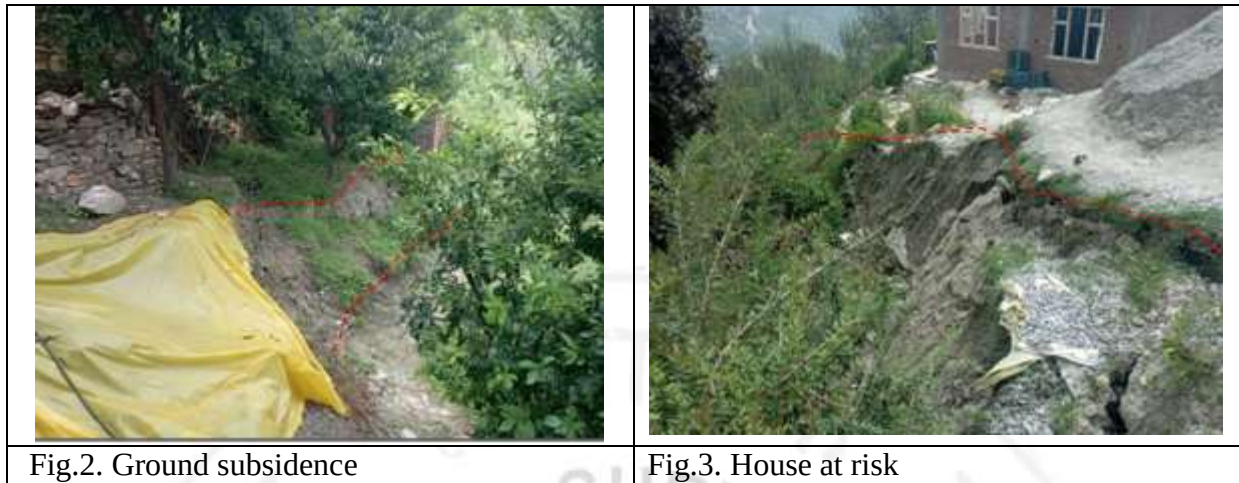


Fig.2. Ground subsidence

Fig.3. House at risk

|    |                                |                                  |
|----|--------------------------------|----------------------------------|
| No | Slide No                       | HP/KUL/53E1/2023/11              |
| 1  | State                          | Himachal Pradesh                 |
| 2  | District                       | Kullu                            |
| 3  | Toposheet No                   | 53E/6                            |
| 4  | Slide Name                     | Daduhar ward No.1                |
| 5  | NH/SH Location                 | --                               |
| 6  | Latitude                       | 31°38'31.20"N                    |
| 7  | Longitude                      | 77°20'35.88"E                    |
| 8  | Landslide alert categorisation | I                                |
| 9  | Length                         | ~100 m                           |
| 10 | Width                          | ~150 m                           |
| 11 | Height                         | ~90 m                            |
| 12 | Run out distance               | --                               |
| 13 | Depth                          | 2-5m                             |
| 14 | Landslide volume               | Data not available               |
| 15 | Material type                  | Debris                           |
| 16 | Movement type                  | Slide                            |
| 17 | Movement rate                  | Moderate                         |
| 18 | Activity                       | Active                           |
| 19 | Distribution                   | Retrogressive and enlarging      |
| 20 | Style                          | Single                           |
| 21 | Failure plane                  | Shallow                          |
| 22 | Failure mechanism              | Shallow translational failure    |
| 23 | Initiation year                | 2023                             |
| 24 | Reactivation year 1            | --                               |
| 25 | Reactivation year 2            | --                               |
| 26 | Reactivation year 3            | --                               |
| 27 | Geomorphology                  | Lowly dissected hill             |
| 28 | Geology                        | Banjar Formation of Rampur Group |

|                            |                             |                                                                                                                                                                                                                                                                              |
|----------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29                         | Structure                   | --.                                                                                                                                                                                                                                                                          |
| 30                         | Land use land cover         | Sparse vegetation                                                                                                                                                                                                                                                            |
| 31                         | Hydrological condition      | Damp, wet and dripping                                                                                                                                                                                                                                                       |
| 32                         | Triggering factor           | Rainfall and toe erosion                                                                                                                                                                                                                                                     |
| 33                         | Persons death               | --                                                                                                                                                                                                                                                                           |
| 34                         | People affected             | --                                                                                                                                                                                                                                                                           |
| 35                         | Livestock affected          | --                                                                                                                                                                                                                                                                           |
| 36                         | Communication affected      | ---                                                                                                                                                                                                                                                                          |
| 37                         | Infrastructure affected     | Damaged 5 houses (Informed by local residence), Road subsidence located upslope of the slide                                                                                                                                                                                 |
| 38                         | Landuse land cover affected | --                                                                                                                                                                                                                                                                           |
| 39                         | Geoscientific causes        | Saturation of slope forming material from upslope surface runoff water during incessant rainfall along moderately inclined hill slope.                                                                                                                                       |
|                            |                             | Lack of proper drainage system in upslope and Toe erosion by Rabhi <i>Khad</i> down slope.                                                                                                                                                                                   |
| 40                         | Remedial measures, if any   | It is suggested to construct an appropriately designed contour parallel drainage along hill ward side of road level to avoid excess surface water/domestic water discharge on the distressed slope                                                                           |
|                            |                             | Construction of adequate retaining walls towards the valley side of the road with a provision of weep holes and installation of culvert at suitable location.                                                                                                                |
|                            |                             | Appropriately designed guide structures for toe support and toe erosion prevention along the bank of flowing <i>nala</i>                                                                                                                                                     |
|                            |                             | Avoid any further construction of civil structures on the distressed slope and immediately vacate the affected houses/school present on the distressed slope as the slide is still active and poses threat to live and properties in case of any extreme weather conditions. |
| 41                         | Remarks                     | --                                                                                                                                                                                                                                                                           |
| 42 Photograph of the slide |                             |                                                                                                                                                                                                                                                                              |



Fig.1. ; Daduhar slide as discernable from the opposite slope.



Fig.2. Damaged Sarswati Vidya Mandir  
Sr.Sec. School



Fig.3. Damaged road stretch

|    |                                |                     |
|----|--------------------------------|---------------------|
| No | Slide No                       | HP/KUL/53E1/2023/12 |
| 1  | State                          | Himachal Pradesh    |
| 2  | District                       | Kullu               |
| 3  | Toposheet No                   | 53E/5               |
| 4  | Slide Name                     | Kartah subsidence   |
| 5  | NH/SH Location                 | --                  |
| 6  | Latitude                       | 31°46'47.28"N       |
| 7  | Longitude                      | 77°20'35.20"E       |
| 8  | Landslide alert categorisation | II                  |
| 9  | Length                         | ~35 m               |
| 10 | Width                          | ~150 m              |
| 11 | Height                         | ~30 m               |
| 12 | Run out distance               | --                  |
| 13 | Depth                          | 2-5m                |
| 14 | Landslide volume               | Data not available  |
| 15 | Material type                  | Debris              |
| 16 | Movement type                  | Subsidence          |
| 17 | Movement rate                  | Moderate            |
| 18 | Activity                       | Active              |
| 19 | Distribution                   | Enlarging           |

|                            |                              |                                                                                                                                                                                                                             |
|----------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 20                         | Style                        | Single                                                                                                                                                                                                                      |
| 21                         | Failure plane                | Shallow                                                                                                                                                                                                                     |
| 22                         | Failure mechanism            | Shallow translational failure                                                                                                                                                                                               |
| 23                         | Initiation year              | 2023                                                                                                                                                                                                                        |
| 24                         | Reactivation year 1          | --                                                                                                                                                                                                                          |
| 25                         | Reactivation year 2          | --                                                                                                                                                                                                                          |
| 26                         | Reactivation year 3          | --                                                                                                                                                                                                                          |
| 27                         | Geomorphology                | Lowly dissected hill                                                                                                                                                                                                        |
| 28                         | Geology                      | Bhalan Formation of Rampur Group                                                                                                                                                                                            |
| 29                         | Structure                    | --.                                                                                                                                                                                                                         |
| 30                         | Land use land cover          | Sparse vegetation and Agricultural land                                                                                                                                                                                     |
| 31                         | Hydrological condition       | Damp, wet, dripping and flowing                                                                                                                                                                                             |
| 32                         | Triggering factor            | Rainfall and toe erosion                                                                                                                                                                                                    |
| 33                         | Persons death                | --                                                                                                                                                                                                                          |
| 34                         | People affected              | --                                                                                                                                                                                                                          |
| 35                         | Livestock affected           | --                                                                                                                                                                                                                          |
| 36                         | Communication affected       | ---                                                                                                                                                                                                                         |
| 37                         | Infrastructure affected      | Damaged houses and Road subsidence                                                                                                                                                                                          |
| 38                         | Land use land cover affected | --                                                                                                                                                                                                                          |
| 39                         | Geoscientific causes         | Concentration of pore water pressure in debris due damp and dripping hydrology condition of the slope coupled with toe erosion by Sainj River and lack of proper drainage system is found to be the main triggering factors |
| 40                         | Remedial measures, if any    | Construction of appropriately designed guide structures for toe support and toe erosion prevention along the bank of the river                                                                                              |
|                            |                              | Construction of adequate retaining walls towards the hill side of the road with a provision of weep holes, hill side drainage and installation of culvert at suitable location.                                             |
|                            |                              | Identification of seepages/dripping point and channelized the water away from distressed slope to prevent further slope saturation                                                                                          |
|                            |                              | Immediate filling of ground cracks/tension cracks with appropriate impervious material and avoid any further construction of civil structures towards the valley side of the road                                           |
| 41                         | Remarks                      | --                                                                                                                                                                                                                          |
| 42 Photograph of the slide |                              |                                                                                                                                                                                                                             |



Fig.1. ; Kartah subsidence (Source: Google image)



Fig.2. Damaged houses located near the bank of River



Fig.3. Road subsidence

|    |                                |                     |
|----|--------------------------------|---------------------|
| No | Slide No                       | HP/KUL/53E1/2023/13 |
| 1  | State                          | Himachal Pradesh    |
| 2  | District                       | Kullu               |
| 3  | Toposheet No                   | 53E/6               |
| 4  | Slide Name                     | Sharai subsidence   |
| 5  | NH/SH Location                 | --                  |
| 6  | Latitude                       | 31°39'7.20"N        |
| 7  | Longitude                      | 77°19'56.64"E       |
| 8  | Landslide alert categorisation | II                  |
| 9  | Length                         | ~55 m               |
| 10 | Width                          | ~35 m               |
| 11 | Height                         | ~50 m               |

|    |                              |                                                                                                                                                                                |
|----|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12 | Run out distance             | --                                                                                                                                                                             |
| 13 | Depth                        | 2-5m                                                                                                                                                                           |
| 14 | Landslide volume             | Data not available                                                                                                                                                             |
| 15 | Material type                | Debris                                                                                                                                                                         |
| 16 | Movement type                | Subsidence                                                                                                                                                                     |
| 17 | Movement rate                | Moderate                                                                                                                                                                       |
| 18 | Activity                     | Active                                                                                                                                                                         |
| 19 | Distribution                 | Retrogressive                                                                                                                                                                  |
| 20 | Style                        | Single                                                                                                                                                                         |
| 21 | Failure plane                | Shallow                                                                                                                                                                        |
| 22 | Failure mechanism            | Shallow translational failure                                                                                                                                                  |
| 23 | Initiation year              | 2023                                                                                                                                                                           |
| 24 | Reactivation year 1          | --                                                                                                                                                                             |
| 25 | Reactivation year 2          | --                                                                                                                                                                             |
| 26 | Reactivation year 3          | --                                                                                                                                                                             |
| 27 | Geomorphology                | Lowly dissected hill                                                                                                                                                           |
| 28 | Geology                      | Bhulan Formation of Rampur Group                                                                                                                                               |
| 29 | Structure                    | --.                                                                                                                                                                            |
| 30 | Land use land cover          | Sparse vegetation                                                                                                                                                              |
| 31 | Hydrological condition       | Damp                                                                                                                                                                           |
| 32 | Triggering factor            | Rainfall and toe erosion                                                                                                                                                       |
| 33 | Persons death                | --                                                                                                                                                                             |
| 34 | People affected              | --                                                                                                                                                                             |
| 35 | Livestock affected           | --                                                                                                                                                                             |
| 36 | Communication affected       | ---                                                                                                                                                                            |
| 37 | Infrastructure affected      | Damaged houses and Road subsidence                                                                                                                                             |
| 38 | Land use land cover affected | --                                                                                                                                                                             |
| 39 | Geoscientific causes         | Saturation of slope forming material along steep slope from upslope surface runoff water during incessant rainfall and toe erosion by Tirthan River                            |
| 40 | Remedial measures, if any    | Construction of appropriately designed guide structures for toe support and toe erosion prevention along the bank of the river.                                                |
|    |                              | Construction of adequate retaining walls towards the hill side of the road with a provision of weep holes, hill side drainage and installation of culvert at suitable location |
|    |                              | Immediate filling of ground cracks/tension cracks with appropriate impervious material                                                                                         |

|    |         |                                                                                                          |
|----|---------|----------------------------------------------------------------------------------------------------------|
|    |         | Avoid further slope saturation on distressed slope by constructing adequate drainage network on upslope. |
| 41 | Remarks | --                                                                                                       |

42 Photograph of the slide



Fig.1.Damaged house present along the affected slope.



Fig.2. Road subsidence

Fig.3. Ground subsidence

|    |                                |                              |
|----|--------------------------------|------------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/14          |
| 1  | State                          | Himachal Pradesh             |
| 2  | District                       | Kullu                        |
| 3  | Toposheet No                   | 53E/7                        |
| 4  | Slide Name                     | Rageli, Nigloodhar landslide |
| 5  | NH/SH Location                 | -                            |
| 6  | Latitude                       | 31°28'11.10"N                |
| 7  | Longitude                      | 77°22'00.1"E                 |
| 8  | Landslide alert categorisation | I                            |
| 9  | Length                         | ~145m                        |
| 10 | Width                          | ~80 m                        |
| 11 | Height                         | ~80 m                        |
| 12 | Area                           | ~1160 sq.m <sup>2</sup>      |
| 13 | Run out distance               | ~180 m                       |
| 14 | Depth                          | 2-5m                         |

|    |                             |                                                                                                                 |
|----|-----------------------------|-----------------------------------------------------------------------------------------------------------------|
| 15 | Landslide volume            | 58000m <sup>3</sup>                                                                                             |
| 16 | Material type               | Debris                                                                                                          |
| 17 | Movement type               | Slide                                                                                                           |
| 18 | Movement rate               | Moderate                                                                                                        |
| 19 | Activity                    | Active                                                                                                          |
| 20 | Distribution                | Widening                                                                                                        |
| 21 | Style                       | Successive                                                                                                      |
| 22 | Failure plane               | Shallow                                                                                                         |
| 23 | Failure mechanism           | Shallow translational failure                                                                                   |
| 24 | Initiation year             | 14 <sup>th</sup> August, 2023                                                                                   |
| 25 | Reactivation year 1         | --                                                                                                              |
| 26 | Reactivation year 2         | --                                                                                                              |
| 27 | Reactivation year 3         | --                                                                                                              |
| 28 | Geomorphology               | Moderately dissected hill                                                                                       |
| 29 | Geology                     | Carbonaceous phyllite/slate, quartzite of Chamba Formation, Vaikrita Group                                      |
| 30 | Structure                   | --.                                                                                                             |
| 31 | Land use land cover         | Agriculture, Settlement                                                                                         |
| 32 | Hydrological condition      | Damp                                                                                                            |
| 33 | Triggering factor           | Heavy Rainfall.                                                                                                 |
| 34 | Persons death               | 3 peoples                                                                                                       |
| 35 | People affected             | --                                                                                                              |
| 36 | Livestock affected          | --                                                                                                              |
| 37 | Communication affected      | ---                                                                                                             |
| 38 | Infrastructure affected     | Damaged to houses and retention structures.                                                                     |
| 39 | Landuse land cover affected | --                                                                                                              |
| 40 | Geoscientific causes        | Saturation of slope forming material from surface runoff water during incessant rainfall.                       |
|    |                             | Toe erosion by local <i>nala</i> present on the right flank of settlement.                                      |
|    |                             |                                                                                                                 |
| 41 | Remedial measures, if any   | Channelization of nala/domestic waste water. They shall be aligned and taken away from the slide affected zone. |
|    |                             | Scaling of loose debris in the upslope.                                                                         |
|    |                             | Benches/beams of suitable heights and width shall be provided                                                   |

|                                                                                    |                         |                                                                                                             |
|------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------|
|                                                                                    |                         | with gabion wall.                                                                                           |
|                                                                                    |                         | For toe support, toe drains away from the main slope to carry seepage water away from the slide area        |
|                                                                                    |                         | The wide-open ground/tension cracks shall be filled with locally available impervious material immediately. |
| 42                                                                                 | Remarks                 |                                                                                                             |
| 43                                                                                 | Photograph of the slide |                                                                                                             |
|                                                                                    |                         |                                                                                                             |
|  |                         |                          |
| Fig.1. Rageli landslide in Nigloodhar village                                      |                         | Fig.2. Open ground cracks in Rageli slide                                                                   |

|    |                                |                              |
|----|--------------------------------|------------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/15          |
| 1  | State                          | Himachal Pradesh             |
| 2  | District                       | Kullu                        |
| 3  | Toposheet No                   | 53E/7                        |
| 4  | Slide Name                     | Dharta, Nigloodhar landslide |
| 5  | NH/SH Location                 | -                            |
| 6  | Latitude                       | 31°28'22.8"N                 |
| 7  | Longitude                      | 77°22'03.8"E                 |
| 8  | Landslide alert categorisation | II                           |
| 9  | Length                         | ~100m                        |
| 10 | Width                          | ~25 m                        |
| 11 | Height                         | ~45 m                        |
| 12 | Area                           | ~2500 sq.m <sup>2</sup>      |
| 13 | Run out distance               | ~85 m                        |
| 14 | Depth                          | 2-5m                         |
| 15 | Landslide volume               | ~12500m <sup>3</sup>         |
| 16 | Material type                  | Debris                       |
| 17 | Movement type                  | Slide                        |
| 18 | Movement rate                  | Moderate                     |
| 19 | Activity                       | Active                       |
| 20 | Distribution                   | Enlarging                    |

|    |                              |                                                                                                                 |
|----|------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 21 | Style                        | Successive                                                                                                      |
| 22 | Failure plane                | Shallow                                                                                                         |
| 23 | Failure mechanism            | Shallow translational failure                                                                                   |
| 24 | Initiation year              | 14 <sup>th</sup> August, 2023                                                                                   |
| 25 | Reactivation year 1          | --                                                                                                              |
| 26 | Reactivation year 2          | --                                                                                                              |
| 27 | Reactivation year 3          | --                                                                                                              |
| 28 | Geomorphology                | Moderately dissected hill                                                                                       |
| 29 | Geology                      | Carbonaceous phyllite/slate, quartzite of Chamba Formation, Vaikrita Group                                      |
| 30 | Structure                    | --                                                                                                              |
| 31 | Land use land cover          | Agriculture, Settlement                                                                                         |
| 32 | Hydrological condition       | Wet                                                                                                             |
| 33 | Triggering factor            | Heavy Rainfall.                                                                                                 |
| 34 | Person's death               | ---                                                                                                             |
| 35 | People affected              | --                                                                                                              |
| 36 | Livestock affected           | --                                                                                                              |
| 37 | Communication affected       | ---                                                                                                             |
| 38 | Infrastructure affected      | Cracks observed in houses                                                                                       |
| 39 | Land use land cover affected | --                                                                                                              |
| 40 | Geoscientific causes         | Saturation of slope forming material from surface runoff water during incessant rainfall.                       |
|    |                              | Lack of drainage management in the slope.                                                                       |
|    |                              |                                                                                                                 |
| 41 | Remedial measures, if any    | Channelization of nala/domestic waste water. They shall be aligned and taken away from the slide affected zone. |
|    |                              | For toe support, toe drains away from the main slope to carry seepage water away from the slide area .          |
|    |                              | Wide-open tension cracks shall be treated / sealed/filled with impervious material                              |
|    |                              | Benches/berms of suitable heights and width shall be provided at                                                |

|    |                                                                                   |                                                                                    |
|----|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|    |                                                                                   | intermediate levels with gabions support.                                          |
| 42 | Remarks                                                                           |                                                                                    |
| 43 | Photograph of the slide                                                           |                                                                                    |
|    |                                                                                   |                                                                                    |
|    |  |  |
|    | Fig.1. Dharta landslide in Nigloodhar village                                     | Fig.2. Cracks in house                                                             |

|    |                                |                               |
|----|--------------------------------|-------------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/16           |
| 1  | State                          | Himachal Pradesh              |
| 2  | District                       | Kullu                         |
| 3  | Toposheet No                   | 53E/7                         |
| 4  | Slide Name                     | Gungi                         |
| 5  | NH/SH Location                 | ---                           |
| 6  | Latitude                       | 31°24'12.8"N                  |
| 7  | Longitude                      | 77°26'51.0"E                  |
| 8  | Landslide alert categorisation | II                            |
| 9  | Length                         | ~170m                         |
| 10 | Width                          | ~65 m                         |
| 11 | Height                         | ~55 m                         |
| 12 | Area                           | ~11050 sq.m <sup>2</sup>      |
| 13 | Run out distance               | ~60 m                         |
| 14 | Depth                          | 2-7m                          |
| 15 | Landslide volume               | ~44200m <sup>3</sup>          |
| 16 | Material type                  | Debris                        |
| 17 | Movement type                  | Subsidence                    |
| 18 | Movement rate                  | Moderate                      |
| 19 | Activity                       | Inactive                      |
| 20 | Distribution                   | Retrogressive, Widening       |
| 21 | Style                          | Successive                    |
| 22 | Failure plane                  | Shallow                       |
| 23 | Failure                        | Shallow translational failure |

|                            |                             |                                                                                                             |
|----------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------|
|                            | mechanism                   |                                                                                                             |
| 24                         | Initiation year             | 2023                                                                                                        |
| 25                         | Reactivation year 1         | --                                                                                                          |
| 26                         | Reactivation year 2         | --                                                                                                          |
| 27                         | Reactivation year 3         | --                                                                                                          |
| 28                         | Geomorphology               | Moderately dissected hill                                                                                   |
| 29                         | Geology                     | Sillimanite-Kyanite bearing schist, quartzite of Morang Formation, Vaikrita Group                           |
| 30                         | Structure                   | --.                                                                                                         |
| 31                         | Land use land cover         | Agriculture, Settlement                                                                                     |
| 32                         | Hydrological condition      | Damp                                                                                                        |
| 33                         | Triggering factor           | Heavy Rainfall.                                                                                             |
| 34                         | Persons death               | --                                                                                                          |
| 35                         | People affected             | --                                                                                                          |
| 36                         | Livestock affected          | --                                                                                                          |
| 37                         | Communication affected      | Yes                                                                                                         |
| 38                         | Infrastructure affected     | Damaged to houses.                                                                                          |
| 39                         | Landuse land cover affected | Apple Orchards were damaged.                                                                                |
| 40                         | Geoscientific causes        | Saturation of slope forming material from surface runoff water during incessant rainfall.                   |
|                            |                             | Reactivation of small unchannelized rills/drainage triggered the slide.                                     |
|                            |                             |                                                                                                             |
| 41                         | Remedial measures, if any   | Proper drainage alignment in the form of channelization of nala/ domestic waste water.                      |
|                            |                             | Scaling of loose debris in the upslope.                                                                     |
|                            |                             | Construction of retaining /gabion wall to stabilized the slope forming material.                            |
|                            |                             | Loading of toe support is suggested to protect it further mass movement.                                    |
|                            |                             | The wide-open ground/tension cracks shall be filled with locally available impervious material immediately. |
| 42                         | Remarks                     |                                                                                                             |
| 43 Photograph of the slide |                             |                                                                                                             |
|                            |                             |                                                                                                             |



|    |                                |                               |
|----|--------------------------------|-------------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/17           |
| 1  | State                          | Himachal Pradesh              |
| 2  | District                       | Kullu                         |
| 3  | Toposheet No                   | 53E/7                         |
| 4  | Slide Name                     | Chehva                        |
| 5  | NH/SH Location                 | ----                          |
| 6  | Latitude                       | 31°24'12.8"N                  |
| 7  | Longitude                      | 77°26'51.0"E                  |
| 8  | Landslide alert categorisation | II                            |
| 9  | Length                         | ~47m                          |
| 10 | Width                          | ~15 m                         |
| 11 | Height                         | ~25 m                         |
| 12 | Area                           | ~705sq.m <sup>2</sup>         |
| 13 | Run out distance               | ~60 m                         |
| 14 | Depth                          | 2-5m                          |
| 15 | Landslide volume               | ~3525m <sup>3</sup>           |
| 16 | Material type                  | Debris                        |
| 17 | Movement type                  | Subsidence                    |
| 18 | Movement rate                  | Moderate                      |
| 19 | Activity                       | Active                        |
| 20 | Distribution                   | Retrogressive, widening       |
| 21 | Style                          | Single                        |
| 22 | Failure plane                  | Shallow                       |
| 23 | Failure                        | Shallow translational failure |

|    |                             |                                                                                                                                                                                         |
|----|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | mechanism                   |                                                                                                                                                                                         |
| 24 | Initiation year             | 2023                                                                                                                                                                                    |
| 25 | Reactivation year 1         | --                                                                                                                                                                                      |
| 26 | Reactivation year 2         | --                                                                                                                                                                                      |
| 27 | Reactivation year 3         | --                                                                                                                                                                                      |
| 28 | Geomorphology               | Moderately dissected hill                                                                                                                                                               |
| 29 | Geology                     | Sillimanite-Kyanite bearing schist, quartzite of Morang Formation, Vaikrita Group                                                                                                       |
| 30 | Structure                   | --.                                                                                                                                                                                     |
| 31 | Land use land cover         | Agriculture, Settlement                                                                                                                                                                 |
| 32 | Hydrological condition      | Wet                                                                                                                                                                                     |
| 33 | Triggering factor           | Heavy Rainfall.                                                                                                                                                                         |
| 34 | Persons death               | --                                                                                                                                                                                      |
| 35 | People affected             | --                                                                                                                                                                                      |
| 36 | Livestock affected          | --                                                                                                                                                                                      |
| 37 | Communication affected      | Yes                                                                                                                                                                                     |
| 38 | Infrastructure affected     | ----                                                                                                                                                                                    |
| 39 | Landuse land cover affected | Apple Orchards were damaged.                                                                                                                                                            |
| 40 | Geoscientific causes        | Oversaturation of prolonged water from agricultural land and percolation of rainwater within loose debris material due to heavy rainfall leads for the subsidence and slide activities. |
|    |                             | Small unchannelized rills/drainage triggered the slide.                                                                                                                                 |
|    |                             |                                                                                                                                                                                         |
| 41 | Remedial measures, if any   | Proper drainage alignment in the form of channelization of nala/ domestic waste water.                                                                                                  |
|    |                             | Well dug at suitable location along the distressed slope coupled with line channelized drainage.                                                                                        |
|    |                             | Construction of retaining /gabion wall to stabilized the slope forming material.                                                                                                        |
|    |                             | The wide-open ground/tension cracks shall be filled with locally available impervious material immediately.                                                                             |
| 42 | Remarks                     |                                                                                                                                                                                         |

43. Photograph of the slide-



Subsidence  
observed in  
road



Fig.1. Unstable crown observed in Chehava slide



Fig.2. Open ground cracks in Chehava slide

|    |                                |                     |
|----|--------------------------------|---------------------|
| No | Slide No                       | HP/KUL/53E7/2023/18 |
| 1  | State                          | Himachal Pradesh    |
| 2  | District                       | Kullu               |
| 3  | Toposheet No                   | 53E/7               |
| 4  | Slide Name                     | Lehrarali           |
| 5  | NH/SH Location                 | ----                |
| 6  | Latitude                       | 31°24'42.7"N        |
| 7  | Longitude                      | 77°25'44.5"E        |
| 8  | Landslide alert categorisation | II                  |
| 9  | Length                         | ~25m                |
| 10 | Width                          | ~20 m               |
| 11 | Height                         | ~15m                |

|    |                              |                                                                                                                                                                                         |
|----|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12 | Area                         | ~500 sq.m <sup>2</sup>                                                                                                                                                                  |
| 13 | Run out distance             | ~20 m                                                                                                                                                                                   |
| 14 | Depth                        | 2-5m                                                                                                                                                                                    |
| 15 | Landslide volume             | ~2000 m <sup>3</sup>                                                                                                                                                                    |
| 16 | Material type                | Debris                                                                                                                                                                                  |
| 17 | Movement type                | Subsidence                                                                                                                                                                              |
| 18 | Movement rate                | Moderate                                                                                                                                                                                |
| 19 | Activity                     | Active                                                                                                                                                                                  |
| 20 | Distribution                 | Retrogressive, widening                                                                                                                                                                 |
| 21 | Style                        | Single                                                                                                                                                                                  |
| 22 | Failure plane                | Shallow                                                                                                                                                                                 |
| 23 | Failure mechanism            | Shallow translational failure                                                                                                                                                           |
| 24 | Initiation year              | 2023                                                                                                                                                                                    |
| 25 | Reactivation year 1          | --                                                                                                                                                                                      |
| 26 | Reactivation year 2          | --                                                                                                                                                                                      |
| 27 | Reactivation year 3          | --                                                                                                                                                                                      |
| 28 | Geomorphology                | Moderately dissected hill                                                                                                                                                               |
| 29 | Geology                      | Sillimanite-Kyanite bearing schist, quartzite of Morang Formation, Vaikrita Group                                                                                                       |
| 30 | Structure                    | --.                                                                                                                                                                                     |
| 31 | Land use land cover          | Agriculture, Settlement                                                                                                                                                                 |
| 32 | Hydrological condition       | Wet                                                                                                                                                                                     |
| 33 | Triggering factor            | Heavy Rainfall.                                                                                                                                                                         |
| 34 | Person's death               | --                                                                                                                                                                                      |
| 35 | People affected              | --                                                                                                                                                                                      |
| 36 | Livestock affected           | --                                                                                                                                                                                      |
| 37 | Communication affected       | Footpath road to village is damaged fully.                                                                                                                                              |
| 38 | Infrastructure affected      | ----                                                                                                                                                                                    |
| 39 | Land use land cover affected | Apple Orchards were damaged.                                                                                                                                                            |
| 40 | Geoscientific causes         | Oversaturation of prolonged water from agricultural land and percolation of rainwater within loose debris material due to heavy rainfall leads for the subsidence and slide activities. |
|    |                              | Slope saturation from domestic usage of water also one factor to triggered the slide                                                                                                    |
|    |                              |                                                                                                                                                                                         |
| 41 | Remedial                     | Scaling of loose material on the unstable crown.                                                                                                                                        |

|    |                                                                                     |                                                                      |
|----|-------------------------------------------------------------------------------------|----------------------------------------------------------------------|
|    | measures, if any                                                                    | Proper channelization of nala to be suggested for drainage purposes. |
|    |                                                                                     | Construction of breast wall to stabilized the slide material.        |
|    |                                                                                     | Loading of toe support to be implemented.                            |
| 42 | Remarks                                                                             |                                                                      |
| 43 | Photograph of the slide-                                                            |                                                                      |
|    |  |                                                                      |
|    | Fig.1. Unstable crown with toe side observed in Leharali slide                      |                                                                      |

|    |                                |                            |
|----|--------------------------------|----------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/19        |
| 1  | State                          | Himachal Pradesh           |
| 2  | District                       | Kullu                      |
| 3  | Toposheet No                   | 53E/6                      |
| 4  | Slide Name                     | Mashnoo Nala               |
| 5  | NH/SH Location                 | NH 305                     |
| 6  | Latitude                       | 31°31'41.3"N               |
| 7  | Longitude                      | 77°24' 04.5"E              |
| 8  | Landslide alert categorisation | II                         |
| 9  | Length                         | ~560m                      |
| 10 | Width                          | ~200m                      |
| 11 | Height                         | ~83m                       |
| 12 | Area                           | ~ 112000 sq.m <sup>2</sup> |
| 13 | Run out distance               | ~500m                      |
| 14 | Depth                          | 5-9m                       |
| 15 | Landslide volume               | ~784000 sq.m <sup>3</sup>  |
| 16 | Material type                  | Debris                     |
| 17 | Movement type                  | Slide                      |
| 18 | Movement rate                  | Moderate                   |
| 19 | Activity                       | Active                     |
| 20 | Distribution                   | Retrogressive, enlarging   |
| 21 | Style                          | Multiple                   |

|    |                             |                                                                                                                                                                     |
|----|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 22 | Failure plane               | Deep                                                                                                                                                                |
| 23 | Failure mechanism           | Deep rotational failure                                                                                                                                             |
| 24 | Initiation year             | 2018                                                                                                                                                                |
| 25 | Reactivation year 1         | 2019                                                                                                                                                                |
| 26 | Reactivation year 2         | --                                                                                                                                                                  |
| 27 | Reactivation year 3         | 2023                                                                                                                                                                |
| 28 | Geomorphology               | Moderately dissected hill                                                                                                                                           |
| 29 | Geology                     | Schist, quartzite of Khokhan Formation, Kullu Group                                                                                                                 |
| 30 | Structure                   | --.                                                                                                                                                                 |
| 31 | Land use land cover         | Sparse vegetation                                                                                                                                                   |
| 32 | Hydrological condition      | Wet, damp and dripping                                                                                                                                              |
| 33 | Triggering factor           | Heavy Rainfall                                                                                                                                                      |
| 34 | Person's death              | --                                                                                                                                                                  |
| 35 | People affected             | --                                                                                                                                                                  |
| 36 | Livestock affected          | --                                                                                                                                                                  |
| 37 | Communication affected      | NH 305 Road is damaged fully.                                                                                                                                       |
| 38 | Infrastructure affected     | ----                                                                                                                                                                |
| 39 | Landuse land cover affected | ---                                                                                                                                                                 |
| 40 | Geoscientific causes        | oversaturation of slope forming material from the surface runoff water during heavy rainfall.                                                                       |
|    |                             | Discharge of upslope surface water directly to the distressed slope.                                                                                                |
|    |                             | Seepages points present along the slope could lead to piping out of finer sand, silt and clay material of the slope are also likely to contribute to slope failure. |
|    |                             | Toe erosion of Mashnoo nala.                                                                                                                                        |
|    |                             | Seasonal nalas bounded the periphery of the slide which brings heavy discharge and erode the side slopes further widening the slide zone.                           |
|    |                             |                                                                                                                                                                     |
| 41 | Remedial measures, if any   | Scaling of loose material/ dislodged rock boulders on the unstable crown.                                                                                           |
|    |                             | Channelize the nala course with suitable width cascade structures.                                                                                                  |

|                                                                                    |         |                                                                                               |
|------------------------------------------------------------------------------------|---------|-----------------------------------------------------------------------------------------------|
|                                                                                    |         | Construction of retaining wall with weep holes for proper drainage circulation.               |
|                                                                                    |         | Provide toe protection by RCC wall in consultation with the civil designers as per IS code.   |
|                                                                                    |         | Provide benches /berms at suitable distance in consultation with design Engineers.            |
|                                                                                    |         | Install boulder catch fence/weir mesh at required places below the potential rock fall zones. |
| 42                                                                                 | Remarks |                                                                                               |
| 43. Photograph of the slide-                                                       |         |                                                                                               |
|  |         |            |
| Fig.1. Unstable crown observed in Mashnoo nala slide                               |         | Fig.2. Toe observed in Mashnoo nala slide                                                     |

|    |                                |                     |
|----|--------------------------------|---------------------|
| No | Slide No                       | HP/KUL/53E7/2023/20 |
| 1  | State                          | Himachal Pradesh    |
| 2  | District                       | Kullu               |
| 3  | Toposheet No                   | 53E/6               |
| 4  | Slide Name                     | Kot Nala            |
| 5  | NH/SH Location                 | NH 305              |
| 6  | Latitude                       | 31°31'5.76"N        |
| 7  | Longitude                      | 77°25'0.24"E        |
| 8  | Landslide alert categorisation | II                  |
| 9  | Length                         | ~400m               |
| 10 | Width                          | ~150 m              |

|    |                              |                                                                                                                                                                                                       |
|----|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11 | Height                       | ~65m                                                                                                                                                                                                  |
| 12 | Area                         | ~67500 sq.m <sup>2</sup>                                                                                                                                                                              |
| 13 | Run out distance             | ~20 m                                                                                                                                                                                                 |
| 14 | Depth                        | 5-8m                                                                                                                                                                                                  |
| 15 | Landslide volume             | ~360000 m <sup>3</sup>                                                                                                                                                                                |
| 16 | Material type                | Debris                                                                                                                                                                                                |
| 17 | Movement type                | Slide                                                                                                                                                                                                 |
| 18 | Movement rate                | Moderate                                                                                                                                                                                              |
| 19 | Activity                     | Active                                                                                                                                                                                                |
| 20 | Distribution                 | Retrogressive, widening                                                                                                                                                                               |
| 21 | Style                        | Multiple                                                                                                                                                                                              |
| 22 | Failure plane                | Deep                                                                                                                                                                                                  |
| 23 | Failure mechanism            | Deep translational failure                                                                                                                                                                            |
| 24 | Initiation year              | 2008                                                                                                                                                                                                  |
| 25 | Reactivation year 1          | 2023                                                                                                                                                                                                  |
| 26 | Reactivation year 2          | --                                                                                                                                                                                                    |
| 27 | Reactivation year 3          | --                                                                                                                                                                                                    |
| 28 | Geomorphology                | Highly dissected hill                                                                                                                                                                                 |
| 29 | Geology                      | Schist, quartzite of Khokhan Formation, Kullu Group                                                                                                                                                   |
| 30 | Structure                    | --                                                                                                                                                                                                    |
| 31 | Land use land cover          | Sparse vegetation, Agriculture                                                                                                                                                                        |
| 32 | Hydrological condition       | Wet, damp and dripping                                                                                                                                                                                |
| 33 | Triggering factor            | Heavy Rainfall and toe erosion by the nalas.                                                                                                                                                          |
| 34 | Person's death               | --                                                                                                                                                                                                    |
| 35 | People affected              | --                                                                                                                                                                                                    |
| 36 | Livestock affected           | --                                                                                                                                                                                                    |
| 37 | Communication affected       | NH 305 is blocked due to landslide.                                                                                                                                                                   |
| 38 | Infrastructure affected      | ----                                                                                                                                                                                                  |
| 39 | Land use land cover affected | ---                                                                                                                                                                                                   |
| 40 | Geoscientific causes         | Flowing nalas are present adjacent to the slide area which erode the soft slope forming material from the upslope side to downward direction which is triggered by heavy rainfall leads to the slide. |
|    |                              | Toe erosion by Kot Nala.                                                                                                                                                                              |
|    |                              |                                                                                                                                                                                                       |
| 41 | Remedial measures, if any    | Scaling of loose material on the unstable crown.                                                                                                                                                      |
|    |                              | Proper lined and channelization of nala to avoid surface water                                                                                                                                        |

|    |         |                                                                                                                         |
|----|---------|-------------------------------------------------------------------------------------------------------------------------|
|    |         | discharge from the distressed slope.                                                                                    |
|    |         | Construction of proper lined drainage along the hillside connecting it to the main adjoining <i>nala</i> .              |
|    |         | Adequate retaining wall along the Kot Nala for toe support.                                                             |
|    |         | Installation of underground drainage pipe below the present road level along the major depression of the affected zone. |
|    |         | Loading of toe support to be implemented.                                                                               |
| 42 | Remarks |                                                                                                                         |

43. Photograph of the slide-

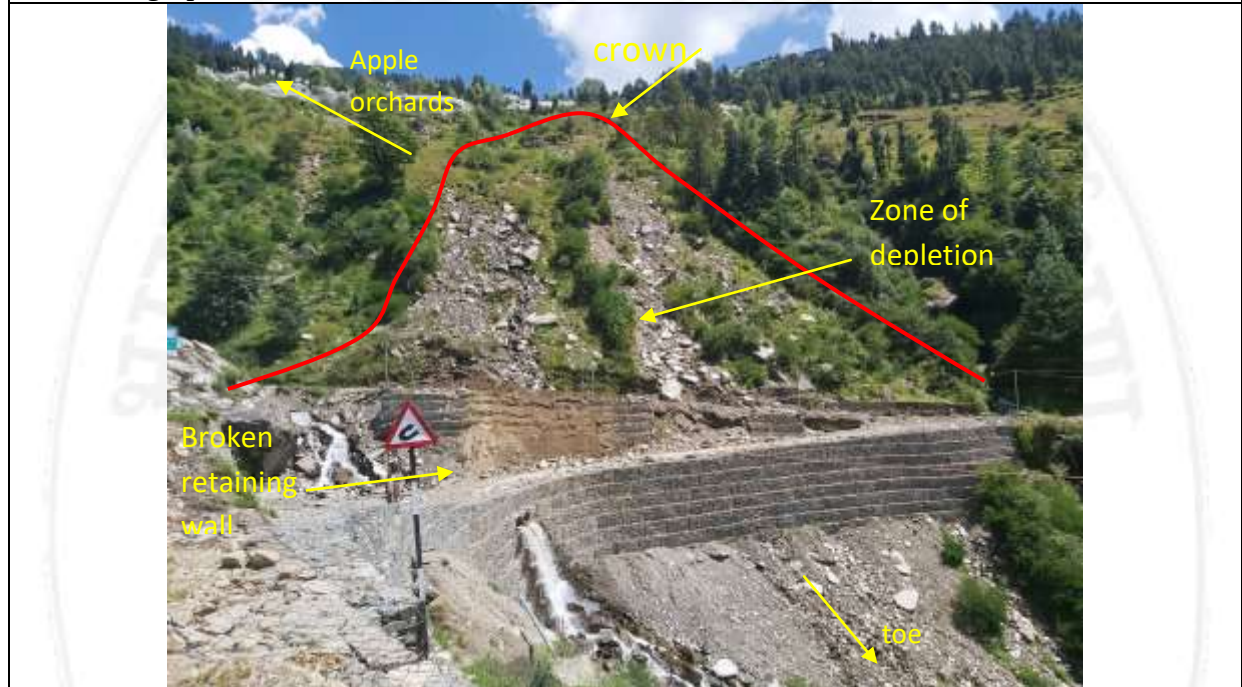


Fig.1. Unstable crown with toe side, and zone of depletion observed in Kot Nala slide

|    |                                |                         |
|----|--------------------------------|-------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/20     |
| 1  | State                          | Himachal Pradesh        |
| 2  | District                       | Kullu                   |
| 3  | Toposheet No                   | 53E/7                   |
| 4  | Slide Name                     | Falela <i>Nala</i>      |
| 5  | NH/SH Location                 | NH 305                  |
| 6  | Latitude                       | 31°29'01.6"N            |
| 7  | Longitude                      | 77°25'23.1"E            |
| 8  | Landslide alert categorisation | II                      |
| 9  | Length                         | ~65m                    |
| 10 | Width                          | ~20 m                   |
| 11 | Height                         | ~45m                    |
| 12 | Area                           | ~1300 sq.m <sup>2</sup> |
| 13 | Run out distance               | ~40 m                   |
| 14 | Depth                          | 5-8m                    |
| 15 | Landslide volume               | ~10400 m <sup>3</sup>   |

|    |                              |                                                                                                                                                                                                                                                                                                 |
|----|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16 | Material type                | Debris                                                                                                                                                                                                                                                                                          |
| 17 | Movement type                | Slide                                                                                                                                                                                                                                                                                           |
| 18 | Movement rate                | Moderate                                                                                                                                                                                                                                                                                        |
| 19 | Activity                     | Active                                                                                                                                                                                                                                                                                          |
| 20 | Distribution                 | Retrogressive, widening                                                                                                                                                                                                                                                                         |
| 21 | Style                        | Multiple                                                                                                                                                                                                                                                                                        |
| 22 | Failure plane                | Deep                                                                                                                                                                                                                                                                                            |
| 23 | Failure mechanism            | Deep rotational failure                                                                                                                                                                                                                                                                         |
| 24 | Initiation year              | 2022                                                                                                                                                                                                                                                                                            |
| 25 | Reactivation year 1          | 2023                                                                                                                                                                                                                                                                                            |
| 26 | Reactivation year 2          | --                                                                                                                                                                                                                                                                                              |
| 27 | Reactivation year 3          | --                                                                                                                                                                                                                                                                                              |
| 28 | Geomorphology                | Highly dissected hill                                                                                                                                                                                                                                                                           |
| 29 | Geology                      | Sillimanite-Kyanite bearing schist and quartzite of Morang Formation, Vaikrita Group.                                                                                                                                                                                                           |
| 30 | Structure                    | --                                                                                                                                                                                                                                                                                              |
| 31 | Land use land cover          |                                                                                                                                                                                                                                                                                                 |
| 32 | Hydrological condition       | Wet, damp and dripping                                                                                                                                                                                                                                                                          |
| 33 | Triggering factor            | Heavy Rainfall and toe erosion by the nalas.                                                                                                                                                                                                                                                    |
| 34 | Person's death               | --                                                                                                                                                                                                                                                                                              |
| 35 | People affected              | --                                                                                                                                                                                                                                                                                              |
| 36 | Livestock affected           | --                                                                                                                                                                                                                                                                                              |
| 37 | Communication affected       | NH 305 is blocked due to landslide.                                                                                                                                                                                                                                                             |
| 38 | Infrastructure affected      | ----                                                                                                                                                                                                                                                                                            |
| 39 | Land use land cover affected | Apple orchards were damaged.                                                                                                                                                                                                                                                                    |
| 40 | Geoscientific causes         | Oversaturation of slope area and surface run off water along steep slope.<br>Excessive erosion from upslope runoff water leading to development of rills and gully along the distressed zone.<br>Heavy rainfall is also a triggered factor for the slide.                                       |
| 41 | Remedial measures, if any    | Proper lined channelization drainage should be constructed along hill side of the road.<br>Construct channelized lined contour parallel drainage above the crown of the slide and divert its channel to the main <i>Nala</i> .<br>Construct adequate retaining/breast wall to support the belly |

|     |                                                                                                                        |                                                                                                                                                                      |
|-----|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|     |                                                                                                                        | portion of the slide.                                                                                                                                                |
|     |                                                                                                                        | Biotechnical stabilisation/ Plantation of suitably identified species that can hold the soil in the failure affected zone in consultation with Botanist/Forest dept. |
| 42  | Remarks                                                                                                                |                                                                                                                                                                      |
| 43. | Photograph of the slide-                                                                                               |                                                                                                                                                                      |
|     |                                      |                                                                                   |
|     | Fig.1. Excessive erosion from upslope runoff water leading to development of rills and gully along the distressed zone | Fig2. Run out material of the slide as descernable from the road                                                                                                     |

|    |                                |                        |
|----|--------------------------------|------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/21    |
| 1  | State                          | Himachal Pradesh       |
| 2  | District                       | Kullu                  |
| 3  | Toposheet No                   | 52H/4                  |
| 4  | Slide Name                     | Shailubhan             |
| 5  | NH/SH Location                 | NH 305                 |
| 6  | Latitude                       | 31°29'11.4"N           |
| 7  | Longitude                      | 77°24'52.8"E           |
| 8  | Landslide alert categorisation | II                     |
| 9  | Length                         | ~25m                   |
| 10 | Width                          | ~ 15m                  |
| 11 | Height                         | ~22m                   |
| 12 | Area                           | ~375 sq.m <sup>2</sup> |
| 13 | Run out distance               | ~15 m                  |
| 14 | Depth                          | 5-6m                   |
| 15 | Landslide volume               | ~2250 m <sup>3</sup>   |
| 16 | Material type                  | Debris                 |
| 17 | Movement type                  | Slide                  |
| 18 | Movement rate                  | Moderate               |
| 19 | Activity                       | Active                 |

|    |                              |                                                                                                                                                                                                       |
|----|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 20 | Distribution                 | Retrogressive, widening                                                                                                                                                                               |
| 21 | Style                        | Multiple                                                                                                                                                                                              |
| 22 | Failure plane                | Deep                                                                                                                                                                                                  |
| 23 | Failure mechanism            | Deep translational failure                                                                                                                                                                            |
| 24 | Initiation year              | 2023                                                                                                                                                                                                  |
| 25 | Reactivation year 1          | ---                                                                                                                                                                                                   |
| 26 | Reactivation year 2          | --                                                                                                                                                                                                    |
| 27 | Reactivation year 3          | --                                                                                                                                                                                                    |
| 28 | Geomorphology                | Moderate to highly dissected hill                                                                                                                                                                     |
| 29 | Geology                      | Sillimanite-Kyanite bearing schist and quartzite of Morang Formation, Vaikrita Group.                                                                                                                 |
| 30 | Structure                    | --                                                                                                                                                                                                    |
| 31 | Land use land cover          | Sparse vegetation                                                                                                                                                                                     |
| 32 | Hydrological condition       | Wet, damp and dripping                                                                                                                                                                                |
| 33 | Triggering factor            | Heavy Rainfall and toe erosion by the nalas.                                                                                                                                                          |
| 34 | Person's death               | --                                                                                                                                                                                                    |
| 35 | People affected              | --                                                                                                                                                                                                    |
| 36 | Livestock affected           | --                                                                                                                                                                                                    |
| 37 | Communication affected       | NH 305 is blocked due to landslide.                                                                                                                                                                   |
| 38 | Infrastructure affected      | ----                                                                                                                                                                                                  |
| 39 | Land use land cover affected | Apple orchards were damaged.                                                                                                                                                                          |
| 40 | Geoscientific causes         | Presence of loose and fragile rock/ debris material in the upslope and along the side slopes of the nala.                                                                                             |
|    |                              | Unchannelized drainage on hill side of the road.                                                                                                                                                      |
|    |                              | Toe portion of slide gets eroded by the flowing nala.                                                                                                                                                 |
|    |                              | Loose and fragile rock/ debris material resting along slopes and nala side slopes gets eroded and trigger debris flows with surface run-off. Heavy rainfall is also a triggered factor for the slide. |
|    |                              |                                                                                                                                                                                                       |
| 41 | Remedial measures, if any    | Loose material along the major nala need to be removed manually/mechanically.                                                                                                                         |
|    |                              | Proper lined channelization drainage should be constructed along hill side of the road.                                                                                                               |
|    |                              | Construction of adequate retaining wall along the Hill side of the road with a provision of weep holes.                                                                                               |
|    |                              | Toe should be stabilized with the construction of bench walls.                                                                                                                                        |

|                                                                                   |         |                                                                                    |
|-----------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------|
| 42                                                                                | Remarks |                                                                                    |
| 43. Photograph of the slide-                                                      |         |                                                                                    |
|  |         |  |
| Fig.1. Crown portion covered with plastic sheets of slide                         |         | Fig.2. Toe side of slide                                                           |

|    |                                |                               |
|----|--------------------------------|-------------------------------|
| No | Slide No                       | HP/KUL/53E7/2023/22           |
| 1  | State                          | Himachal Pradesh              |
| 2  | District                       | Kullu                         |
| 3  | Toposheet No                   | 52H/4                         |
| 4  | Slide Name                     | Shaleen                       |
| 5  | NH/SH Location                 | --                            |
| 6  | Latitude                       | 32°11'55.1"N                  |
| 7  | Longitude                      | 77°11'05.9"E                  |
| 8  | Landslide alert categorisation | II                            |
| 9  | Length                         | ~15m                          |
| 10 | Width                          | ~10 m                         |
| 11 | Height                         | ~5m                           |
| 12 | Area                           | ~150 sq.m <sup>2</sup>        |
| 13 | Run out distance               | ~20 m                         |
| 14 | Depth                          | 2-5m                          |
| 15 | Landslide volume               | ~ 750m <sup>3</sup>           |
| 16 | Material type                  | Debris                        |
| 17 | Movement type                  | Subsidence                    |
| 18 | Movement rate                  | Moderate                      |
| 19 | Activity                       | Inactive                      |
| 20 | Distribution                   | Retrogressive                 |
| 21 | Style                          | Single                        |
| 22 | Failure plane                  | Shallow                       |
| 23 | Failure mechanism              | Shallow translational failure |
| 24 | Initiation year                | 2023                          |

|                              |                              |                                                                                                                                                 |
|------------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 25                           | Reactivation year 1          |                                                                                                                                                 |
| 26                           | Reactivation year 2          | --                                                                                                                                              |
| 27                           | Reactivation year 3          | --                                                                                                                                              |
| 28                           | Geomorphology                | Moderately dissected hill                                                                                                                       |
| 29                           | Geology                      | Sillimanite-Kyanite bearing schist and quartzite of Morang Formation, Vaikrita Group.                                                           |
| 30                           | Structure                    | --                                                                                                                                              |
| 31                           | Land use land cover          | Sparse vegetation                                                                                                                               |
| 32                           | Hydrological condition       | Wet, damp and dripping                                                                                                                          |
| 33                           | Triggering factor            | Heavy Rainfall and toe erosion by the nalas.                                                                                                    |
| 34                           | Person's death               | --                                                                                                                                              |
| 35                           | People affected              | --                                                                                                                                              |
| 36                           | Livestock affected           | --                                                                                                                                              |
| 37                           | Communication affected       | --                                                                                                                                              |
| 38                           | Infrastructure affected      | ----                                                                                                                                            |
| 39                           | Land use land cover affected | Apple orchards were damaged.                                                                                                                    |
| 40                           | Geoscientific causes         | Oversaturation of water within semi consolidated material during heavy rainfall weakens the slope forming material triggered the subsidence     |
|                              |                              | Seepage points could lead to piping out of finer material of the slope are also likely to contribute to subsidence.                             |
|                              |                              | Lack of drainage management.                                                                                                                    |
|                              |                              |                                                                                                                                                 |
| 41                           | Remedial measures, if any    | Construction of adequate retaining wall with a provision of weep hole.                                                                          |
|                              |                              | Dripping/flowing <i>Nala</i> present along the slide area need to be properly channelized coupled with installation of culvert across the road. |
|                              |                              | Construct channelized lined contour parallel drainage above the crown and divert it to the main <i>Nala</i> .                                   |
|                              |                              | Proper drainage management.                                                                                                                     |
| 42                           | Remarks                      |                                                                                                                                                 |
| 43. Photograph of the slide- |                              |                                                                                                                                                 |



Fig.1. Subsidence of road observed in Shaleen village



Fig.2. Unstable crown portion of Shaleen slide

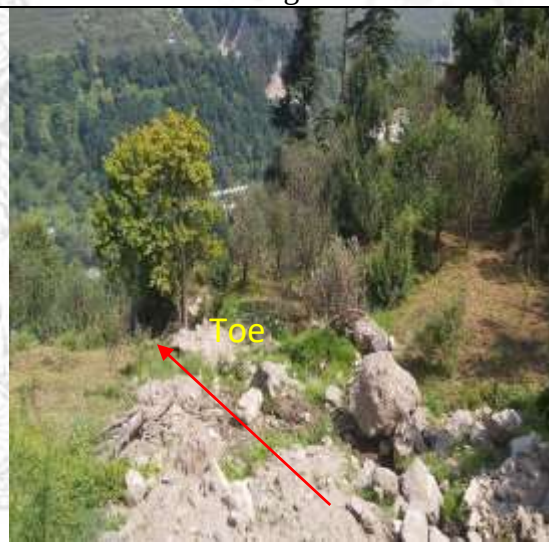
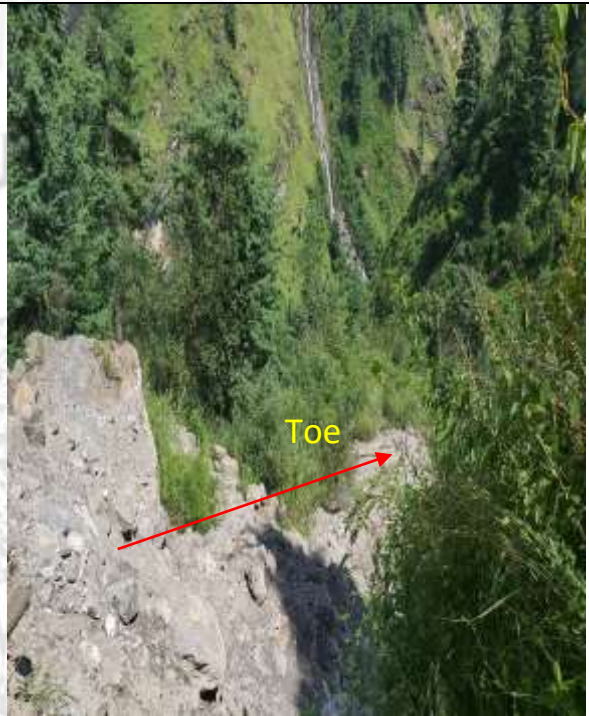


Fig.3. Toe side of Shaleen slide

|    |                                |                     |
|----|--------------------------------|---------------------|
| No | Slide No                       | HP/KUL/53E7/2023/23 |
| 1  | State                          | Himachal Pradesh    |
| 2  | District                       | Kullu               |
| 3  | Toposheet No                   | 52H/4               |
| 4  | Slide Name                     | Darsha              |
| 5  | NH/SH Location                 | ---                 |
| 6  | Latitude                       | 32°08'56.51"N       |
| 7  | Longitude                      | 77°09'8.44"E        |
| 8  | Landslide alert categorisation | II                  |
| 9  | Length                         | ~35m                |
| 10 | Width                          | ~30 m               |

|    |                              |                                                                             |
|----|------------------------------|-----------------------------------------------------------------------------|
| 11 | Height                       | ~25m                                                                        |
| 12 | Area                         | ~1050 sq.m <sup>2</sup>                                                     |
| 13 | Run out distance             | ~20 m                                                                       |
| 14 | Depth                        | 2-5m                                                                        |
| 15 | Landslide volume             | ~5250 m <sup>3</sup>                                                        |
| 16 | Material type                | Debris                                                                      |
| 17 | Movement type                | Slide                                                                       |
| 18 | Movement rate                | Moderate                                                                    |
| 19 | Activity                     | Active                                                                      |
| 20 | Distribution                 | Retrogressive, widening                                                     |
| 21 | Style                        | Multiple                                                                    |
| 22 | Failure plane                | Shallow                                                                     |
| 23 | Failure mechanism            | Shallow translational failure                                               |
| 24 | Initiation year              | 2023                                                                        |
| 25 | Reactivation year 1          | --                                                                          |
| 26 | Reactivation year 2          | --                                                                          |
| 27 | Reactivation year 3          | --                                                                          |
| 28 | Geomorphology                | Highly dissected hill                                                       |
| 29 | Geology                      | Schist, Gneiss, Migmatite of Khari Formation, Vaikrita Group.               |
| 30 | Structure                    | --                                                                          |
| 31 | Land use land cover          | Dense vegetation                                                            |
| 32 | Hydrological condition       | Wet and dripping                                                            |
| 33 | Triggering factor            | Heavy Rainfall                                                              |
| 34 | Person's death               | --                                                                          |
| 35 | People affected              | --                                                                          |
| 36 | Livestock affected           | --                                                                          |
| 37 | Communication affected       | PMGSY road is blocked due to slide.                                         |
| 38 | Infrastructure affected      | ----                                                                        |
| 39 | Land use land cover affected | -----                                                                       |
| 40 | Geoscientific causes         | Saturation of water on loose debris material during heavy rainfall.         |
|    |                              | Lack of drainage management.                                                |
|    |                              | Road cutting along steep slope.                                             |
|    |                              |                                                                             |
| 41 | Remedial measures, if any    | Construct adequate retaining wall along the hill side.                      |
|    |                              | Construction of lined channelized drainage along the hill side of the road. |

|                                                                                    |         |                                                                                                      |
|------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------|
|                                                                                    |         | Repair/replaced the damaged retaining wall along the valley side along the Manali-Darsha PMGSY Road. |
|                                                                                    |         | Channelization of seasonal nalas with construction of culverts along nala-road junctions.            |
| 42                                                                                 | Remarks |                                                                                                      |
| 43. Photograph of the slide-                                                       |         |                                                                                                      |
|  |         |                   |
| Fig.1. Unstable crown portion of Darsha slide                                      |         | Fig.2. Toe side of Darsha slide                                                                      |