H.P. COUNCIL FOR SCIENCE TECHNOLOGY & ENVIRONMENT (HIMCOSTE)
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SCSTE /CCC/F (7)-7/10 **DATED, THE SHIMLA**

To,

The Director-cum- Spl. Secretary (Rev-DM) to the Government of Himachal Pradesh,
Shimla-2, Himachal Pradesh.

Subject: **Technical Report on the Cause and Impact Analysis of Land Subsidence and Landslide Activity in Shimla.**

Sir,

Kindly refer to your office order No . Rev (DMC) (F)11-09/2021 –LM dated 19-08-2023 vide which a Committee consisting of following members from different department was constituted by the Government to carry out the cause and impact analysis of the landslide activities in Shimla during current monsoon season.

1. Dr.S.S.Randhawa, Principal Scientific officer, HIMCOSTE, Coordinator
2. Sh.Puneet Guleria, State Geologist, Geological Wing, Industry Deptt.
3. Sh.Sunil Verma, Assistant Geologist, Geological Wing, Industry Deptt.
4. Er.Neelam Gupta, XEN Design, HPPWD ,E-in-C Office, , Nirman Bhawan,
5. Er.Basant Rathore, XEN, JSV, Kasumpti, Division
6. Er. Rajiv Kaundal, AE Design, HPPWD E-in-C Office, , Nirman Bhawan,
7. Sh.Dinesh Thakur, AE, MC Shimla
8. Sh Khem Chand Verma, Naib Tehsildar, DC Office Shimla

Based on the field survey carried out by the Committee, the findings have been compiled in the form a technical report and the copy of the same is being submitted for the further action at your end please.

Yours sincerely,

(Dr.SS.Randhawa)
Principal Scientific Officer &
Coordinator -Technical Commitee

No. 1079, dt. 04-09-2023

Copy forwarded to all the Committee Members for information please.

Principal Scientific Officer & 04/09/2023
Coordinator -Technical Commitee

A Preliminary Report
On

Landslide, Land Subsidence Incidents in and Around Shimla During July/August 2023 Monsoon Season

CONTENTS

INTRODUCTION

The State of Himachal Pradesh forms a part of the North-western Himalaya and is environmentally fragile and ecologically vulnerable. The occurrence of natural hazards emanating from the effects of climatological variations is a matter of immediate concern to the State of Himachal Pradesh, as every year the state experiences the fury of nature in various forms, like cloudbursts, flash floods, landslides, earthquakes, snow avalanches, droughts, etc. The fragile ecology of the mountain state, coupled with large variations in physio-climatic conditions, has rendered it vulnerable to the vagaries of climate and natural disasters. Physio-graphically, the State has been divided into three broad units: the Lower or Outer Himalaya, the Middle Himalaya, and the Higher or Great Himalaya, and each unit is susceptible to different types of hazards depending upon the lithology, soils, and local climatic variations.

Due to the diverse topography of the area, the flood problem in the state is largely isolated in nature. The monsoon, apart from acting as the lifeline in the young, lofty, and fragile mountain belt of the Himalaya, becomes a potential cause for disturbing slope stability, inflicting heavy loss of life, and damaging Government, private, and public property. High monsoon rains in the areas of the Shiwalik and Lower and Mid Himalayan ranges cause extensive floods during the rainy season. In the upper reaches of the Beas and Satluj valleys, the main problems are flash floods and bank erosion because of the steep slopes of rivers and high river flows due to heavy rains. Often, flash floods caused by cloudbursts and temporary blockages of the river channels have also been observed. Extremely high-intensity rainfall events over a short period of time, or ‘cloudbursts, as they may be called, are a natural phenomenon in the Himalaya and have been found to be a dominant factor in causing extensive damage in different parts of the State during the monsoon period every year.

During the current monsoon period of 2023, the State witnessed very heavy damage due to high precipitation on July 20, 2023, resulting in a loss of more than 8000 crore to the Government exchequer and a great loss of more than 200 precious human lives in different parts of the State. Chamba, Kullu, Mandi, Shimla, and Solan were the worst affected districts of the State that suffered heavy losses in life and property.

The major loss in the State was occurred in two different spells of monsoon depressions. The first monsoon depression that coincides with that of Western Disturbance during the period 9-11 July 2023 resulted very heavy damage and destruction in the State followed by the second

spell during 13-16 August 2023, wherein, the continuous and heavy precipitation resulted heavy damage again in the differ districts of the State. During the second spell, Shimla town experienced very heavy damage in terms of loss of the public property and human lives at different places in and around the city. The major destruction sites were the Shiv Bauri Summer Hill, Krishna Nagar, Phagli where human loss and property loss was reported due to landslides activity resulting collapsing of houses etc.

SHIMLA TOWN

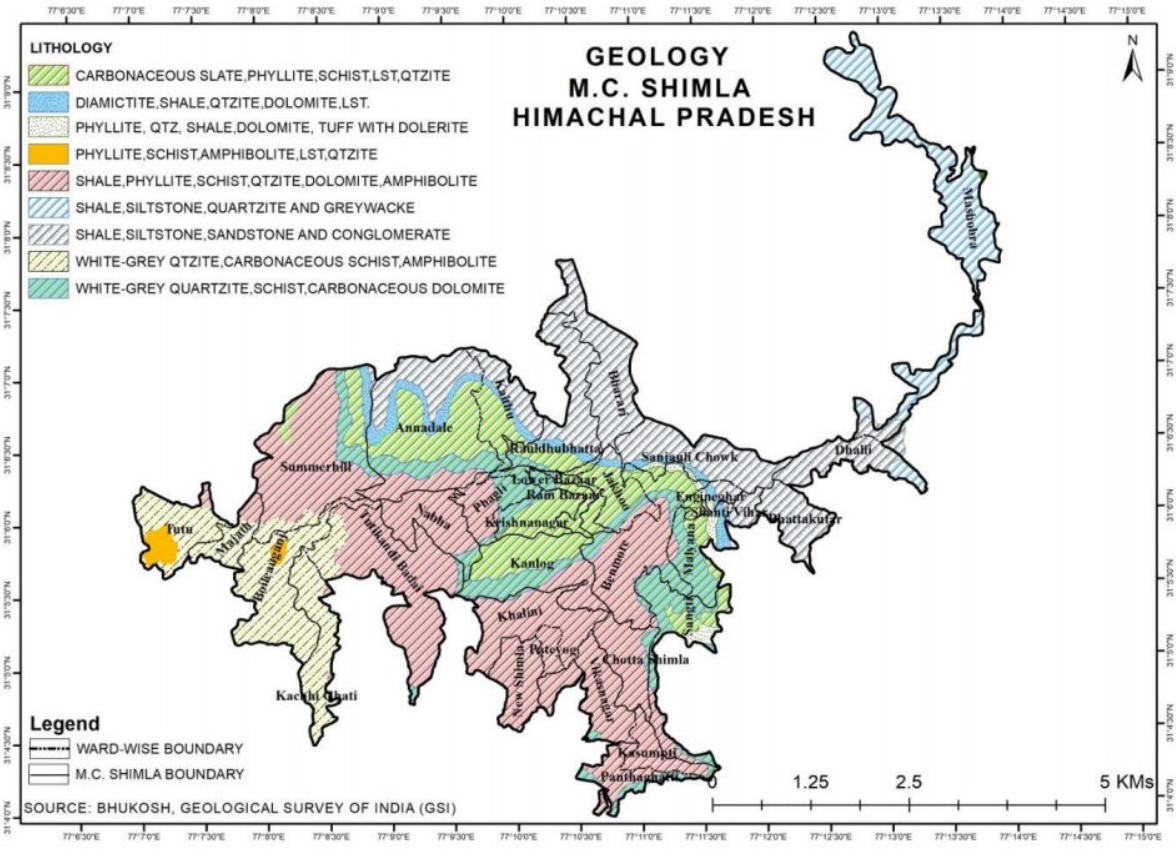
Shimla is the Capital Town of Himachal Pradesh. It was formerly the summer capital during the British Rule. The town of Shimla is built over several hills and connecting ridges. The important hills are Jakhu (8050 ft), Prospect Hill (7140 ft), Observatory Hill (7050 ft), Elysium Hill (7400 ft), and Summer Hill (6900 ft). There is a great controversy over the origin of the name Shimla. The name Shimla was derived from 'Shyamalaya' meaning blue house said to be the name of house built of blue slate by a faqir on Jakhu. According to one version Shimla takes it name from 'Shamla' meaning a blue female another name for Goddess Kali. The place was on the Jakhu Hillside, there was a temple of Goddess Kali. During the British period the image of the Goddess was shifted to a new place, now famous Kali Bari Temple. Shimla remained unnoticed during the Gurkha War. It was only in 1819 A.D. that the then Assistant Political Agent of hill states Lt. Ross set up first British residence, a mere wood cottage. His successor Lt. Charles Patt Kennedy' erected the first pucca house in 1822 named after Lt. Kennedy as 'Kennedy House'.

The construction of Hindustan Tibet Road was started in 1850-51 commencing from Kalka and first lap was up to Shimla. The Road up to Shimla came to be used for wheeled traffic by 1860. A 560 feet long tunnel was constructed beyond Sanjauli. In 1864 Shimla was declared as the summer capital of India. After Independence, Shimla became the capital of Punjab and was later named the capital of Himachal Pradesh. In 1903 a rail line was constructed between Kalka and Shimla. Shimla has been blessed with all the natural bounties; one can think of. Dwelling on a panoramic location, the hilly town is surrounded by green pastures and snow-capped peaks. The spectacular cool hills accompanied by the structures made during the colonial era create an aura, which is very different from other hill stations. Bulging at its seams with unprecedented expansion, Shimla retains its colonial heritage, with grand old buildings, among them are the stately Viceregal Lodge, Charming iron lamp posts and Anglo-Saxon names. The Mall, packed with shops and eateries, is the centre of attraction of the town, and Scandal Point,

associated with the former Maharaja of Patiala's escapades, offers a view of distant snow-clad peaks. In 1946 leaders of the Indian nationalist movement came to Shimla for a crucial conference that paved the way to Independence. The completion of the Kalka-Shimla narrow-gauge railway line, in 1903, gave a fillip to the town's development. After Independence, Shimla was initially the capital of Punjab. Following the creation of Himachal Pradesh, in 1966, it was designated the capital of the Himachal Pradesh.

GENERAL GEOLOGY OF THE SHIMLA TOWN

Geologically Shimla town is characterized by the presence of rocks of Jutogh Group and Shimla Group respectively. Jutogh Group mainly comprises of Schist, Phyllites, Slates, Metaquatzites, Limestone and Gneisses. Oldham (1897) described that Jutogh Group Limestone, Carbonaceous Schist and Quatzites exposed in Jutogh cantonment. Later Pilgrim & West (1928) defined Jutogh series as comprising Quartzite and Mica schist (Boileauganj beds) and Carbonaceous Slates and Phyllites as Jakhoo series. In general, the dominant litho units found in Shimla area are the Schist, Phyllies and Slates as the dominant litho units of Jutogh formation and Shales, Slate Quartzite forming part of the Shimla formation in the town. The general Geological Map as per GSI is as per Fig.1.



RAINFALL TREND ANALYSIS IN HIMACHAL PRADESH

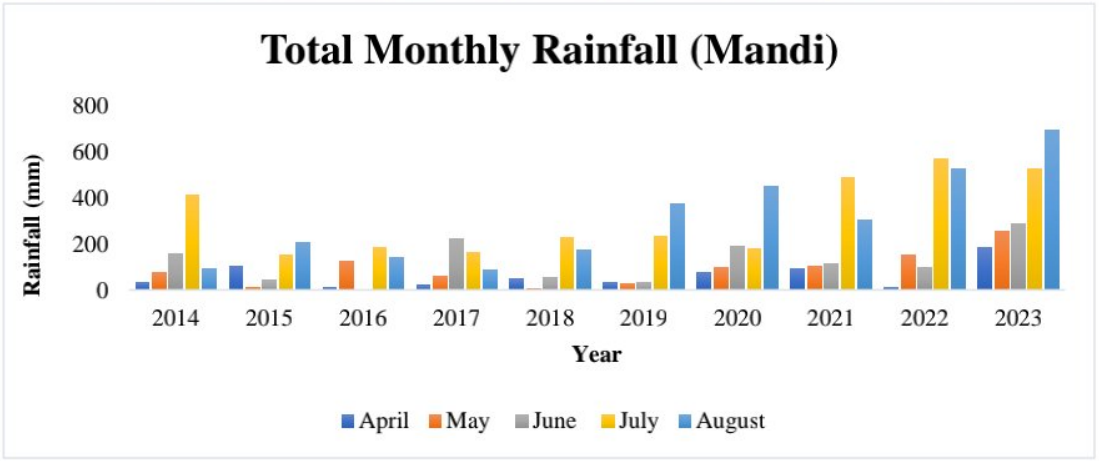
In order to supplement the view of heavy precipitation during 2023, the rainfall analysis for the state of Himachal Pradesh was carried out using the available IMD data from 2014-2023 during the period April to August each year. The rainfall data at five locations Mandi, Shimla, Bhuntar, Kangra and Kalpa in district Kinnaur has been used to validate and to quantify the rainfall data at these locations in H.P. Based on the analysis carried out, the following inferences were made:

- A large variation was recorded in the summer precipitation during the period 2014-2023 i.e in April 2023, the rainfall recorded was on higher side in 2023 than the preceding years. In April 2014 (33.00mm) where as in 2023 it increased to 185.20 mm at Mandi.
- Likewise in May 2014, the rainfall recorded at Mandi was 76.50 mm (2014) whereas in 2023 (253.80 mm) with a few variations i.e. 2021(104.80 mm) and 2022(150.80 mm) respectively.
- In June, the rainfall recorded at Mandi varies from 155.50 mm (2014) to 286.80 mm (2023) with high rainfall during 2017 (220.50) ,2020 (190.70) ,2021 (112.30) respectively and the variation is mainly due to arrival of monsoon which generally arrives Himachal in the month of June.
- July is the peak monsoon month and the rainfall varies from 414.60 mm (2014) to 528.70 mm (2023) with a comparatively more rainfall in 2022 (571.80 mm) than 2023.
- Likewise, similar trend of rainfall was recorded at Shimla i.e from April to August, the rainfall varies from 62.90 mm (April 2014) to 47.60 mm (August 2014) where as in 2023 it varies from 221.40 mm (April 2023) to 552.10 mm (August 2023) respectively.
- Likewise, at Bhuntar during 2023, the rainfall varies from 396.70 mm (April) to 138.50 mm (May) to 86.50 mm (June) to 257.10 mm (July) to 134.10 mm (August) which is comparatively more in summer months April and May 2023 than the preceding years.
- In Kangra, similar increasing trend was observed in 2023 which varies from 122.30 mm (April) to 213.20 mm (May) to 336.00mm (June) to 595.20 mm (July) to 628.30 mm (August) in comparison to the preceding years.
- At Kalpa which is on eastern side of the state and also falls on the rain shadow zone, the recorded rainfall in 2023 has varied from 120.80 mm (April) to 82.60 mm (May) to 31.20mm (June) to 196.60 mm9July) to 14.6 mm (August) respectively and is on the higher side than the preceding years except a few exceptions.

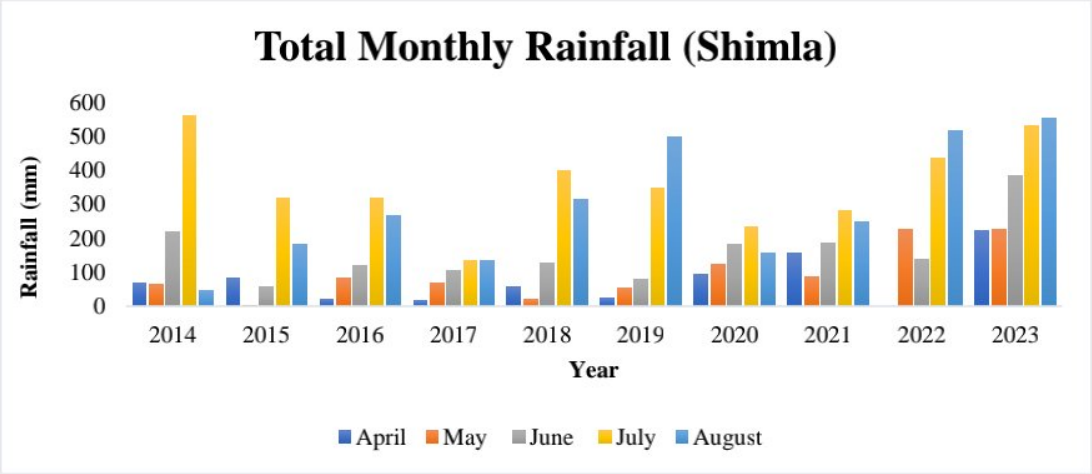
- In other words, we can say that during 2023, the rainfall was on higher side even in the summer months in April & May in the state and at these stations with very high rainfall during peak monsoons months i.e., July and August.
- On the other hand, it is also seen that by and large number of rainy days have been reduced in 2023 and the rainfall has increased indicating heavy spells during 2023.

RAINFALL TREND ANALYSIS

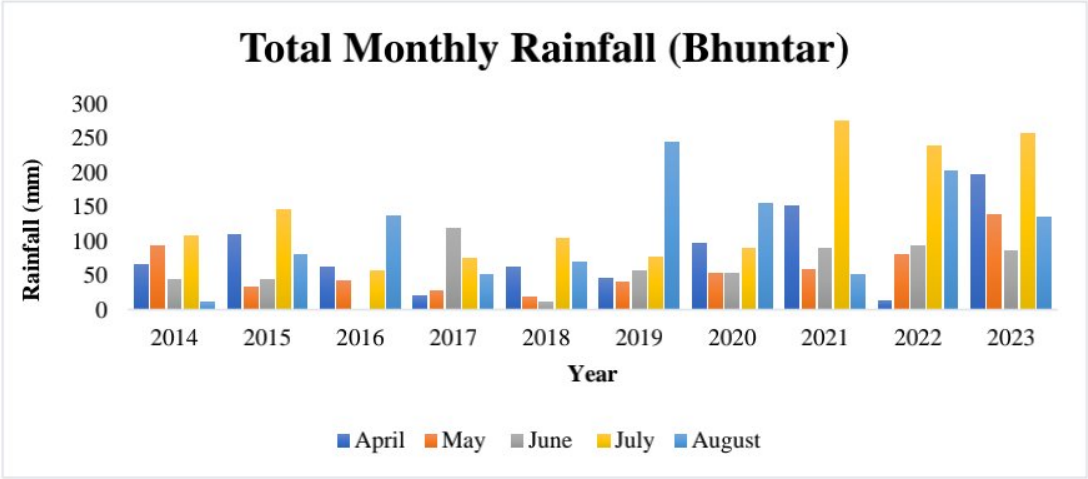
Rainfall Mandi (Monthly Rainfall)										
Year	**No. of Rainy Days (April)**	**Total Monthly Rainfall (April)**	**No. of Rainy Days (May)**	**Total Monthly Rainfall (May)**	**No. of Rainy Days (June)**	**Total Monthly Rainfall (June)**	**No. of Rainy Days (July)**	**Total Monthly Rainfall (July)**	**No. of Rainy Days (August)**	**Total Monthly Rainfall (August)**
2014	4	33.00	8	76.50	10	155.40	21	414.60	10	89.60
2015	8	105.10	1	9.40	9	41.60	12	150	15	204.40
2016	2	11.90	7	127.00	0	0	12	185.70	10	138.90
2017	2	20.20	4	60.40	9	220.50	12	164.80	9	87.30
2018	3	47.10	1	6.20	3	51.6	14	229.60	11	173.4
2019	4	32.60	3	28.50	5	33.60	18	232.30	20	372.60
2020	8	73.90	9	97.50	16	190.70	13	176.50	19	451.00
2021	5	93.60	12	104.80	13	112.30	23	485.80	22	305.40
2022	5	13.20	18	150.80	9	96.40	24	571.80	20	525.40
2023	14	185.20	18	253.80	15.00	286.80	27	528.70	17	693.7



Rainfall Shimla (Monthly Rainfall)										
Year	**No. of Rainy Days (April)**	**Total Monthly Rainfall (April)**	**No. of Rainy Days (May)**	**Total Monthly Rainfall (May)**	**No. of Rainy Days (June)**	**Total Monthly Rainfall (June)**	**No. of Rainy Days (July)**	**Total Monthly Rainfall (July)**	**No. of Rainy Days (August)**	**Total Monthly Rainfall (August)**
2014	7	68.90	11	65.00	13	218.00	22	560.10	8	47.40
2015	12	81.70	2	1.50	13	58.10	18	317.80	17	182.70
2016	4	21.10	6	81.50	9	118.80	18	316.50	17	267.20
2017	3	16.20	8	68.40	11	105.20	14	133.70	10	134.80
2018	8	56.20	7	20.60	5	128.50	19	398.50	14	313.70
2019	4	24.50	9	54.90	10	79.50	24	346.20	25	499.00
2020	10	94.20	13	124.00	11	183.20	22	232.90	22	156.90
2021	5	156.50	13	86.20	16	186.00	21	281.40	22	246.40
2022	0	0.00	14	227.40	14	139.50	28	433.90	27	514.30
2023	14	221.40	18	225.40	21	383.60	30	530.70	20	552.1

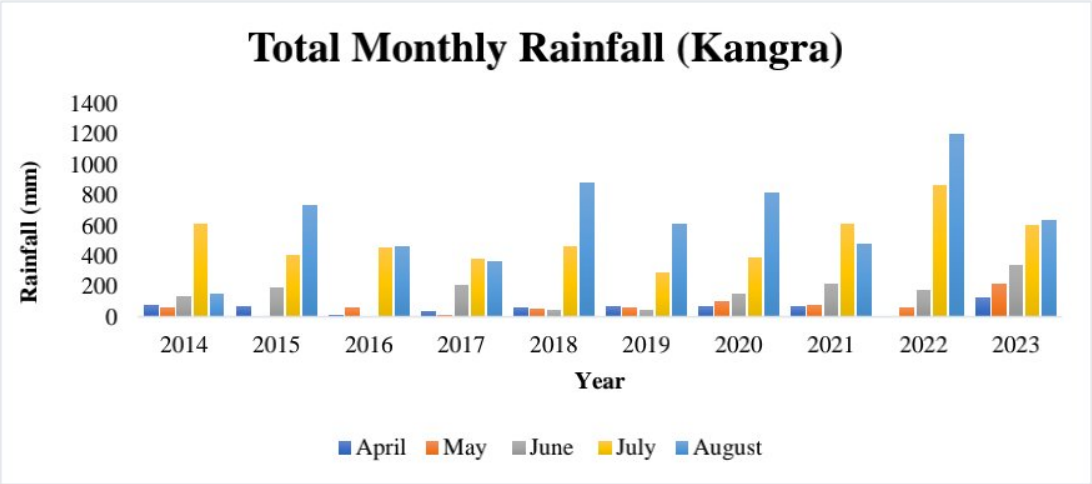


Rainfall Bhuntar (Monthly Rainfall)										
Year	**No. of Rainy Days (April)**	**Total Monthly Rainfall (April)**	**No. of Rainy Days (May)**	**Total Monthly Rainfall (May)**	**No. of Rainy Days (June)**	**Total Monthly Rainfall (June)**	**No. of Rainy Days (July)**	**Total Monthly Rainfall (July)**	**No. of Rainy Days (August)**	**Total Monthly Rainfall (August)**
2014	8	66.10	12	92.8	10	44.50	13	106.80	4	10.5
2015	11	108.40	3	33.10	13	43.80	10	146	14	80.60
2016	4	62.60	6	42.10	0	0	15	57.10	15	137.00
2017	2	20.4	7	27.90	10	118.70	11	74.50	10	50.50
2018	9	61.40	6	17.50	4	11.1	14	104.10	9	69
2019	6	45.40	8	40.00	11	56.60	13	77.30	20	243.30
2020	16	96.90	13	52.60	12	52.8	16	88.70	17	153.90
2021	7	150.40	14	57.60	11	89.40	19	274.70	12	50.30
2022	9	13.40	17	80.00	15	92.30	26	239.30	18	201.90
2023	14	196.70	17	138.50	15	86.50	19	257.1	7	134.1

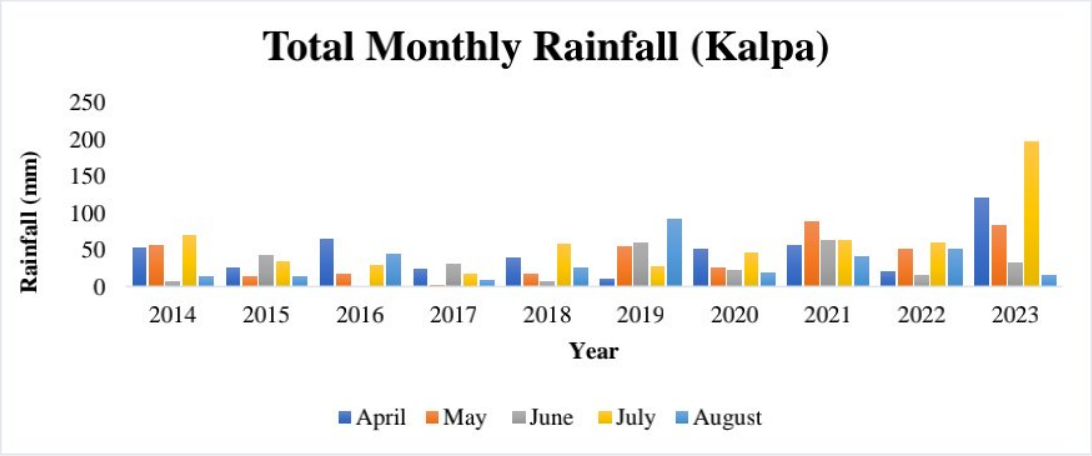


Rainfall Kangra (Monthly Rainfall)										
Year	**No. of Rainy Days (April)**	**Total Monthly Rainfall (April)**	**No. of Rainy Days (May)**	**Total Monthly Rainfall (May)**	**No. of Rainy Days (June)**	**Total Monthly Rainfall (June)**	**No. of Rainy Days (July)**	**Total Monthly Rainfall (July)**	**No. of Rainy Days (August)**	**Total Monthly Rainfall (August)**
2014	6	71.10	6	59.10	9	132.30	22	606.90	10	145.00
2015	7	69.20	0	0.00	9	186.70	17	399.20	20	731.00
2016	2	10.00	6	55.30	0	0	19	450.30	12	456.00
2017	2	31.20	3	12.10	10	209.40	15	377.90	11	359.10
2018	8	60.00	5	50.80	4	44.4	20	461.90	15	881
2019	3	63.50	7	59.90	9	40.10	22	288.80	22	608.80
2020	10	62.70	10	98.00	14	147.40	21	387.80	24	814.60

2021	6	64.30	14	74.00	13	216.80	23	609.30	26	477.30
2022	3	2.80	12	56.90	12	175.00	30	863.80	23	1196.00
2023	12	122.30	16	213.20	19	336.00	28	595.50	22	628.3



Rainfall Kalpa (Monthly Rainfall)										
Year	**No. of Rainy Days (April)**	**Total Monthly Rainfall (April)**	**No. of Rainy Days (May)**	**Total Monthly Rainfall (May)**	**No. of Rainy Days (June)**	**Total Monthly Rainfall (June)**	**No. of Rainy Days (July)**	**Total Monthly Rainfall (July)**	**No. of Rainy Days (August)**	**Total Monthly Rainfall (August)**
2014	9	51.60	9	55.30	5	7.00	11	69.30	6	12.90
2015	8	25.00	7	13.50	11	42.90	11	34.20	11	13.90
2016	5	64.40	8	17.00	0	0.00	9	28.20	16	44.60
2017	3	23.80	3	1.80	7	30.60	14	16.60	6	7.60
2018	9	38.20	5	16.40	3	7.2	15	57.80	6	25.2
2019	5	10.70	10	53.50	11	59.80	15	26.80	20	91.20
2020	15	51.00	13	25.40	12	21.00	13	44.90	13	17.80
2021	8	56.20	12	87.20	18	62.00	18	62.00	11	39.60
2022	14	20.20	13	50.60	9	14.20	19	58.40	17	50.90
2023	17	120.80	19	82.60	12	31.70	22	196.60	5	14.6



In order to review and prepares a preliminary report on the cause and impact analysis of the damages occurred in and around Shimla, government of Himachal Pradesh vide office order no. Rev (DMC) (f)11-09/2021-lm dated 19-08-2023 constituted a multi expert committee from different departments like JSV, HPPWD, State Geological Wing, HIMCOSTE, MC Shimla and the district administration to prepare a preliminary on the possible cause and its impact on

account of recent landslide and land subsidence activity in the town during second spell of destruction. The following are the Members of the Committee:

1. Dr. S.S. Randhawa, Principal Scientific officer, HIMCOSTE, Coordinator
2. Sh. Puneet Guleria, State Geologist, Geological Wing, Industry Deptt.
3. Sh. Sunil Verma, Assistant Geologist, Geological Wing, Industry Deptt.
4. Er. Neelam Gupta, XEN Design, HPPWD, E-in-C Office, Nirman Bhawan,
5. Er. Basant Rathore, XEN, JSV, Kasumpti, Division
6. Er. Rajiv Kaundal, AE Design, HPPWD E-in-C Office, Nirman Bhawan,
7. Sh. Dinesh Thakur, AE, MC Shimla
8. Sh. Khem Chand Verma, Naib Tehsildar, DC Office Shimla

As a follow up of the directions of Government Order, the Committee visited different spots from 21st August 2023 onwards. On the first day, the following sites were visited to make a prelim assessment.

LOCATION 1: NEAR WATER TANK, SANJAULI CHOWK

At this site, the following observations were made:

- Land subsidence along the road was the main cause of concern.
- Mainly characterized by Shimla Group of rocks and dominant litho units exposed are the thinly horizontally bedded Shales which are fractured in nature.

- No external seepage could be seen but may be the fractures along the road may have caused infiltration of the rainwater thereby by local setting of the land surface.
- Caving mainly seems to be due to failure of the retaining wall resting on the fractured shales.
- The land subsidence appears to be because of the saturation of the subsurface material and the underlying shales formation leading to the setting of the land by virtue of failure of the retaining wall.

SUGGESTIONS FOR RESTORATION

- The retaining wall having proper weep holes needs to be restored ensuring the foundation on hard strata

LOCATION 2: HOUSING BOARD COLONY, BENMORE (MC ROAD)

Along the road section, the area has settled down. The area is basically characterised by a high runoff zone having thick vegetation cover and no rock exposures could be seen. Along the retaining walls, cracks have been developed that may cause subsurface infiteration into the walls leading to its failure. The other characterstcs feature are as under:

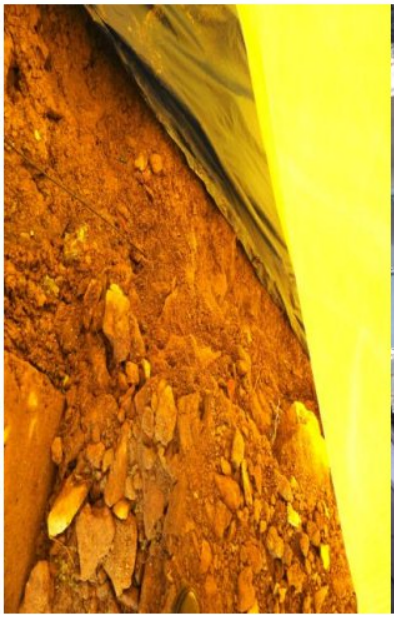
- Dominant litho units exposed are the Phyllites belonging to Jutogh Group of rocks and are fractured in nature.
- Slope falls within the shadow zones resulting to be moist for longer duration.

- Saturation level of soil is quite high in this region
- Failure of the slope along with retaining walls and uprooting of trees.
- Long duration moisture and heavy precipitation resulted to oversaturation of the soil cover and failure of the slope

SUGGESTIONS FOR RESTORATION

As the subsidence in road might be due to settlement of sub grade because of high moisture content, the road needs to be repaired as per specifications ensuring proper drainage system.

LOCATION 3: UDYOG BHAWAN, MAJITHA HOUSE, CHOTTA SHIMLA


At the Majitha House near the Industry Department building a slide has occurred because of the erosion of loose debris cover leading to debris flow along with heavy precipitation. The slope is about 70^0 to 80^0 and is about 25-30mts wide and about 250-300 mt long slide. The soil cover is quite thick because of which no *In-situ* rock could be seen. The other characteristic features of the area as under:

- Failure of the slope along with uprooting of tree led to debris flow.
- Dominant lithology is the Phyllites forming part of Jutogh Group of rocks which are overlain by thick unconsolidated debris material deposition.
- Rainwater percolation from the adjoining infrastructure into the hill slope.
- Heavy precipitation led to the oversaturation and failure of the slope along the building side.

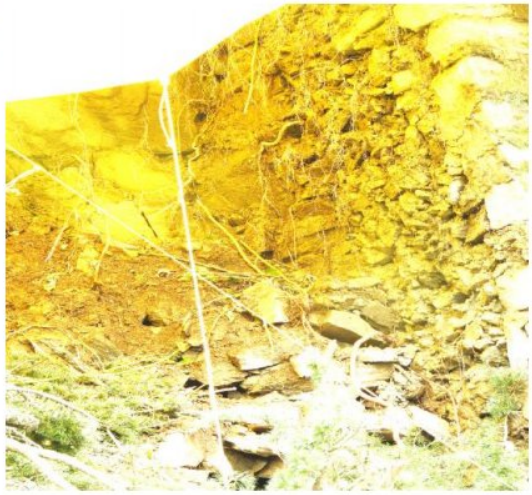
- Underlying Insitu rock seems to be deep seated as observed from the section exposed.
- The backfill soil behind the retaining wall is washed away. Though the footings of building are not yet exposed but may get exposed if further backward erosion occurs.

SUGGESTIONS

Damaged RCC retaining wall needs to be repaired and proper disposal of surface water is required.

- Immediate slope stabilization required to save the structure starting initially from the middle point to the upstream side by way of putting retaining structures resting on the *In-situ* rock. Safe disposal of roof top rain water is required

LOCATION 4: OPPOSITE HOTEL HIMLAND, CART ROAD



At this site, a slip occurred along the hill slope resulting in the opening of the scar adjoining to a multi-storey building posing threat for its collapse. The characteristic features of the site are as under:

- Failure of the retaining wall along the slope
- Debris cover underlain by the phyllitic rocks forming part of the Jutogh Group of rocks.
- Heavy structure constructed along the edge of the slope might have resulted in vertical load transfer on the retaining wall.
- Due to oversaturation of the sub surface material the retaining wall could not sustain and failed.

SUGGESTIONS:

- Protection wall from the *In-situ* rock needs to be constructed to protect the structure and roof top rain water needs to disposed properly.

LOCATION 5: SHIVPURI, MC ROAD & ROAD TOWARDS GULKANDI NIWAS

The slip occurred on the road to Shivpuri on the backside of the Hotel Himland along the hill slope due to oversaturation of the loose unconsolidated material comprising clays pebbles etc slide leading to the setting of the road along the slope. Surface water contributions along the road also enhanced its saturation conditions and thereby failure took place. The characteristic features of the site are as under:

- Direct slope failure along the slope from the roadside comprising loose debris cover.
- The main cause is the oversaturation of the sub surface material and direct inflow of rainwater from the roadside.
- Dominant litho units exposed are Phyllites forming part of Jutogh formation.
- Collapsing of the road toward Bulgandi Niwas was mainly due to retaining wall structure collapse.

SUGGESTION

Restoration of road and protection work is to be done as per specifications ensuring cross drainage wherever required.

LOCATION 6: KRISHNA NAGAR (2 DEATHS & 5 BUILDINGS COLLAPSED INCLUDING SLAUGHTER HOUSE)

On 15th Augustv2023 around 5.00PM, in the Krishnanagar area of the Shimla town, a massive landslide occurred along the hill slope resulting in the collapse of the Slaughter House along with other 5 residential buildings. The characteristic feature of the area as under: Dominant litho unit is Phyllites & Schists forming part of Jutogh Group of rocks.

- Along the body of slide, Carbonaceous material, clays, could be seen resulting to have black soil all along the section having extremely thick deposition of unconsolidated material.
- Thick overburden material along the slope and *In-situ* rock is well exposed on the periphery.
- Main cause of the slide is slope failure leading to debris flow along with uprooting of trees resulting to total collapse of buildings along the slope.
- Contribution from the open drainage system is very significant feature of the area even from the springs in the upper catchments.
- Slope is totally unstable due to thick debris cover and liable to be eroded away in future as well.


GPS Map Camera
Shimla, Himachal Pradesh, India
452F+WQ4, Krishna Nagar, Shimla, Himachal Pradesh 171001, India
Lat 31.102451°
Long 77.174937°
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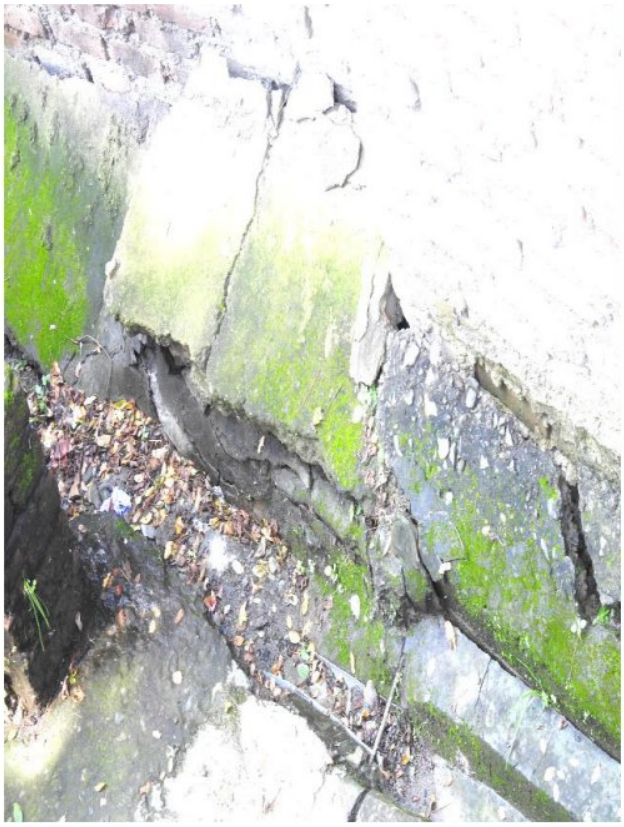


LOCATION 7: LALKOTHI, PHAGLI

At Laklkothi Phagli another debris slide activated due to heavy rains along the hill slope originating just below the Shimla Railway Station. Along the debris flow path, few temporary shelters washed away causing burial of 5 people (3 Males and 2 Females) and injuring 7 others. The *In-situ* rocks on the periphery of the slide are the Schists forming part of Jutogh group of

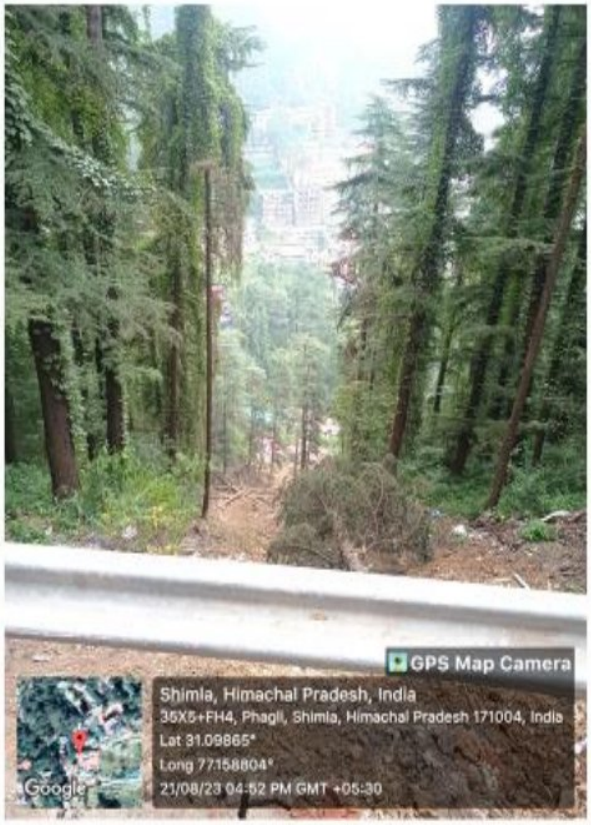
rocks. The debris material i.e., black soil which may be the carbonaceous material and is almost similar to the material observed in the adjoining Krishnanagar slide.

LOCATION 8: TUTIKANDI ON THE ROADSIDE

At Tutikandi slope failure occurred along the roadside eroding the material deposited along the road side. No retaining structure could be seen. Due to heavy rains and percolation of the rainwater into the subsurface soil, the failure took place eroding all the debris cover uprooting the tree cover along its path. Due to debris flow, damaging 2 cowshed and I house downstream along its path near Bengali Bagicha

SUGGESTIONS

Protection works by providing retaining wall & removal of uprooted trees is urgently required in order to check further erosion and debris flow which may be threating to the inhabited areas down.



LOCATION 9: TALLAND (OPPOSITE RAIN SHELTER)

A slide occurred over here within the Phyllites forming part of Jutogh Group. The Phyllites are fractured in nature. Failure occurred along the hill slope and uprooting of tree resulting slope failure. *In-situ* rocks are very well exposed in this area.

LOCATION 10: URBAN DEVELOPMENT OFFICE TALLAND

At Talland near Urban Development Office, landslide occurred along the hill slope damaging the one side of the office building. The slide initiated due to uprooting of trees from top eroding top soil cover leading to debris flow along it path due to heavy rains. Water percolated inside

the first floor of building due to blockage because of trees and muck and due to damage of roof.

The characteristic features of the slide area as: -

- Failure of the slope from top leading to uprooting of trees almost the vertical slope, damaging roof of the UD building.
- The dominant litho unit is Phyllite which are quartzitic in nature and are well exposed in the area.
- Thick vegetation cover in the top needs to be checked as it may further create risk to building as the scar of the slide is open now.
- Percolation of water could be seen in the building inside

SUGGESTIONS

The uprooted trees and muck need to be removed and roof is to be repaired.

LOCATION 11. ADVANCED STUDIES BUILDING

Public Entry Building (Front Side) On the valley side, the ground which is on the backfill of the retaining wall, is subsided and cracks developed on the ground surface due to very heavy rains and saturation of soil. Some of the trees are tilted and road (below) adjoining the retaining wall is also subsided and further the portion of Boileaugunj Chaura Maidan Road just beneath this subsided portion is also subsided. Dominant lithology along the road section is Schist from the Jutogh Group. The main cause of the sinking seems to be oversaturation of the subsurface which is reflected by the moisture in the retaining walls along the adjoining road.

SUGGESTIONS

The subsided ground in the Advance Studies campus is to be restored and the tilted trees are to be removed. The retaining wall and the Boileugunj Chaura Maidan Road needs to be restored.




LOCATION 12: SHIV BAUVDI TEMPLE, SUMMER HILL

The scar of the one of massive landslide that took place on 14.08.2023 around 7.30am in the morning from back side of the Indian Institute of Advanced Study (IIAS) that extended downstream to the Shiv Bauri in the Summer Hill area. The total length of the slide is about 230mts from the IIAS to the Shiv Bauri but it has further extended along the nala section. The slide has activated due to the failure of the thick over burden from IIAS which is on the water divide and no *In-situ* rock exposures could be seen in this area along the slope. The bending of tree alike the hockey blade indicates that region seems to be characterized by debris cover. The failure of the slope occurred along this slope due to over saturation of the sub surface thick debris cover resulting thick debris flow along the slope uprooting big trees due to heavy precipitation. At the midpoint of the slope along the Boileauganj Summer hill road, *In-situ* schist forming part of Jutogh Group are very well exposed. The debris flow has activated along

a linear depression. The section downstream of the road also seems to follow the linear depression which appears to be a buried channel which has been filled over a period of time. The debris flow, caused caving of the railway track and the collapse of the Shiv Bauri temple structure in which 20 persons buried alive.

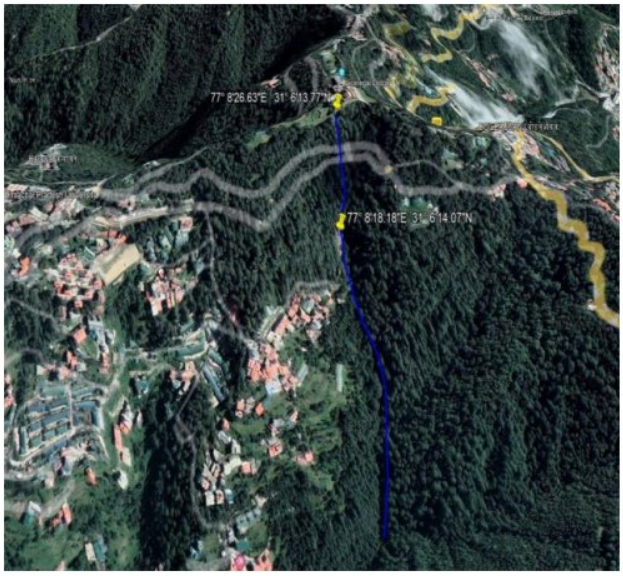
SUGGESTION

The damaged part of advanced studies campus needs to restored by providing Retaining Wall. The railway track is needed to be restored. The muck and trees are to be removed so as to protect the existing roads. Cost drainage provision must be examined.

In-situ rock exposed along the road section

Damaged railway track along the path of slide


The slide that initiated from the IIAS campus, damaged the temple along its path. Based on the first-hand information gathered from the field, it is observed that the debris flow started from IIAS campus moved along with heavy material along the weak plane of the depression which seems to be old buried channel of a dry stream and is highly fractured and structurally controlled which has now filled up. Such locations are predominantly are the conduits for the infiltration of sub surface water in case of metamorphic terrains as the metamorphic rocks are poor aquifers and thus lacks primary porosity and all infiltration takes place along the fractures having secondary porosity. Thus, the region was highly oversaturated under such conditions along with very heavy precipitation the impact was very high.

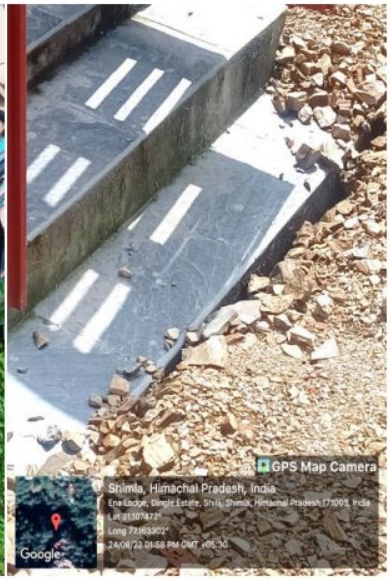



LOCATION 13: CAMBLEY BANK

Most of the part Cambley bank area of the land/road is subsided causing cracks to many buildings. The area is highly sinking and the features are very well reflected in the stairs, buildings and land surface. Dominant litho units are Phyllites which area quartzitic and fractured in nature. From the firsthand information, it appears that the region is characterized by a large catchment area draining into a stream reflecting that the region is fractured in nature as these are the conduits for the subsurface infiltration in metamorphic terrains. The inhabited area developed along the depression seems to be ideal site for the retention of sub surface water and thus highly saturated. The sinking problem of this area seems to be chronic one and thus constructional activity should be avoided.

SUGGESTIONS

This area seems to be of muck/debris dumped and sinking with time. Any type of construction should be avoided.

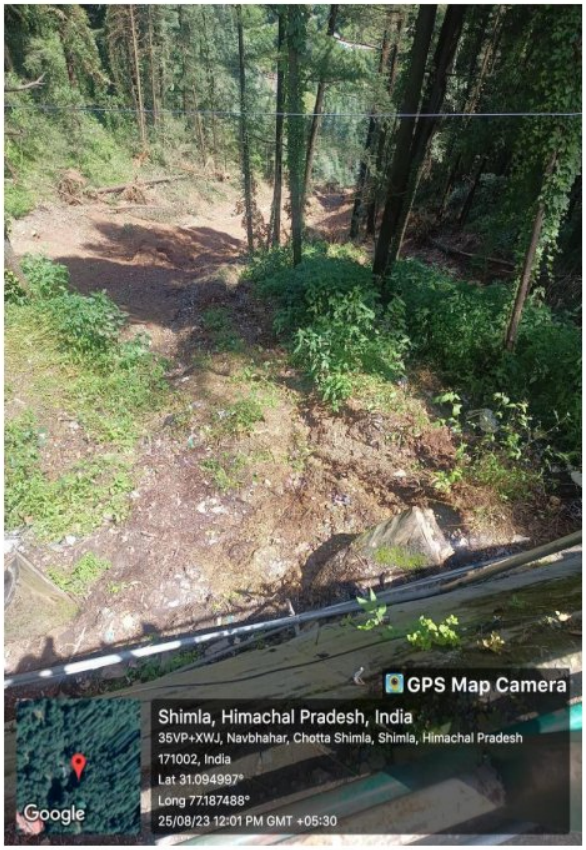


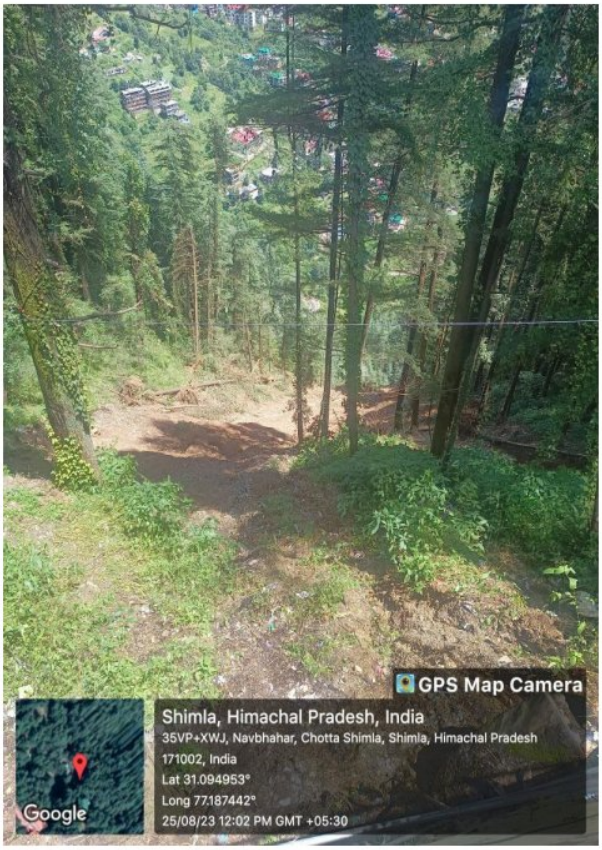
LOCATION 14. BHARARI

Due to heavy rainfall and rain water inflow from upstream about 50mts road subsided and the road seems to be constructed on filling and strata on valley side is also loose. Road to be restored by providing Retaining structure.


LOCATION 15. NAVBAHAR CHOWK

Slope failure due to the oversaturation of the slope triggered the slide along with movement of debris cover and uprooted the trees along its path of movement. Input of rainwater from the road also accelerated the process of movement at the time of heavy precipitation and thus channelization of surface flow is required in view of the gradient in the area and proper cross drainage are required.





LOCATION 16. MC PARKING TUTIKANDI

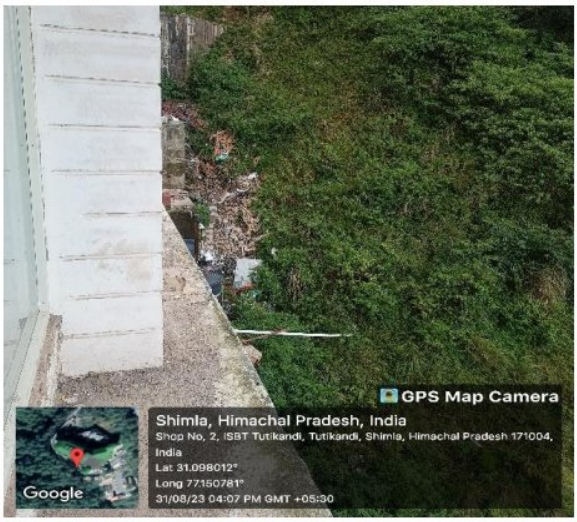
MC parking at Tutikandi on the Shimla-Chandigarh NH is multistory parking having 11 floors. In this parking number of Government offices are likely to come up beside a restaurant and banquet hall already running on the 11th floor which is the road level. This huge parking has been built on the nala section which is a seasonal one with its catchment from the Boileauganj area and joins the Ashwani khad in the downstream area. Thus, from the first-hand information gathered from the field, the following observations are made:

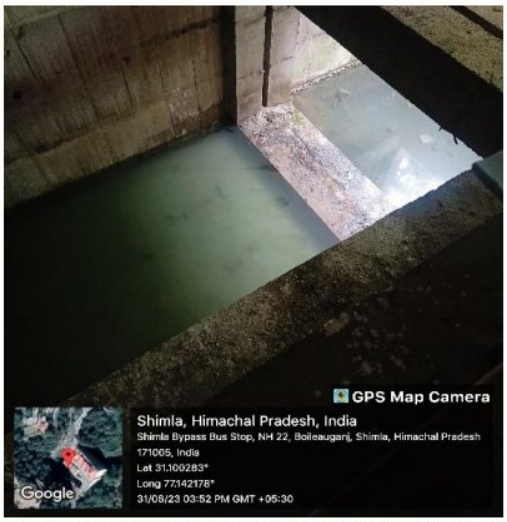
- The huge structure lies on the dry seasonal nala section originating from the Boileauganj area.
- The litho units exposed in the nala section and in the adjoining area along the road section, are the Phyllites forming part of the Jutogh group are the dominant lithology of the area.
- The structure as a whole seems to be stable except few superficial cracks in the cement concrete flooring which may be due to the quality of construction material/curing.
- The major cause of concern in the structure is the drainage system, which has been totally found to be chocked.
- The structure made for the channelization nala has been found to be filled up with great load of silt having a height of 3-4mts from its inlet and outlets points resulting that there would be no inflow of water during the rains along the channelized path underneath the structure and would be totally blocked.

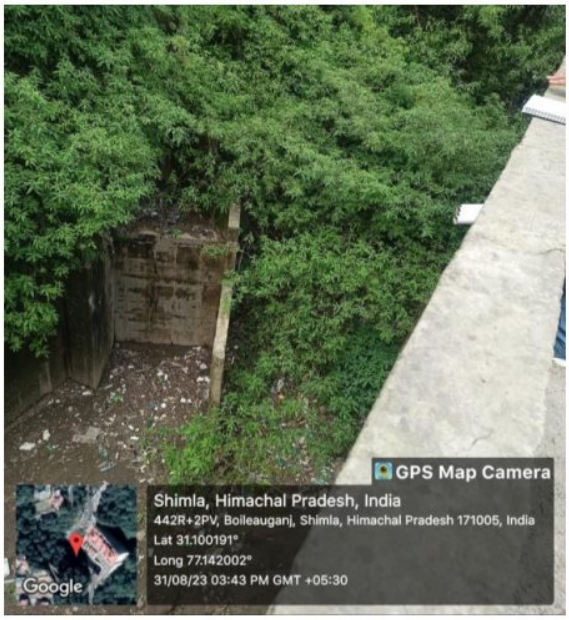
- The ponding of water could also be seen in the structure on the lower floors which may be the rainwater or the water seepage from the moisture of the adjoining structure or may be contribution of washing center running on one of the floors and chocking of the channelized path.
- Along the sides below the ramps structure is totally filled up with debris cover.

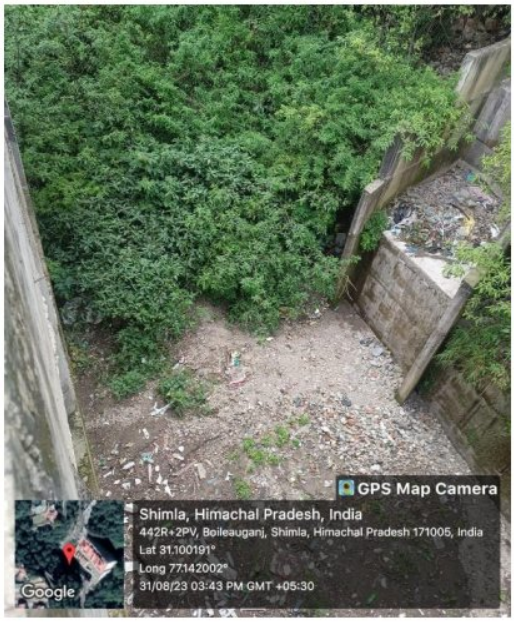
SUGGESTIONS

Steps may be taken for clearing of the debris cover, and the inflow and the outflow may be normalized after clearing the inlet and outlet points of the channel. The percolation of the rainwater also needs to be channelized. As a whole, the structure seems to be stable, but the drainage systems require proper channelization in order to avoid any eventuality in future that would arise only because of the improper drainage systems in and around the structure.









CONCLUDING REMARKS

Based on the firsthand information gathered, the major destruction in Shimla town during the second spell of disaster between 14-16 August 2023 mainly seems to be due to the following possible reasons:

1.DEPOSITION OF THICK DEBRIS COVER ON THE FRAGILE SLOPES.

Most of the Himalaya's slopes are fragile by virtue of their origin, as the Himalayas are the youngest mountain chains in the world and are still in the building phase. The Indian Plate is moving northward and subducting under the Eurasian Plate, and the Himalayas are still rising at a rate of about 5mm per year, making them geologically very active and structurally weak. Geologically, Shimla town is situated over a dislocated block formed by the tectonic dislocation of older rocks overriding the younger formations along the Jutogh Thrust. This has resulted in fragility in litho units comprising metasediments, mainly the phyllites, shales, schists, carbonaceous phyllites, quartzites, etc., supporting the slopes on which the town is situated. Over a period of time, these slopes are characterized by thick debris cover in the form of overburden overlying the metasediments at varying depths by virtue of erosion, deforestation, and other ill-planned constructional activities, and the changing land use patterns have resulted in the slopes being highly fragile. Most of the events that took place during the current monsoon season in Shimla may be due to the thick debris cover, as observed in most of the cases, which resulted in slope failure by virtue of the oversaturation of the unconsolidated subsurface material supporting these slopes.

2.OPEN DRAINAGE SYSTEMS LEADING TO POOR DISPOSAL OF SURFACE WATER

Over a period of time, the expansion in Shimla town has also resulted in the development of unplanned drainage systems, and their open disposal on the slopes has further contributed to making them more unstable.

3.DECREASED BINDING FORCES OF THE TREES IN VIEW OF THEIR LIFE SPAN.

The uprooting of the deodar trees from the almost vertical slopes during heavy precipitation has also resulted in the failure of the slopes supporting thick soil cover or debris cover, leading to debris flow in most of the cases in the recent disaster. A large number of trees have been uprooted during the heavy precipitation from these fragile slopes may be by virtue of their life

span, and decreasing binding strength with the subsoil surface has also contributed to enhancing the debris flow in most of the cases in Shimla during the current disaster.

4.HEAVY AND CONTINUOUS PRECIPITATION

The heavy and continuous precipitation that took place in 2023 seems to be one of the major causes of concern for the recent disaster. Analysis of the IMD data at Mandi, Bhuntar, Shimla, Kangra, and Kalpa during the period 2014–2023 from April to August reveals that during 2023, heavy rainfall was recorded at all locations except Kalpa in comparison to the preceding years. From the analysis, it was observed that at Mandi, the total recorded rainfall varies from 186 mm, 254 mm, 287 mm, 529 mm, and 694 mm, respectively, whereas at Shimla, it varies from 221 mm to 225 mm to 384 mm to 531 mm to 552 mm, respectively, from April to August 2023 and was considerably on the higher side in comparison to the total rainfall during the preceding years. Similar trends were also observed at Kangra and Bhuntar that vary from 122 mm, 213 mm, 336 mm, 596 mm, and 628 mm at Kangra and 197 mm, 138 mm, 86 mm, 257 mm, and 134 mm at Bhuntar from April to August, respectively. Further from the analysis, it is observed that although the total rainfall has increased in each month, the number of rainy days has decreased in each month, reflecting heavy spells of rainfall in 2023 in comparison to the preceding years. Thus, the long-wet spell starting from April to August this year has enhanced the saturation of subsoil, making it highly oversaturated, resulting in debris slides at the time of heavy and continuous rains during August 2023, converting into a major disaster.

5. FRACTURED NATURE OF META SEDIMENTS

The metasediments from the Jutogh and Shimla groups of rocks supporting the slopes are generally found to be fractured in nature and contribute to enhancing the fragility of the slopes.

6. CONSTRUCTIONAL ACTIVITIES ON THE DEBRIS COVER

Over a period of time, considerable expansion has been seen in Shimla, leading to unplanned urbanization on these fragile hill slopes, which is another major cause of concern in the current disaster. The slopes that support the built-up environment on the debris cover were unable to withstand the heavy rains, which caused slope failure and collapsing of the structure along the debris flow path.

7. STRUCTURAL DEPRESSIONS

In metamorphic terrains, the rocks lack primary porosity, and these are permeable along the fractures having secondary porosity only. The linear depressions in the Himalayas are assumed to be structurally controlled and are the weak planes. These fractures and the structural depressions are the conduits for the infiltration of subsurface water, and all infiltration takes place along these fractures, which have secondary porosity, enhancing the saturation of the substrata.

Thus, to summarize, the damage that occurred during the recent disaster in Shimla seems to be the combination of the depositions of the thick debris cover on the slopes at the major slide areas like Krishnanagar, Phagli, Shiv Bauri, Majitha House, etc., wherein, by virtue of the heavy precipitation, the subsurface material was highly oversaturated, resulting in slope failure and debris flow movement in the region along with uprooting of the tree cover. The fractured and linear structural depressions have further helped in enhancing the impact, like at Shiv Bauri, where major destruction took place. The unplanned construction on the hill slopes and open drainage systems further accelerated the process of making the slopes more fragile and unstable. The prolonged wet spell during 2023 with a gradual increase in the total rainfall even in the summer months has enhanced the saturation level of the subsoil material, resulting being highly oversaturated and weak at times of heavy precipitation, leading to slope failure along with the uprooting of tree cover.

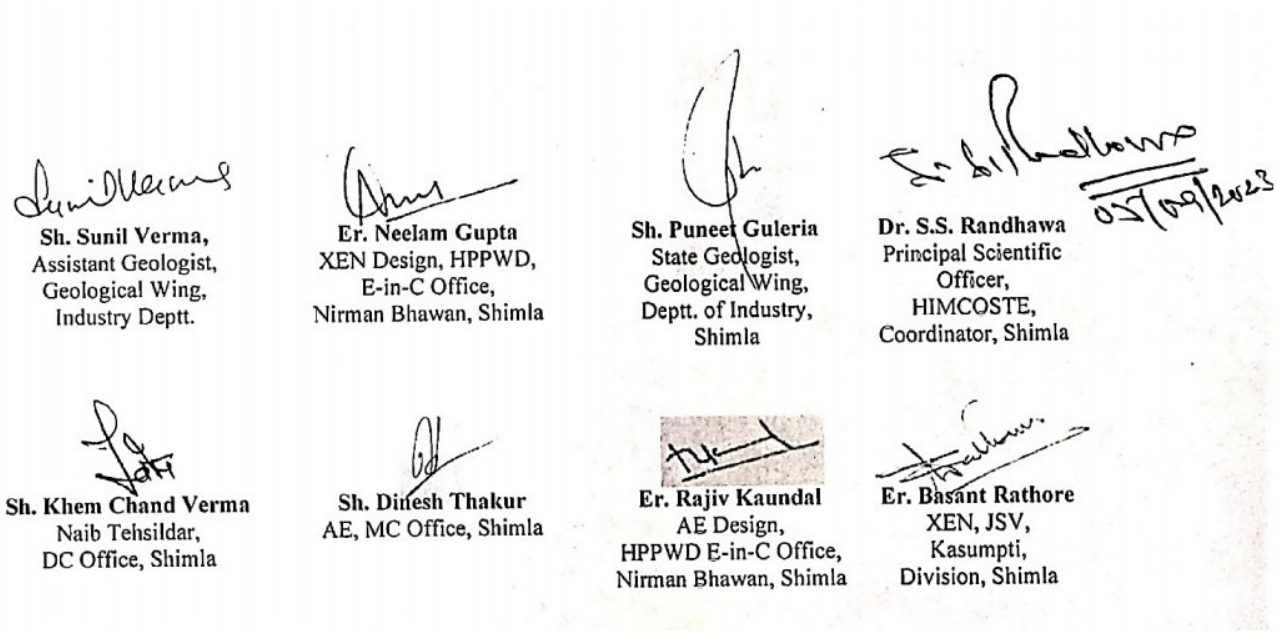
SUGGESTIONS/RECOMMENDATIONS

Based on the preliminary survey carried out for the damages that occurred in Shimla during the second spell of the disaster in Himachal Pradesh, the preliminary findings have been compiled in the form of a technical report along with some suggestions and the possible causative analysis for the landslide, slips, and land subsidence. Since the preliminary report is qualitative in nature and is based on the field observations derived from the different sites where either landslides or land subsidence has occurred. The Committee is of the opinion that detailed field investigations can be carried out for some of the sites where either the damage is very prominent or geologically very active areas requiring specific recommendations for their mitigation in order to avoid any eventuality in future. The following sites can be taken up for further investigations by involving the Geological Survey of India, the nodal agency at the

country level for landslide management or any other agency having expertise for the landslides management and mitigation over Himalayan Region.

1. Krishnanagar Landslide
2. Phagli Landslide
3. Shiv Bauri, Summer Hill Landslide
4. Majitha House Landslide
5. Indian Institute of Advance Study land subsidence
6. Benmore land subsidence
7. Cambley Bank land subsidence

COMMITTEE MEMBERS



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