

Proceeding of the meeting organized to discuss “Early Warning System (EWS) & Mitigation Strategies for the Landslides in the State”: held under the Chairmanship of Sh. Ram Subhag Singh, Chief Secretary, Himachal Pradesh on 21st September 2021 4:30 PM, at C.S Committee Room, HP Secretariat


List of Participants are enclosed as (Annexure-I)

At the outset, the Principal Secretary (Revenue) welcomed the Chairperson and all other participants for joining meeting through video conference. Thereafter Sh. Sudesh Kumar Mokhta, Director-cum-Special Secretary (Revenue-DM) gave a brief presentation on current monsoon losses due to recent landslides & discussed key aspects related to Landslide Early Warning System (EWS) & Mitigation Strategies for the State. He also apprised the Chairman about the work done by HPSDMA and the way forward for EWS and mitigation strategy required for landslides hazard in the State. **(Presentation enclosed as Annexure-II)**

The participants thereafter discussed various issues regarding landslide EWS and Mitigation strategies for landslide in following manner.

GSI-

DG, GSI Sh. R.S. Garkhal briefed about importance of the matter and capabilities of GSI on the matter. Then he allowed GSI expert Dr. Saibal Ghosh, Director Landslide Studies Division to make specific reference. He presented the landslide susceptibility maps of Himachal Pradesh which is being prepared by using various influencing factors such as geology, rainfall, land use, soil and other factors. Land use change as per above factors must also be considered while planning any development initiatives. GSI has identified nearly 17000 probable sites in Himachal, out of this 6000 are validated by the GSI through field survey which mainly falls in 4 districts namely Chamba, Kinnaur, Kullu & L& S. He emphasised that data prepared by the GSI need to be updated in a periodical manner and if the State is facing difficulty to update the same GSI will assist the officials through conducting training programmes. In his presentation, he highlighted the reasons of the Boh, Nigulsari & Batsari landslides. He also apprised the Chair that GSI has selected 9 landslide-prone areas (4 for year 2020 and 5 for year 2021) in the State for the development of an advance spatial database using the scale of 1:10,000 which becomes useful source for the State for planning purposes. They also mentioned that there are huge chances of reactivation of landslides; therefore history of landslide events must be taken into consideration. For example Rekong Peo in Kinnaur is very susceptible for the landslide vulnerability and we need to plan for that. A landslide consortium also needs to be constituted for better expert advice.

 Dr. Saibal Ghosh also apprised the Chair that GSI is experimenting with a prototype regional early warning system for landslides in and model for Shimla and Kinnaur is included under this study. In Kalimpong (West Bengal) and Nilgiris (Tamil Nadu) this EWS system is in advance stage. The model is based on a terrain-specific rainfall threshold, which is the amount of rainfall a slope can hold before a landslide gets triggered. GSI are using past rainfall and landslide occurrence data for this experiment, but rainfall distribution in hills can be quite variable. This is the reason GSI need to validate this model on the ground for multiple monsoon years. If proven successful after ground testing and validation, this model would be rolled out as an

operational regional early warning system in all landslide-prone areas in the State in the phased manner.” (Presentation enclosed as Annexure-III)

IIT- Mandi:-

Prof. Uday Kala and Prof. Varun Dutt of IIT Mandi, demonstrated the indigenous Low cost Early warning System developed by IIT-Mandi and installed in 39 location in NH-154, 707-A, & 03 on pilot basis and highlighted the use of Early Warning System. They suggested the need to replicate it in Himachal Pradesh. (Presentation enclosed as Annexure-IV)

DGRE (DRDO):-

SASE and DGRE is now common entity known by DGRE only. They urged the State to adopt a holistic model for landslide hazard which shall be mix of measures and techniques like mapping, EWS, Preventing strategy and Mitigation Strategy etc. There is lot of data already available which need to coordinated for proper implementation of Landslide strategy in Himachal Pradesh.

(Mr. Verma, Technical Director & Dr. Sujata, Scientist-G)

MoRTH:-

Regional officer has apprised the Chair that the MoRTH has signed MoU with Defence Geo-informatic Research Establishment (DGRE) to identify the vulnerable sites along the National highways and after the Nigulsari incident. The ministry has been taking short term remedial measures for the vulnerable sites and also funding the same.

(Sh. Varun Aggarwal)

HIMCOSTE:-

Pr. Scientific officer has apprised the Chair that The State Centre on Climate Change (SCCC) under HIMCOSTE has conveyed they have relevant spatial data on landslide sites like zonation map for Kullu, District level landslide inventory for HP and also monitoring river basins, Parechhu lake, GLOF and climate change aspects. SDMA needed to make specific zonation maps from this data for micro planning.

(Sh. SS Randhawa)

Inputs by Deputy Commissioners: -

- **DC-Kinnaur** Sh. Abid Hussain has apprised that GSI team had visited Kinnaur district for the assessment of the Landslide prone areas identified by the District Administration. One team under Dr. G.S. Tiwari (DDG-GSI) is doing ground investigation at present. He also apprised the Chair that most of the landslides triggered along the Road are caused by the adjoining lands which belong to Forest department & HP-PWD department are unable to take remedial steps.
- **DC-Mandi** Arindam Chaudhary has highlighted the provisions of NHAI-Act and suggested to amend the legislation as per the requirement of the State.
- **DC-Chamba** Sh. DC Rana, highlighted use of EWS developed by IIT-Mandi EWS and provisions under State Disaster Mitigation Fund for the treatment of landslide prone areas. He suggested that SDMA shall make specific DPRs for landslide mitigation by using expert advice.
- **DC-Lahaul & Spiti** Sh. Neeraj Kumar has informed that the Chair that the HP-PWD has identified landslide prone sites along the roads & are interested to install Early Warning System in selected sites with the help of IIT-Mandi.
- **ADC-Sirmaur** Miss Sunakshi Singh suggested for improvising Network provided in Early Warning Systems installed in NH-707A.

Inputs by Secretaries:

- **ACS(Forest) Govt. of HP** suggested that services of JSV hydrologist may be utilized to prepared landslide DPRs, details of closed mining site which could be sent to Forest department so that afforestation activities could be done through CAMPA. A regular webinar could be conducted for forest department officials with the help of national/state level training institute. She also added that a lot of vertical cutting is done for the erection of infrastructure and some sort of SOPs also needs to be developed.
- **Pr. Secretary (PWD) Govt. of HP** has appraised the Chair that there are 203 landslide sites identified by HPPWD and we are also perusing Bio engineering and Bio remedial solutions through CBRI Roorkee. On 20.09.2021 a meeting has been organised and we have planned our strategy and information available with Disaster Management Department and Geological Survey of India (GSI) has been shared with HP-PWD by Director (Rev-DM).
- He pointed out the Forest land issue due to which HP-PWD is unable to takes remedial steps for road infrastructure. He also appraised the chair that department has created its own inventory where landslide took place every year in the Monsoon season and deploys Manpower & Machineries every year. Now, the department is taking four roads in four zone and start takeing remedial steps i.e. Bio-engineering & second engineer & technology. Now, we came to know through this meeting that department could develop the DPR with help of CBRI-Roorkee, will hire the constancy from them and also get the funds from NDMA, MoRTH and Revenue (Disaster Management) department. The HP-PWD will try and put in best efforts to prevent the landslide in the State especially along the road infrastructure.

NDMA:-

Sh.Rajinder Singh Member NDMA apprised that after Chamoli incident of Utrakhand NDMA has suggested specific measures/guidelines which are in final stage and will improve management of these kind of disasters. For EWS common alert protocol NDMA has approved 375 Cr budget. For other initiatives taken by NDMA i.e Aapda Mitra Scheme to strengthen the State response GOI has released Rs 370 Cr. For Mitigation purpose Rs 32000Cr has been kept under 15th Finance Commission. Disaster Management-Cell need to send the DPRs as earlier two landslide mitigation DPRs of Karchham Sangla & Urni Dhank needed revision as per NDMA DPR template. NDMA has also conducted two training programmes with the help of IIT-Mandi and CBRI Roorkee to train the State official. He urged that State has to utilise the services of trained official and the DPR on Landslide mitigation be sent to NDMA for funds at the earliest. He also ensured NDMA is always there with HP Government in Landslide EWS and Mitigation strategy.

(Sh. Rajender Singh, Member NDMA & Ravinder Singh-Landslide Consultant)

After detailed discussions, the following directions were issued by worthy Chief Secretary, Himachal Pradesh for necessary actions:

- Identification State level Core Team of Experts for Landslide EWS & mitigation in the State. This team will help in proper planning for EWS and Mitaigation strategies required for Landslide hazard in HP.

(Action by: DM- Cell, Revenue)

- More landslide sites could be chosen for the State to preparation of advance Landslide spatial data on 1:10,000 scale and its profiling and process should be expedited.

(Action by: GSI)

- State need to install Landslide Early warning System in the State so that suitable wide network of Landslide EWS could be developed to the State

(Action by: IIT-Mandi)

- The List of the Closed Mining site be provided to Forest department for afforestation purpose.

(Action by: Forest, Industry)

- The DPR under Landslide Risk Mitigation Project be sent to National Disaster Management Authority (NDMA) and services of trained manpower be utilize for preparation of Detail Project Report.

(Action by: DM-Cell, Revenue and PWD)

- The Hazard Risk Vulnerability Assessment (HRVA) atlas prepared by the DM-Cell be made available to Stakeholder departments through website or other means so that the same could be used for planning purposes and also be uploaded in public domain.

➤ (Action by: the DM-Cell, Revenue)

- HIMCOSTE to share Landslide related information with SDMA and also made it available on their website. Similarly SDMA shall coordinate with other departments/agencies to make common repository of various works/studies done by them in landslide field & ensure to make it available to Stakeholder departments through their website.

The Chair in his concluding remarks said that the main intention to organize this meeting is to identify the resource persons for landslide mitigation and to introduce the resource person before Stakeholder departments & the respective Deputy Commissioners so that multi-dimension & multi-stakeholder approach could be developed in the State while planning disaster related activities. We need to consult the resource persons and come up with the best solution before the onset of next monsoon seasons (2022) so that the losses due to landslide could be minimized in the State and sustainable last-mile connectivity be ensured to the public.

The meeting concluded with a vote of thanks.

Encls. As above.

Approved by

(Ram Subhag Singh)

Chief Secretary to the
Government of Himachal Pradesh.

Endst. No. Rev(DMC)(F) 11-09/2021

Dated the 30th September, 2021

Copy forwarded for information and necessary action to:

1. All the participants.



(Sudesh Kumar Mokhta)
Director-cum-Spl. Secy. (Rev-DM)
Government of Himachal Pradesh.

Annexure-I

List of Participants

State Government					
Sr. No	Name and Designation	Department	Contact Details	Email ID	Mode
1.	Smt. Nisha Singh, ACS to the GoHP	Forest	2621877	forestsecy-hp@nic.in	Personally
2.	Sh. Prabodh Saxena, ACS to the GoHP	Sci. Env. & Tech	2624538	envsecy-hp@nic.in	Personally
3.	Sh. Onkar Sharma, Pr. Secretary	Revenue	2622269	revsecy-hp@nic.in	Personally
4.	Sh. Subhasish Panda, Pr. Secretary	HPPWD	2621897	pwdsecy-hp@nic.in	Personally
5.	Dr. Savita, PCCF	Forest	2623155	pccf-hp@nic.in	Personally
6.	Sh. Sudesh Kumar Mokhta, Sp. Secy.	Rev-Disaster Management	2880331	sdma-hp@nic.in	Personally
7.	Sh. Mukesh Repamal Director	Information Technology	2620623	Itmin-hp@nic.in	Personally
8.	Sh. DC Rana, DC-Chamba	Revenue	01899-224847	dc-cha-hp@nic.in	Virtually
9.	Sh Abid Hussain Sadiq DC-Kinnaur	Revenue	01786-222252	dc-kin-hp@nic.in	Virtually
10.	Sh. Ashutosh Garg DC-Kullu	Revenue	01902-222727	dc-kul-hp@nic.in	Virtually
11.	Sh. Arindam Chaudhary DC-Mandi	Revenue	01905-225201	dc-man-hp@nic.in	Virtually
12.	Sh. Aditya Negi, DC-Shimla	Revenue	0177-2655988	dc-shi-hp@nic.in	Virtually
13.	Sh. Neeraj Kumar DC-Lahual & Spiti	Revenue	01900-202501	dc-lah-hp@nic.in	Virtually
14.	Sh. Sonakshi Singh, ADC- Sirmaur	Revenue	01702-222410	adm-sir-hp@nic.in	Virtually
15.	Sh. Punit Guleria, State Geologist	Industries	2653779	geologicalwing@gmail.com	Personally
16.	Prof. Uday Kala	IIT-Mandi	01905-267149	uday@iitmandi.ac.in	Virtually
17.	Dr. Varun Dutt	IIT-Mandi	01905-267150	Varun@iitmandi.ac.in	Virtually
18.	Dr. S.S. Randhawa, Scientific Officer	HIMCOSTE	94183-82126	ssrandhawa15@gmail.com	Personally
19.	Dr. P. Rana CCF(IT/GIS)	Forest	86280-68190	pccf-hp@nic.in	Personally
20.	Sh. Praveen Bhardwaj, DMS	DM-Cell	94594-61361	sdma-hp@nic.in	Personally

21.	Sh. Vijay Singh, ITS	DM-Cell	94592-55230	sdma-hp@nic.in	Personally
22.	Dr. Krishan, Sr. Scientific Professional	AGiSAC	0177-2622490	krishan.hpushimla@gmail.com	Virtually

Centre Government					
23.	Sh. Rajinder Singh, Member	NDMA	26701738	rajendra.59@ndma.gov.in	Virtually
24.	Sh. Rajendra Singh Garkhal, Director General	GSI	94147-80181	dg.gsi@gov.in	Virtually
25.	Dr. S. Raju , ADG & NHM-V	GSI	033-2520616	hodm4@gsi.gov.in nmh3@gsi.gov.in	Virtually
26.	Dr. S K Som, Dy DG Mission IVA	GSI	0172-2621232	sandip.sam@gsi.gov.in	Virtually
27.	Dr. G.S Tiwari, Dy. Director General PHHP	GSI	94506-45286	g.tewari@gsi.gov.in	Virtually
28.	Dr Saibal Ghosh, Director Landslide Division	GSI	85954-56216	saibal.ghosh@gsi.gov.in ; dir.ghrm.landslide@gsi.gov.in	Virtually
29.	Dr. Atul Kohli, Director	GSI	0172-2621232	g.tewari@gsi.gov.in	Virtually
30.	Sh. Prateek Kishore	DGRE (DRDO)	0172-2699802	director@dgre.drdo.in	Virtually
31.	Dr. Sujata, Scientist-G	DGRE (DRDO)	97178-35419	director@tbl.drdo.in	Virtually
32.	Dr. BK Varma, Tech. Director	DGRE (DRDO)	81461-71122	rk.varma@dgre.drdo.in	Virtually
33.	Sh. Varun Aggarwal, Regional Officer	MoRTH	23739075	varun.aggarwal@nic.in	Personally
34.	Dr. Ravinder Singh, Consultant	NDMA	8800338608	ravinder.ndma@gmail.com	Virtually

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LANDSLIDE EWS & MITIGATION STRATEGIES (PLANNING MEETING)

**Disaster Management, Department of Revenue,
Government of Himachal Pradesh**

Brief

1.	Area-	55673 KM ²
2.	Physio- graphically Zones	5
3.	River	5
4.	District	12
5.	Sub-division	74
6.	Panchayats	3615
7.	ULB	61
8.	Population	68,64,602 (Census- 2011) 73,35,095 HP Eco- Survey 2020-21
9.	Number of Household	14,83,280
10.	Sex Ratio	974
11.	Population Density	123



landslide vulnerability

- The hills and mountains of Himachal Pradesh are liable to suffer landslides during monsoons
- The vulnerability of the geologically young and not so stable steep slopes
- Rapid rate in the recent decade due to inappropriate human activity
- Hydro-meteorological conditions and fragile structural fabric of geological strata of Himachal Pradesh increase the possibility of landslides

3

District-wise Landslide Vulnerable Areas of Himachal Pradesh (District area in sq, km)

Sr. No	District	Severe to very high	High	Moderate to low	No risk	Total area
1.	Bilaspur	216	842	83	1	1142
2.	Chamba	2120	3829	351	70	6370
3.	Hamirpur	0	851	204	45	1100
4.	Kangra	123	3698	1233	557	5611
5.	Kinnaur	868	4956	498	0	6322
6.	Kullu	1820	3513	65	3	541
7.	Lahaul & Spiti	127	11637	1825	2	13591
8.	Mandi	968	1978	826	98	3870
9.	Shimla	893	3345	767	14	5019
10.	Sirmaur	95	1805	614	228	2742
11.	Solan	556	1118	157	79	1910
12.	Una	2	678	517	311	1508

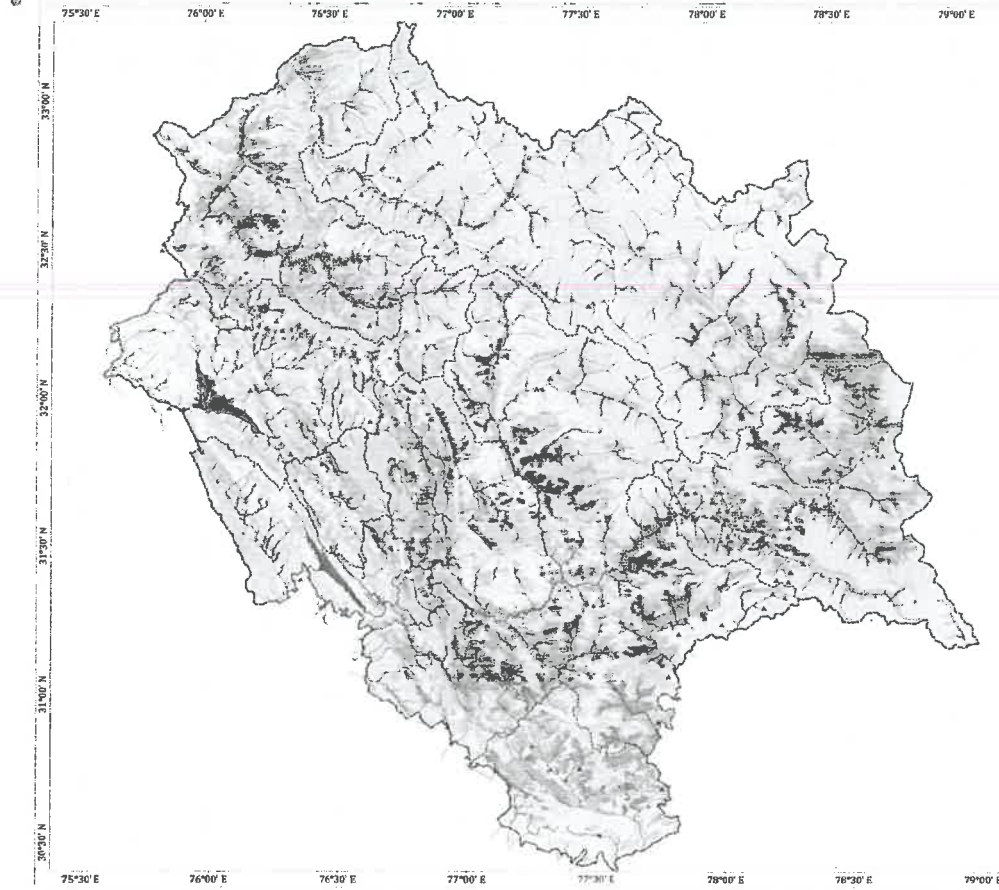
Source: Vulnerability Atlas of India, BMTPC, 2006

4

**Himachal Pradesh Landslide Hazard Risk Zonation: Landslide Hazard Risk Map
(As per the Methodology adopted in BMTPC Vulnerability Atlas)**



Hazard, Vulnerability & Risk Analysis Atlas
Government of Himachal Pradesh



Legend

- ▲ Landslide Events
- ◆ Hydro power
- Rivers
- Claciers
- Waterbody

Landslide Hazard risk

- Low
- Medium
- High

Note:
The location of past landslides obtained from three different sources was overlaid on the Landslide Hazard risk map obtained from Analytical hierarchical process. The Inventory of Past landslide locations was prepared using data from the following sources: 1) GSI, 2) BMTPC & 3) TARU

Source:
GSI, GLCF 2000, Aster (30m), BMTPC, IITM, IMD, TARU Analysis (2014)

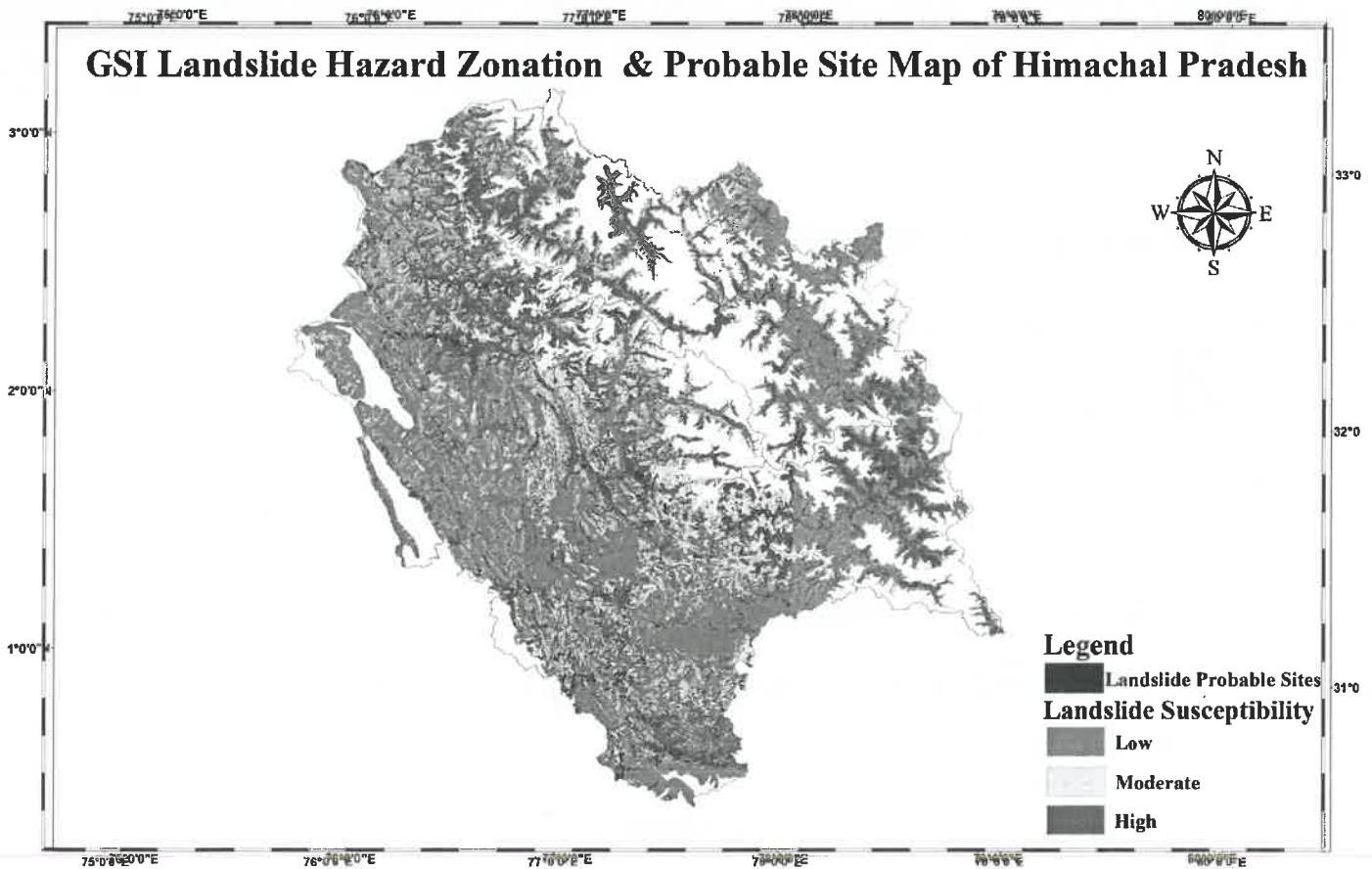
0 50 km

Datum: WGS 84
Projection: UTM 43 (N)

Map No.: LSM 02 OF 03
Date: 12-Sep-2015

TARU

GSI Landslide Hazard Zonation & Probable Site Map of Himachal Pradesh



Legend

- Landslide Probable Sites

Landslide Susceptibility

- Low
- Moderate
- High

Landslide Causes

Natural

- Gravity
- Overburden of Rock Material
- Rainfall
- Slope
- Fracture Line
- Soil Erosion
- Climate Change

Man Made

- Removal of Lateral Support
- Road Cutting
- Change in Land use Pattern
- Expansion of Settlement
- Removal of vegetable

7

Sectors under landslide Threat

- Loss of life
- Damage to houses,
- Agricultural fields,
- Roads and Infrastructure.
- Communication systems are affected,
- Water supply schemes
- Disrupting movement of people, goods and services,
- Adverse impact on economy.

8

2021 Monsoon Season Losses

Sr. No	Losses	Numbers
1.	Total Death	410
2.	Missing	12
3.	Cattle Loss	688
4.	House Damage	1050
5.	Cowshed Damaged	676

Departmental Losses

Sr. No	Department Name	Monetary losses (Cr)
1.	PWD	338
2.	Jal Shakti	308
3.	Agriculture	45
4.	Horticulture	28
5.	Rural Development	4
6.	Electricity	5
7.	Education	.6
8.	Health	.6
9.	Urban Development	8

**Total Loss
1064 Crore**

Minor & Major Landslide 2021

District Wise Detail of Landslide Events (i.e. 13th June, 2021 to 20th September, 2021)

Sr. No	Name of District	Date & Location of occurrence	Loss Reported
1	Chamba	1. Sub division Tissa (12-07-2021)	House - 1
		2. Dunali Sub division Chamba(19-07-2021)	Human Loss- 3 & 1- Missing
		3. Village Laghera near at place Kakira Tehsil (26-08-2021)	Human Loss- 1
2.	Kangra	4. Boh village. (12-07-2021)	Human Loss – 10 and 5 injured House -11
		5. Village Lahri Panchaya kanol Sub Division(11-08-2021)	
		6. Malling Nallah (17-07-2021)	Houses - 3
3.	Kinnaur	7. Batseri Village Gate (Sangla Chhitkul road) (25-07-2021)	Human – 9 & 3 injured Vehicle – 1 Tempo traveller
		8. Chota Kamba tehsil Nichar (30-07-2021)	Road Blocked
		9. Nigulsari Tehsil Nichar (11-08-2021)	Human -28 Died & 13 injured Vehicle – 1 Govt. Bus, 1 Truck & 2 Cars
		10. Village Asrang Tehsil Moorang (12.09.2021)	Human Died -01 Injured- 02

Minor & Major Landslide 2021

Sr.No	Name of District	Date & Location of occurrence	Loss Reported
4.	Lahaul Spiti	11. NH-505, nearby Garmphu Sub Division, Lahaul, (16-06-2021)	6 vehicle, 3 Bikes with 35 Passengers are stranded.
		12. (Garmphu), Sub Division, Lahaul (17-06-2021)	Road Blocked
		13. ZING-ZINGBAR, Sub Division, Lahaul (02-07-2021)	Road Blocked
		14. Madgran village Sub Division of Udaipur,	Road blocked
		15. SH-26, in Sub Division Udaipur.	
		16. Udaipur, Lahaul & Spiti. (12-07-2021)	
		17. Tabo Village NH-505(Sumdo Kaza) (25-07.2021)	Road blocked
		18. Village Kukumseri in Sub Division Udaipur.	Road blocked
		19. Chhota Dara on NH-505(Sumdo-Kaza Gramphu) in Sub Division Lahaul(27.07.2021)	
		20. Daldal Nullah nearby Kurched village, Sub Division Udaipur.	Road blocked
21. Village Kukumseri in Sub Division Udaipur			
22. Daldal Nullah nearby Kurched village, Sub Division Udaipur. (28-07-2021)			
23. Village Nalda Sub division Udaipur District Lahaul &Spiti. (13-08-2021)	Houses -4, Cowshed - 5 Animal Loss - 1 Calf and Land Loss -30 Bighas agriculture land		
24. Kourik village (25-08-2021)	Human - 1 and 1 injured		

Minor & Major Landslide 2021

Sr. No	Name of District	Date & Location of occurrence	Loss Reported
5.	Mandi	25. Aut Bazaar, PO & Tehsil Aut, Mandi	Road blocked
		26. 7- Mile near Pandoh PO Pandoh, Tehsil-Sadar, Mandi (12-07-2021)	
		27. Shani Dev temple near Dawada PO & Tehsil Aut, Mandi(13-07-2021)	Road blocked
		28. Sub-division Joginder Nagar Gumma (26.07.2021)	Road blocked
		29. NH-21 Mandi to Kullu roadway 7 miles (Pandoh) (06.08.2021)	Road blocked
6.	Shimla	30. 7- Mile near Pandoh PO Pandoh, Tehsil-Sadar, Mandi (25.08.2021)	Road blocked
		31. Jhakri in Sub division Rampur.(12-06-2021)	Road blocked
		32. Sub division Rohru	Human - 2
		33. Sub division Chopal (13-06-2021)	
		34. Sub division Chopal (17-06-2021)	Human - 2
		35. Vikas Nagar Near CID office Shimla urban (2-09-2021)	Road blocked
		36. Jeori- Sub division Rampur District Shimla (06-09-2021)	Road blocked
37. Rampur Bahli Rohru road and the road is blocked at near Bahli no human loss reported.(10.09.2021)	Road blocked		
7.	Sirmaur	38. Judicial Academy Gandal in which NH-205 (13.09.2021)	Road blocked
		39. Paonta Sahib to Shillai-Hatkoti, (30-07-2021)	Road blocked
		40. (Nahan, Kumharhatti) (03-08-2021)	Road blocked
8.	Solani	41. NH- 5 near Kandaghat (13-07-2021)	Road blocked
		42. Kandaghat (21-07-2021)	Road blocked
		43. Sub division Kasauli (03-08-2021)	Human -1

Total

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Minor & Major Landslide 2020

Sr. No	Name of District	Date of occurrence	Location	Loss Reported
1.	Chamba	31.08.2020	Keru, sub-division Bhattiyat	-
2.	Kullu	26.08.2020	Sub division Kullu koisudhar	-
		27.08.2020	Sub div. Bhuntar.	-
		05.09.2020	Kullu -Mandi NH near dawada.	-
3.	Kinnaur	12.08.2020	Kinnaur, NH-05	NH-05 damaged
		18.08.2020	Mooling Bridge- NH - 03.	-
4.	Lahual & Spiti	08.08.2020	Chokhang - Naingar link route	-
27.08.2020		Lahaul Division	-	
5.	Mandi	14.08.2020	Hanogi Mata	02 Human died & 02 injured
		16.08.2020	Riwalsar to Dharpur.	Road Blocked
		15.08.2020	Sadher Thanehara Muhalla	13 house damaged
		21.08.2020	Mandi Kamand Road	-
6.	Shimla	20.07.2020	Apple Mandi Dhalli.	-
7.	Solan	28.06.2020	Tehsil Kandaghat	02 Human died
8.	Hamirpur	27.08.2020	village Thhathhi At Sub Div. Sujanpur.	-
Total Events Reported			16	

13

Action Plan for Landslide Risk Mitigation (SDMP-2017)

Structural Measures

The structural measures for landslide risk mitigation include various techniques for stabilizing the slopes that are sliding.

- Geometric,
- Hydrological,
- Mechanical,
- Chemical,

Non-Structural Measures

The non-structural measures for landslide risk mitigation include

- **Plantation,**
- **Land use planning**
- **Early warning systems**
- **Transfer the risks of landslides through insurance**

14

Previous Studies and its recommendations

- **Landslide Hazard Risk management Study Report-2015**
(Taru HRVA Study)
- **Geological Survey of Preliminary Field Study Reports**
(Kali Dhank, Nugalsari, Batsari, Boh, Kotrupi & Hanogi Mata, etc)
- **AK Mahajan Report on “Preparation of Landslide Hazard Zonation Map of Dharmshala Town and Adjoining Area”**
- **Shukla Committee Reports.**

15

Work Done by HPSDMA till date

- ✓ **Conducted Hazard, Vulnerability Risk Assessment (HVRA) in the year 2016.**
- ✓ **Installed Early Warning System developed by IIT Mandi: as pilot project in 39 selected sites.**
- ✓ **Constituted a core Group in the year 2018**
- ✓ **Conducted various Landslide specific training programs**
- ✓ **Conducted periodic season-specific review meetings**
- ✓ **Amendemented TCP Act to cater to the DRR concerns in 2013.**
- ✓ **Strengthen Emergency Communication Network**
- ✓ **Initiated various schemes in the State**

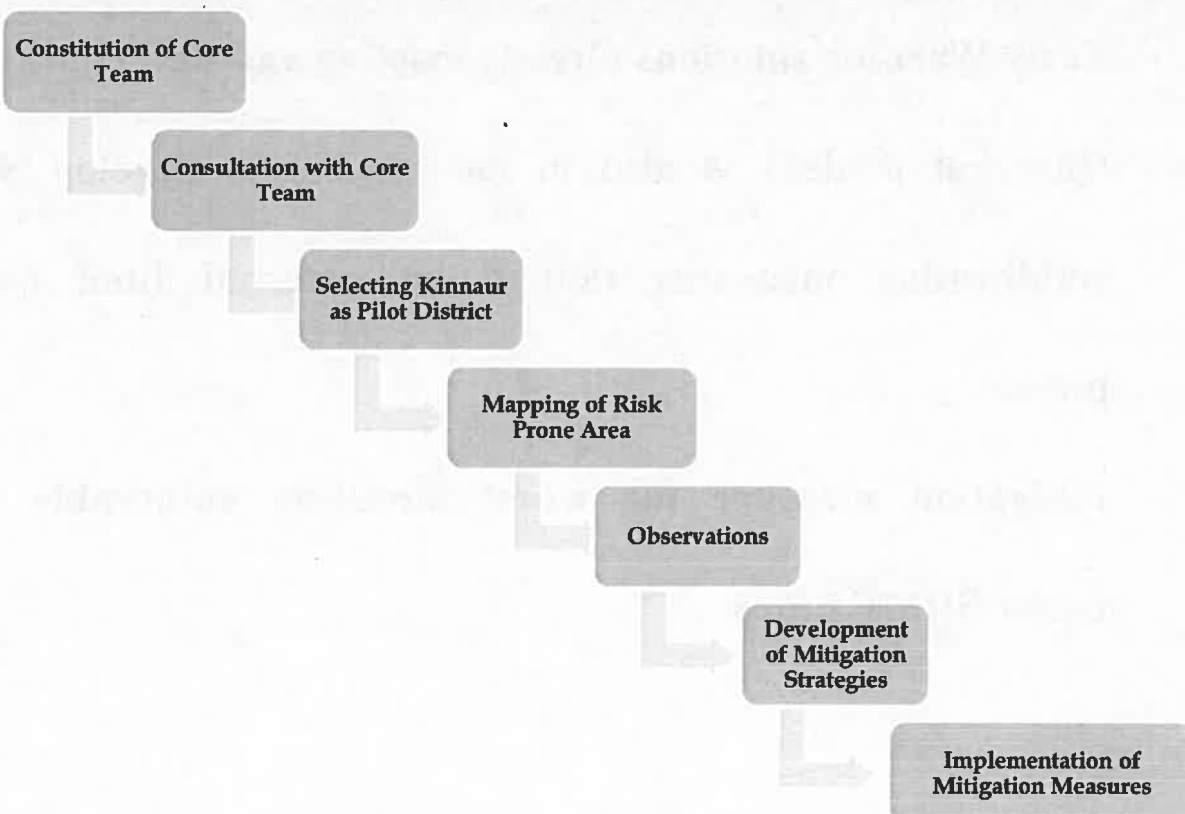
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Work Done by HPSDMA till date

- ✓ **Become member of Technical Advisory Committee (TAC).**
- ✓ **Preparing Landslide Specific Studies repositories**
- ✓ **Conducting two Mass. Awareness activities in the month of April and October ('Samarth and Remembering Kangra Earthquake)**
- ✓ **Conducted Basin wise Climate Change studies for river basin of HP through DEST.**
- ✓ **Monitoring of Landslide Lake Outburst Flood (LLOF)**

17

Strategies/Planning under discussion



18

- ✓ **Identification and constitution of Core Team:** a Core Team comprising various agencies such as Ministry of Road Transport and Highway, Wadia Institute of Himalayan Studies, Defense Geoinformatics Research Establishment (DRDO), CBRI Roorkee, Geological Survey of India (GSI), Centre Water Commission, , HPU-Shimla, HIMCOSTE, IIT-Mandi, NIT-Hamirpur, Chikara University,

19

- ✓ **Early Warning solutions already existing and new concepts**
- ✓ Himachal Pradesh is also in the process to develop **Slope stabilization measures through an external fund (AFD) project.**
- ✓ **mitigation measure for worst landslide vulnerable sites under SDMF funds**

20

Thank You

for further information, please visit:

<https://hpsdma.nic.in>

Send your valuable suggestions on
following email ID

sdma-hp@nic.in



GEOLOGICAL SURVEY OF INDIA

Landslide scenarios of Himachal Pradesh & Regional Landslide Early Warning System (LEWS)

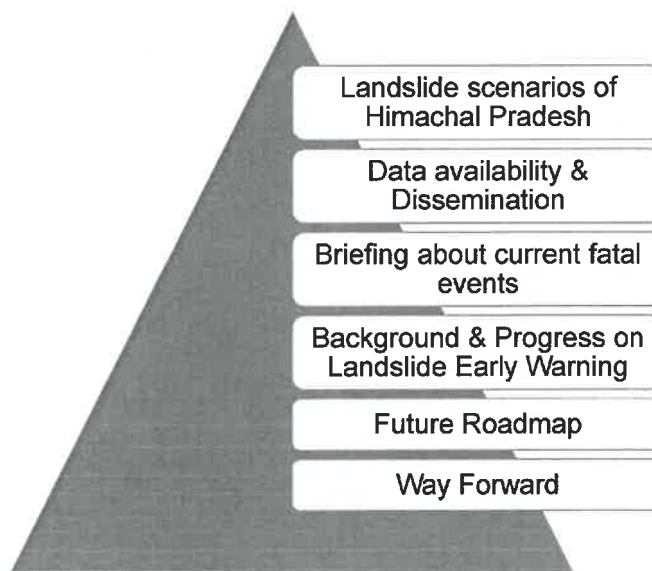
**Review Meeting on Landslide Issues
Convened by the Chief Secretary,
Himachal Pradesh
21.09.2021**

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Discussion Topics

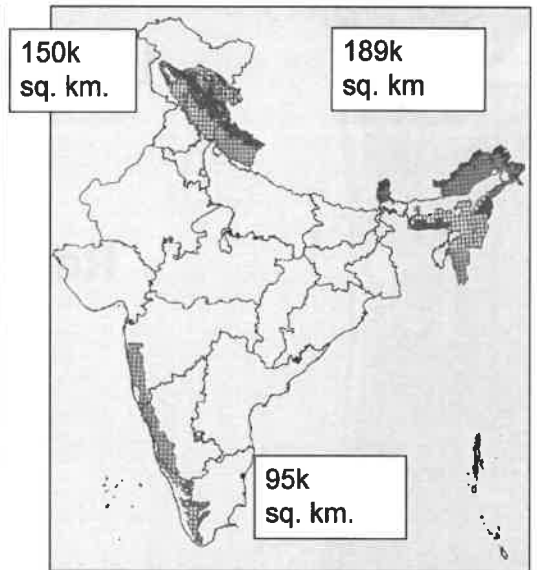
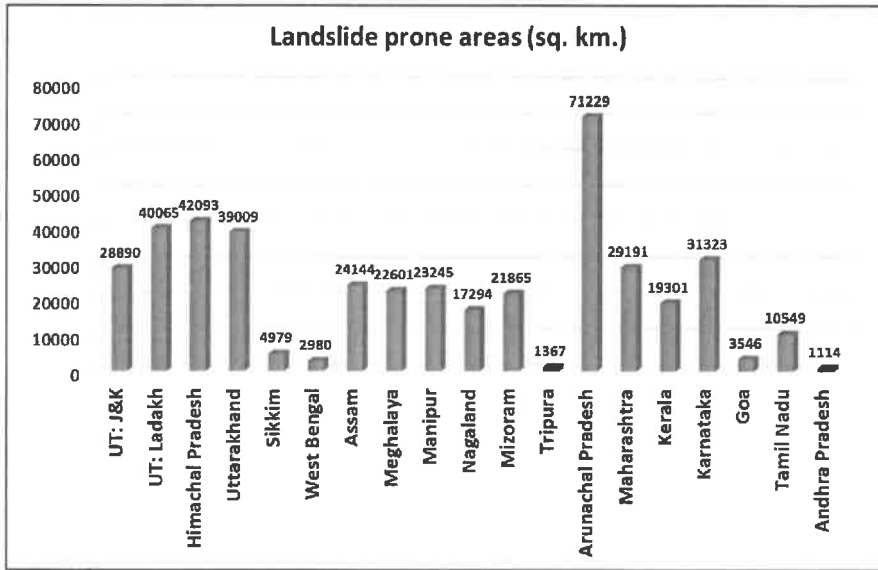


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Landslide scenarios



- 434k sq. km. area is landslide prone (12.6% of the Indian landmass)
- Varied geo-environments & complex failure mechanisms

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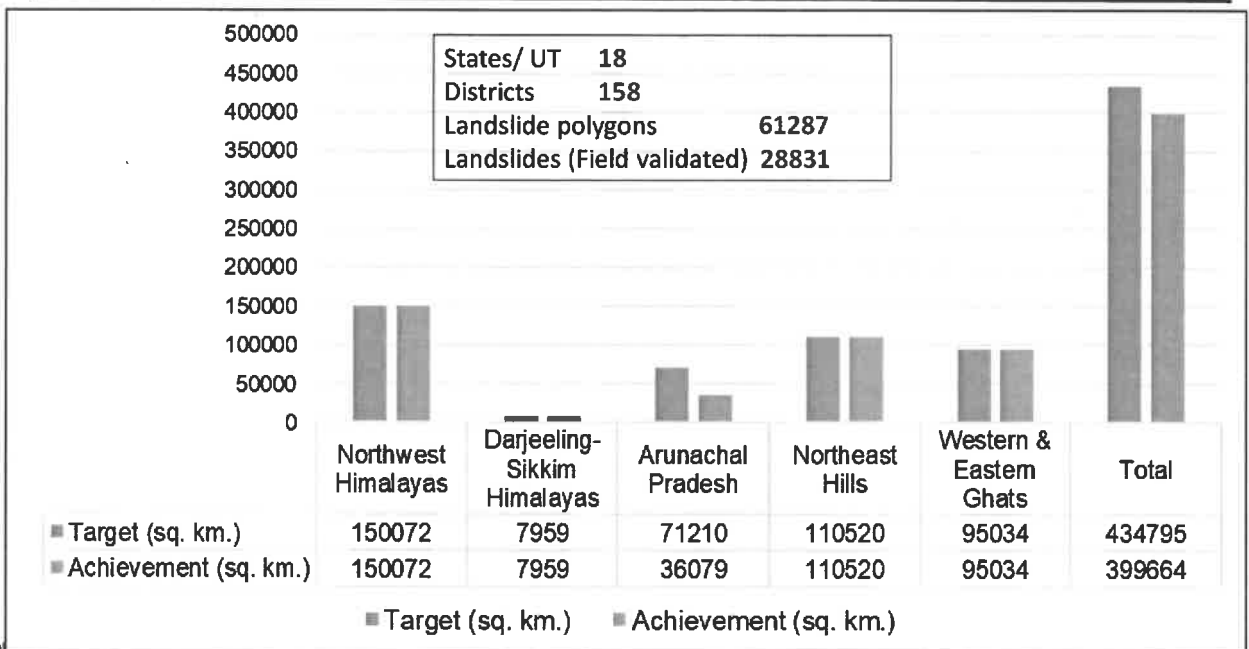


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Progress in susceptibility mapping (NLSM)

Completion by March 2022



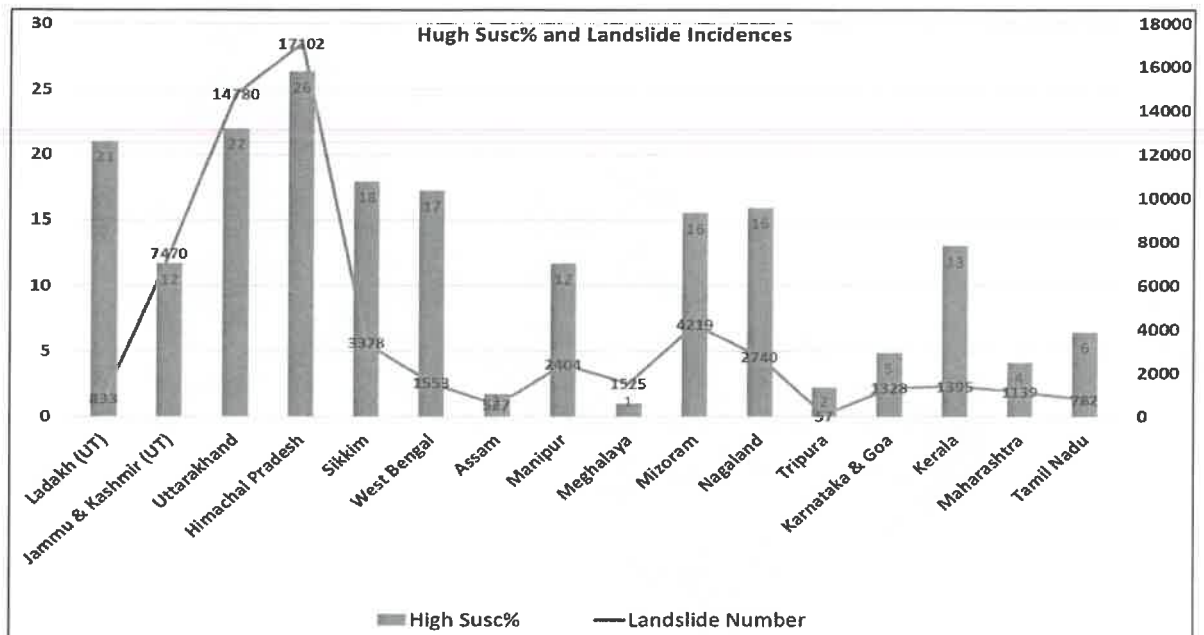
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Status of landslide susceptibility scenario



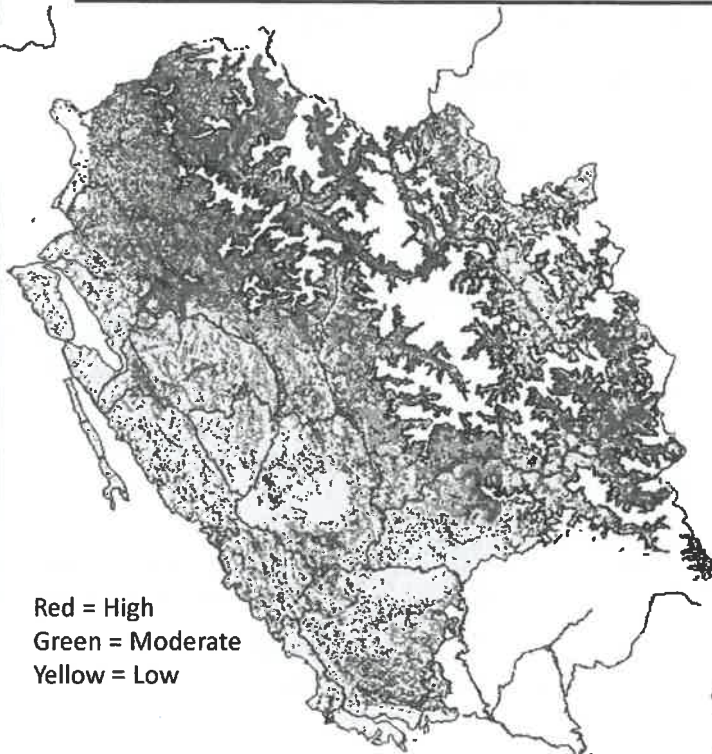
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Himachal Pradesh (1:50k landslide susceptibility)



Area Landslide Prone (sq. km.)	42093
Already mapped on 1:50k	42093
Landslide polygons (Nos.)	17102
Landslides field validated	6420
High Susceptibility %	26
Landslide no. density	0.41

District	High Susc %	No. of landslides
Bilaspur	7.61	375
Chamba	42.86	3983
Hamirpur	9.38	114
Kangra	21.88	1509
Kinnaur	39.93	1560
Kullu	24.30	1063
Lahul and Spiti	22.32	1282
Mandi	10.86	1774
Shimla	14.95	1369
Sirmaur	17.22	2515
Solan	10.54	1068
Una	8.27	490

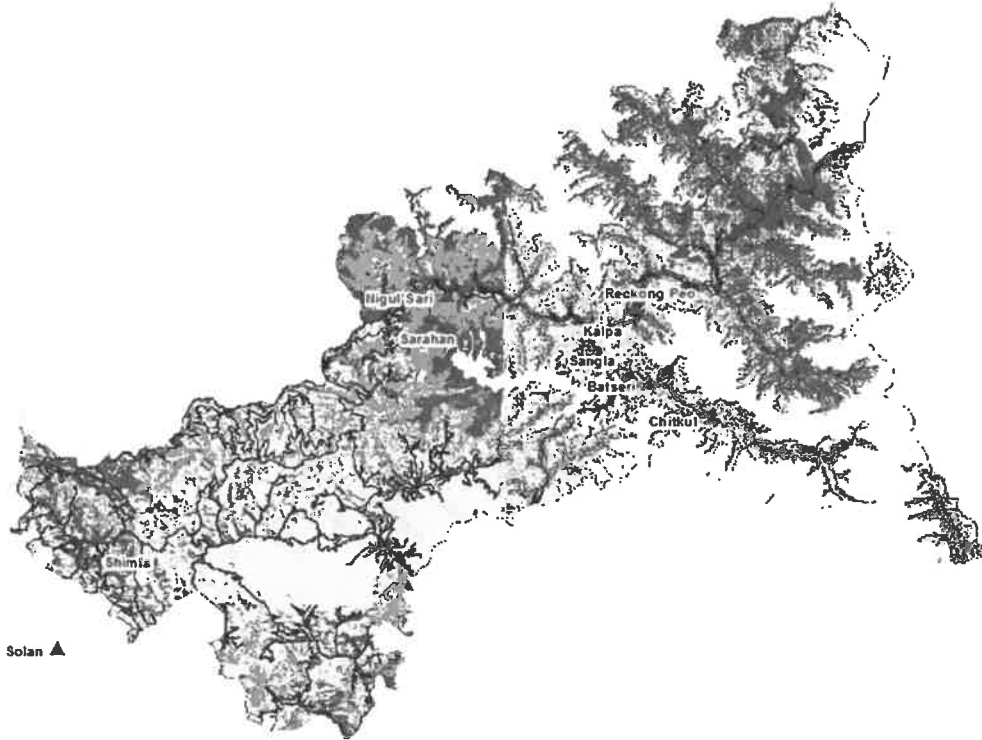
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Himachal Pradesh (Kinnaur & Shimla Districts)



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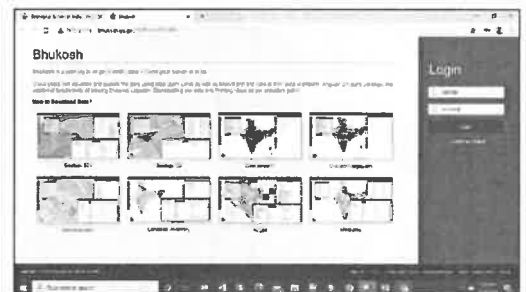
www.gsi.gov.in



Data dissemination in public domain

(<http://bhukosh.gsi.gov.in/Bhukosh/Public>)

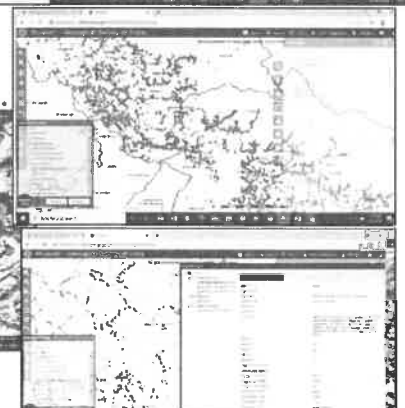
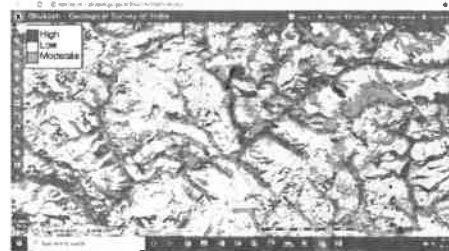
Metrics	Landslide Inventory	NLSM
Total number of download instances	6519	5322
Total no. of unique non-GSI users who downloaded	926	710
Number of different unique affiliations of the non-GSI registered users who downloaded	487	394



The data is also shared through WMS with NDMA Map Portal

Directly shared

- SDMA - West Bengal
- SDMA - Sikkim
- SDMA - Uttarakhand
- SDMA - Himachal Pradesh
- SDMA - Kerala
- SDMA - Tamil Nadu used in TMSMART APP of State Govt.
- SDMA - J&K - Landslide Inventory only
- SDMA - NORTH - Uttarakhand Map
- SDMA - SOUTH - Landslide Inventory only



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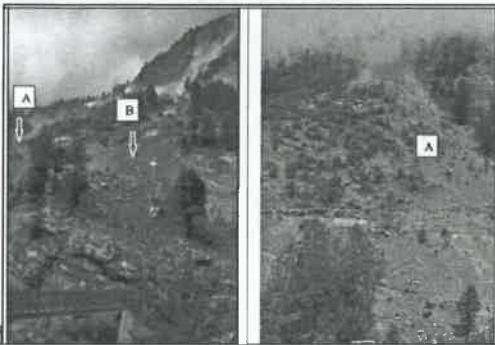




Main Causes – Himachal Incidences (Batseri)



1. In view of immature topography and active fluvio-glacial processes, the Baspa valley area possesses a fragile geo-environment condition.
2. The area including Batseri has already been identified as High landslide susceptibility zone by Geological Survey of India (GSI, 2018-2019).
3. The landslide area exposes highly tectonised contact between Kharo gneiss and intrusive (overlying) Raksham Granite of Vaikrita Group.
4. The incidence has been identified as rock fall caused by rock slide from uphill escarpment.
5. The escarpment is composed of granitoid rocks which are naturally amenable to deep weathering and erosion with the release of larger boulders



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Main Causes – Himachal Incidences (Boh, Kangra)



- The damage was caused by a **flash flood charged with debris flow** in the upslope incised gully triggered by headword erosion and debris flow along the channel due to incessant heavy rainfall during previous night.
- A **short curve in nala course** at the downstream end, possibly facilitated the spread of debris flow over the entire Boh village establishment



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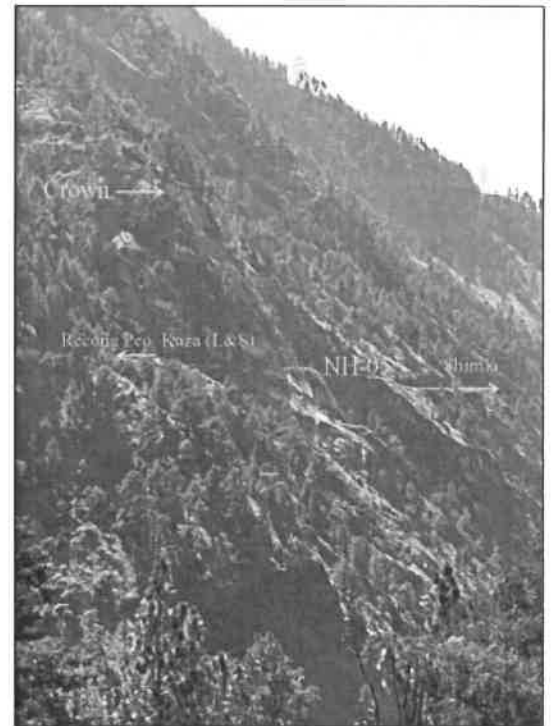


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Main Causes – Himachal Incidences (Nugulsari, Kinnaur)

- Site visit revealed that it is a reactivated landslide, the first failure occurred at this place during 2019-monsoon.
- There was incessant rainfall in this area for 3 days prior to the date of the event (11.08.2021)
- GSI has already classified this spot and the entire abutment slope as “Highly susceptible” in its 1:50k landslide susceptibility mapping
- Slope steeply inclined and dissected, bottomed by steeper natural and cut slopes
- Rockmass is highly jointed with unfavorable valley ward dipping unfavourably-oriented open joints.



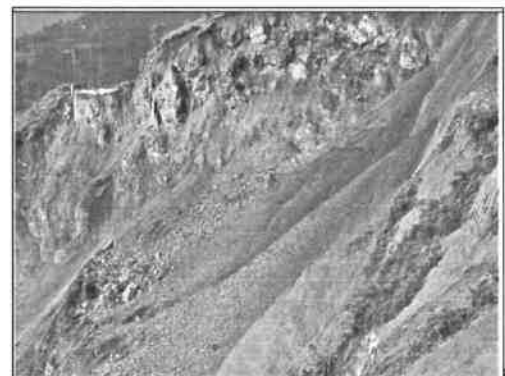
Follow



Main Causes – Himachal Incidences (Kali Dhank)



- The landslide is a **natural landslide** and has geogenic causes, and is a large debris slide affecting 150 m stretch of road bench, which completely failed
- Thick unconsolidated, and non-cohesive debris lying over fractured bed rock
- Toe area was **affected by quarrying**, now abandoned led to long exposure and weathering.
- Failure triggered on **slope saturation** by heavy rainfall during monsoon.



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Regional LEWS – Background

Developing a **prototype regional landslide early warning system** that combines **meteorological and landscape dynamics** information in the test case areas of **Nilgiris District, Tamil Nadu and Darjeeling District, West Bengal.**

Spatial scale: catchment & region.

Temporal scale: daily.

LANDSLIP Consortium



Newcastle University

LANDSLIP Research (2017-2021)

Currently the prototype models are under testing at three study sites

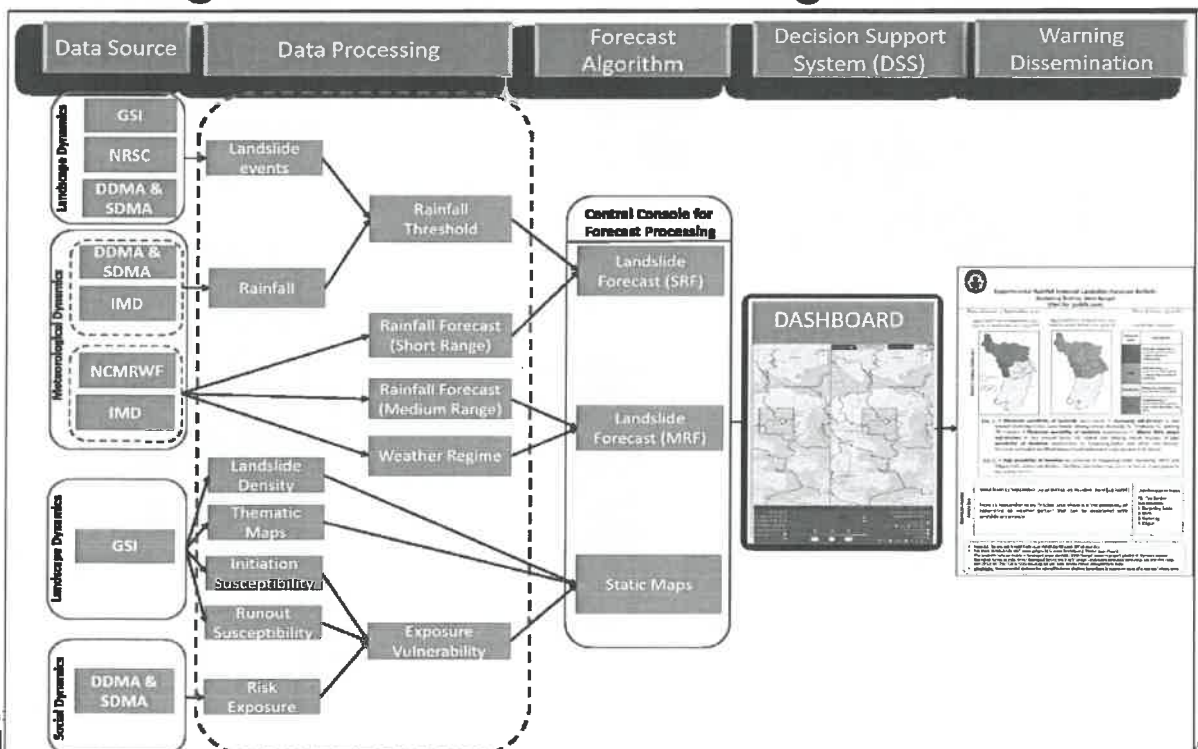
www.landslip.org

www.gsi.gov.in

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Regional LEWS – Forecasting Processes



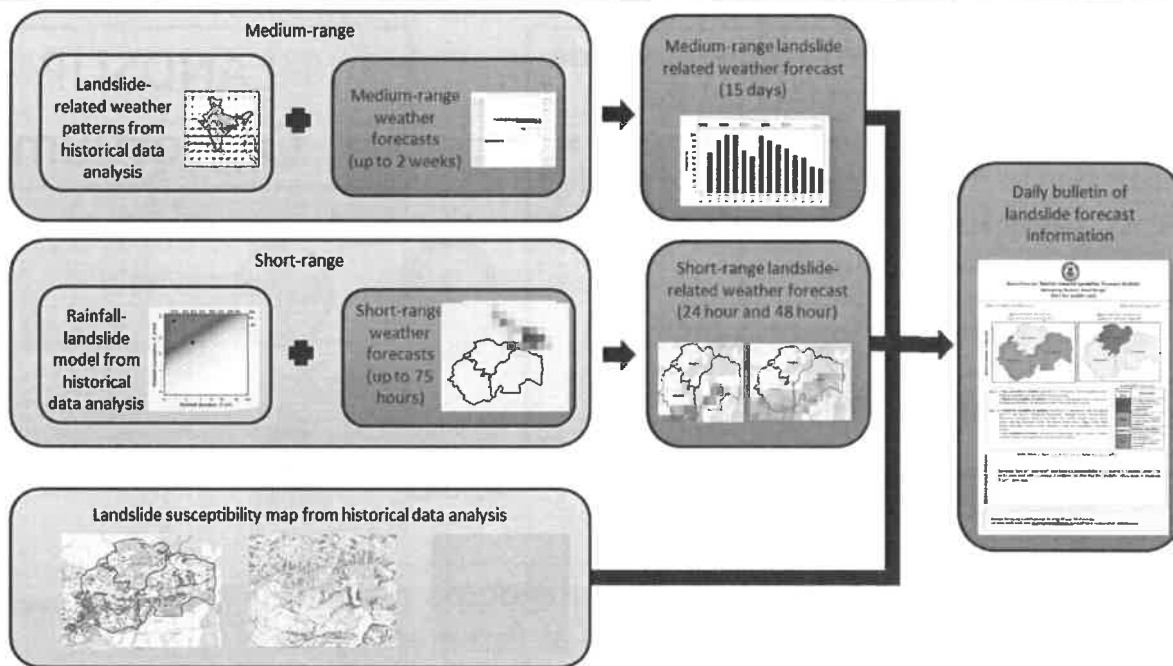
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Regional LEWS – Science



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Daily Forecast Bulletin

Date of Issue: 08 June 2021

Page-1

Time of Issue: 14:00 IST

Day 1 (valid from 08 June 2021 14:30 to 09 June 2021 14:30 IST)

Day 2 (valid from 09 June 2021 14:30 to 10 June 2021 14:30 IST)

SHORT-RANGE FORECAST



- Day 1:**
- High possibility of landslide occurrences in Kalimpong I and Gorubathan blocks. Multiple landslides may occur in the entire two blocks.
 - Moderate possibility of landslide occurrences in Kalimpong II block in and around Gt Dubling Khasmahal, Gt Beong Khasmahal, Pa'la Khasmahal mauzas.
- Day 2:**
- Moderate possibility of landslide occurrences in Kalimpong I and Gorubathan block in and around Kalimpong Khasmahal, Mangwa Forest, Rhyong Forest, Bhalukhop Khasmahal, Padung Khasmahal, Birk Forest, Tangia Forest, Chichu Forest, Samsing Khasmahal, Kumai Tea Garden, Paren Forest, Rang Forest, Patan Godak Khasmahal, Eastnar Forest, Pankasari Forest and Gorubathan Khasmahal mauzas.
 - Low possibility of landslide occurrences in Kalimpong II block, however untreated modified slopes (road/settlement cuts) are prone to failure.

Landslide Forecast

Forecast level	Description
Very High	Very high possibility of occurrences of landslides in many locations (widespread).
High	High possibility of occurrences of landslides in one or many locations (localised).
Moderate	Moderate possibility of occurrences of landslides.
Low	Low possibility of occurrences of landslides, a few small landslides may occur.

Page-2

Landslide Susceptibility Map of Kalimpong District, West Bengal



Valid from 10 June (14:30 IST) to 22 June 2021 (24:00IST)

The period from 10th June to 17th June there is a low possibility of occurrence of a weather pattern that can be associated with occurrence of landslide and after that the possibility will increase to moderate till 22nd June 2021.

Follow

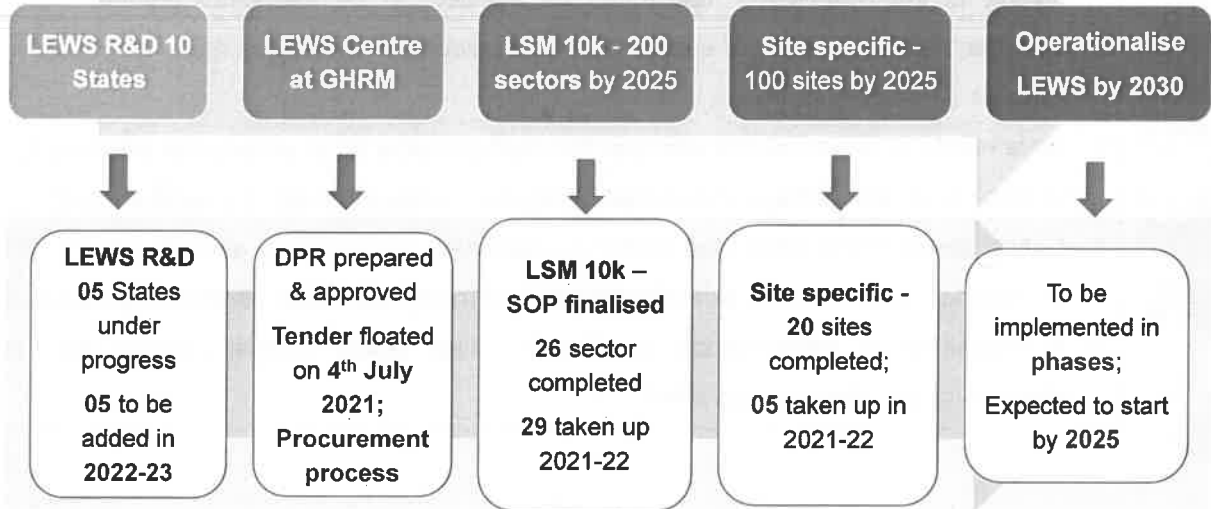


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Nodal agency's journey for 2020 -2030

Secretary MoM already approved the strategy plan of GSI in August 2020



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Mitigation & Remediation – Way Forward (1/3)



1. Multi-scale landslide inventory, hazard and risk mapping, and its periodic updation are a must for all the vulnerable locations in hills/ mountains, including debris flow modeling, vulnerability mapping etc.
2. Use of such multi-scale landslide inventory, hazard and risk maps should be made mandatory in hills/ mountains by the local authorities for planning and execution of any infrastructure project.
3. Land use zoning in hills/ mountains should be strictly executed/ implemented as per the prevalent landslide hazard and risk scenarios/ conditions brought out in such geoinformation.
4. All vulnerable locations/ villages in the Himalayas, and other landslide prone terrains must be identified, and monitored for any slope movements during the monsoon.
5. Vulnerable stretches of hill roads, vulnerable villages, and major landslide spots are to be marked with signboards cautioning local commuters/ residents for possible slope failures, rockfall etc., and if possible may also be manned during monsoon for reporting any pre-emptive signs for failure.

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Mitigation & Remediation – Way Forward (2/3)



6. During monsoon, vehicular movement along extremely vulnerable stretches of the roads (mainly in the Himalayas) may either be avoided, or be restricted/ regulated as much as possible; night movement of vehicle during monsoon be avoided as much as possible for those extreme vulnerable stretches.
7. More numbers of permanent solutions for road corridors such as tunnels/ viaducts/ bridges are to be planned and constructed so that perennial trouble spots can be avoided permanently.
8. Critical landslides in each road sector be identified, appropriately studied, and be remedied at the earliest, using suitable and relevant short-term and long-term engineering solutions
9. In rockfall areas, more number rock fencing, high tensile rockfall catching nets, rock bolts, shotcreting etc. are to be provided

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Mitigation & Remediation – Way Forward (3/3)



10. Constructions in buildings must be made far away from the mountain streams/ nalas/ jhoras
11. Indian hill towns (mostly in the Himalayas) are already overloaded with buildings/ super structures. The foundation hill mass is not only fragile but in most cases is unable to hold such huge load or normal force. Thus new multi-storeyed constructions in Indian Himalayan townships can only be allowed if the same is extremely necessary or urgent.
12. Critical facility such as hospitals, police stations, administrative buildings, school buildings, safe shelter homes must be constructed at the most safer places available in an area
13. Last but not the least, as early as possible, the country should have Early Warning Systems (EWS) for landslides for the critical and inhabited areas of the landslide prone locations

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**THANK
YOU
Sir...**

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Intiot Services Pvt. Ltd.*

Building Intelligence for Society to save lives

* A company incubated by IIT Mandi Catalyst

Our Team



Ankush Pathania

Director

Masters from IIT Mandi. Having 1-2 years of experience in hydro-electric projects involving use of sensors in the field.



Dr. Varun Dutt

Director

Faculty at IIT Mandi. Three+ years of industrial work experience. Worked as consultant on a number of projects as a data science expert.



Dr. K. V. Uday

Director

Faculty at IIT Mandi. Three+ years of industrial work experience. Worked as a consultant in a number of projects as a soil expert.



Praveen Kumar

Director

Masters from IIT Mandi. Having 5+ years of experience in software development industry with specialization in microprocessor programming.



Chandan Vaidya

Business Manager

MBA in Marketing with 10 + years of experience in sales and Business Development.



Aveg Agarwal

Advisor

Senior Vice President at Toppr.com and ex-IFS officer
Specialties: International expansion, business development, public policy, strategic planning, renewable energy



Ishwar Kumar

Operations Engineer

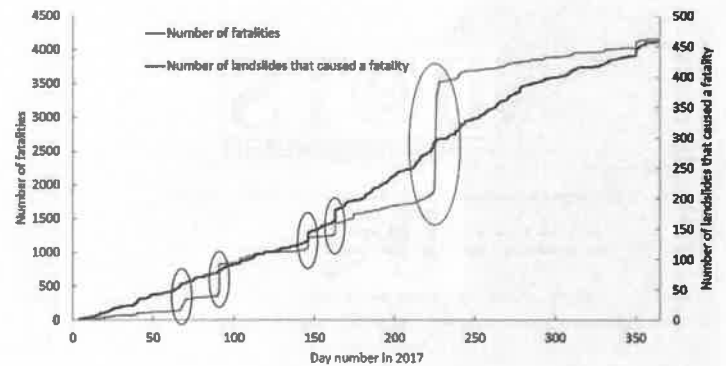
B. Tech. (CSE) having experience in lane and vehicle detection using Python as a front-end developer.

The Problem

- Landslides cause major infrastructure damages and deaths: More than 5000 people are buried alive under landslides with economic losses of more than INR 26,000 crores suffered every year globally.¹
- India tops the global landslide list: Landslides cause more than INR 1000 crores/year in economic losses and more than 1000 deaths/year in India.²
- Existing landslide monitoring solutions are extremely costly³ – A system in Munnar and in Sikkim costed INR 2 crores.



A major landslide at Kotrupi village, Mandi district on August 12th, 2017: 46 dead and buses and houses buried. Source: HT



Cumulative number of fatal landslides and landslide fatalities in 2017 globally

1. NIDM, 2018: <http://nidm.gov.in/pdf/modules/landslide.pdf>

2. Deccan Herald, 2018: <https://www.deccanherald.com/national/india-tops-world-landslide-689244.html>

3. Chaturvedi et al. 2018: <https://www.wiley.com/en-us/Internet+of+Things+A+to+Z%3A+Technologies+and+Applications>

Existing landslide monitoring technologies

Some of the existing landslide monitoring systems (LMSs) involve the following (Chaturvedi et al., 2018):

- Global Positioning System (GPS) method – monitor movement of certain points on a landslide.
- Light Detection and Ranging (LiDAR) method – constructing a 3D representation of landslide via lasers.
- Unmanned Aerial Vehicle (UAV) method – photography via a flying quad-copter.
- Radar Satellite method – low-resolution photography via satellites.
- Conventional geotechnical landslide monitoring methods
- ***Low-cost MEMS-based landslide monitoring methods***

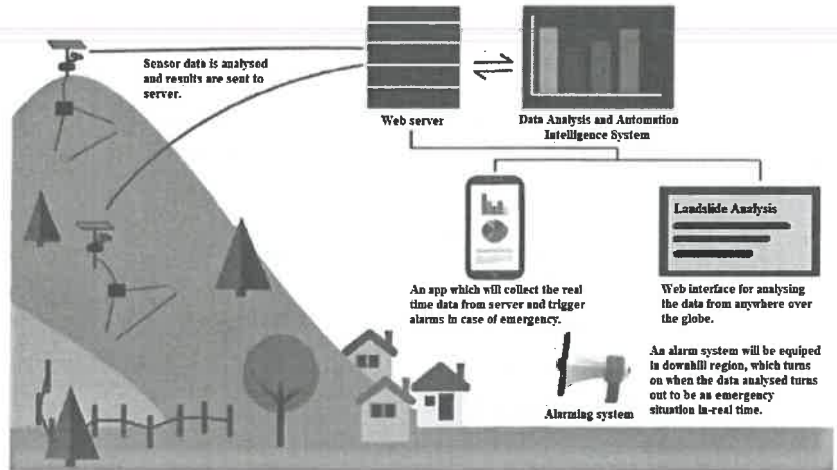
The Solution



Our Contribution: Low – cost Landslide Monitoring System

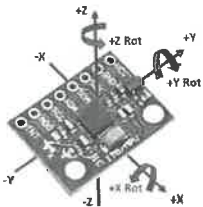
A patented low – cost landslide monitoring and warning system (system) - one that reduces damages due to landslides at deployment sites by monitoring and warning of weather and soil properties.

Model Architecture

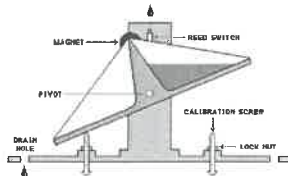


Landslide Monitoring & Warning System - Architecture

Measuring Devices



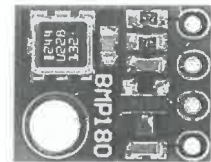
MPU6050



Rain Gauge



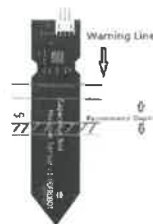
Temp/Hum Sensor



Barometric Pressure Sensor



Force Sensor



Capacitive Soil Moisture Sensor



Ambient Light Sensor



The LMS deployed on the hill.

Our system monitors several weather and soil parameters via sensors on deployment location



Temperature & Humidity
(-40 to 85°C & 0-100 %)



Barometric Pressure
(300-1100 mb)



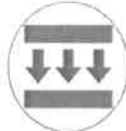
Rainfall Intensity
(in mm)



Light Intensity
(0 - 65535 Lux)



Soil movement
(±2000°/sec rotational & ±16g gravitational acceleration)



Soil force
(0-100N)



Soil moisture
(0-100 %)



Soil temperature
(-40 to 85°C)

NAML OR LOGO

Our Solution's Benefits

In India alone, our solution has the potential for saving yearly more than 1000 human lives and INR 1000 Crores in damages.¹



Rainfall Alerts

Warnings via SMSes for upcoming heavy rainfall



Predictive Analytics

Predictions about movement ahead in time at deployment site.



Movement Alerts

Warnings via hooters and SMSes for movements recorded at deployment sites



Cloud integrated

Data logging at deployment sites on regular intervals



Weather Alerts

Prediction about weather ahead in time at deployed site.

1. Deccan Herald, 2018: <http://www.deccanherald.com/rational/india-roads-would-land-price-bus241.html>

Deployment and Data acquisition



Fig A: Different wired sensors can be seen deployed on the sliding soil mass beyond the crack.



Team deploying the landslide monitoring station on top of Salgi village landslide.

Date/Time	Temperature (C)	Humidity (%)	Pressure (Pa)	Rain (mm)	Light intensity (lux)	Depth 0 Accelerations (g) (Ax,Ay,Az,Wx,Wy,Wz,Pitch,Roll,Yaw)	Force (N)	Moisture (%)
2020-08-09 22:41:19	19.99	1047.52	0.00	0.76, 0.06, 0.66, -17.90, -23.78, 0.26, 35.29, -45.02, 35.28	0.00	0.00	75	
2020-08-09 22:37:38	19.99	1047.51	0.00	0.76, 0.06, 0.66, -17.90, -23.78, 0.26, 35.29, -45.02, 35.28	0.00	0.00	75	
2020-08-09 22:18:58	19.99	1047.56	0.00	0.76, 0.06, 0.66, -17.90, -23.78, 0.26, 35.29, -45.02, 35.28	0.00	0.00	75	
2020-08-09 22:00:18	19.99	1047.57	0.00	0.76, 0.06, 0.66, -17.90, -23.78, 0.26, 35.29, -45.02, 35.28	0.00	0.00	75	

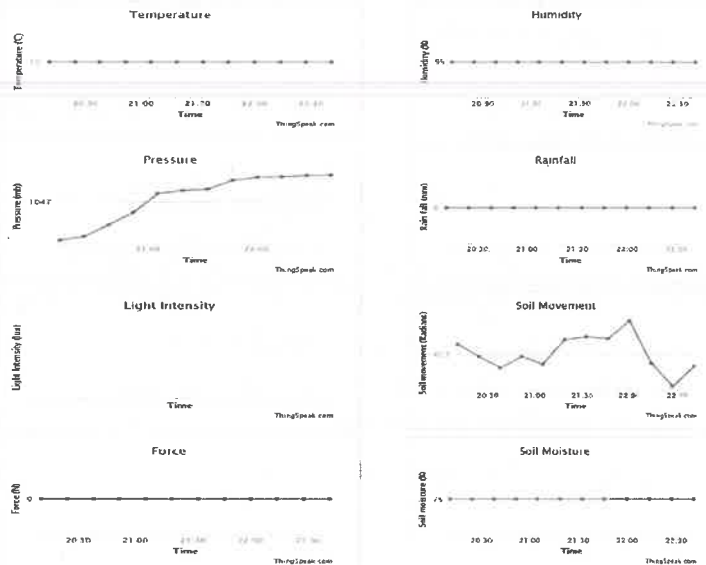


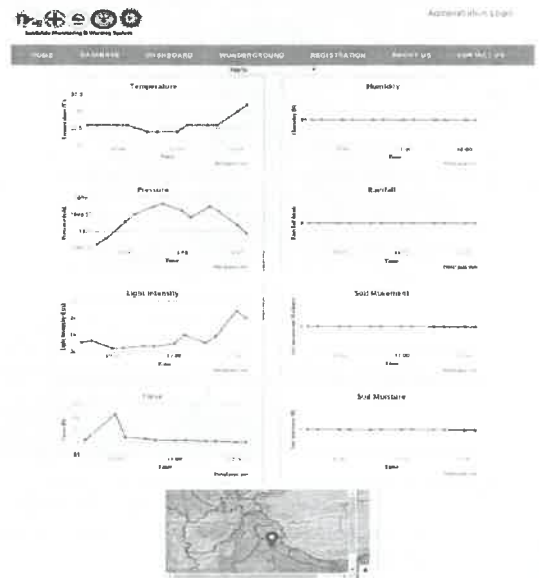
Fig. Data acquisition from the sensors from selected site

Warning light, SMSes, and website showing LMS in action



Rainfall alert:
There is a significant rainfall event coming up at Pandoh. Please look out for landslides. iIoT's IIT Mandi

Movement alert:
There has been moderate soil movements on hills at Pandoh. Please look out for potential landslides. iIoT's IIT Mandi



Alert Generation: How to create actionable intelligence?

- Displacement is computed from Kinematic equation with time $t = 0.001s$.
- The z-score is calculated on soil movement using the formula below:

$$z\ score = \frac{(\Omega_{total} - \bar{\Omega}_{total})}{\Omega_{total\sigma}}$$

where $\bar{\Omega}_{total}, \Omega_{total\sigma}$ are mean and standard deviations of all previous non-zero Ω_s in the database respectively.

$$\Omega_{total} = |\Omega_x| + |\Omega_y| + |\Omega_z|$$

- As per the Z score, movements are classified to small, medium and large.

(Chaturvedi et al., 2018; Pathania et al., in press)

A Case from Balianala, Nainital

There have been small soil movements on hills at Balianala2. Map: <https://bit.ly/2koAzfS>. Please look out for potential landslides. IIoTs IIT Mandi

56 min ago

There have been small soil movements on hills at Balianala2. Map: <https://bit.ly/2koAzfS>. Please look out for potential landslides. IIoTs IIT Mandi

42 min ago

There have been small soil movements on hills at Balianala2. Map: <https://bit.ly/2koAzfS>. Please look out for potential landslides. IIoTs IIT Mandi

28 min ago

There have been small soil movements on hills at Balianala2. Map: <https://bit.ly/2koAzfS>. Please look out for potential landslides. IIoTs IIT Mandi

15 min ago

There have been small soil movements on hills at Balianala3. Map: <https://bit.ly/2kiqosI>. Please look out for potential landslides. IIoTs IIT Mandi

1 min ago

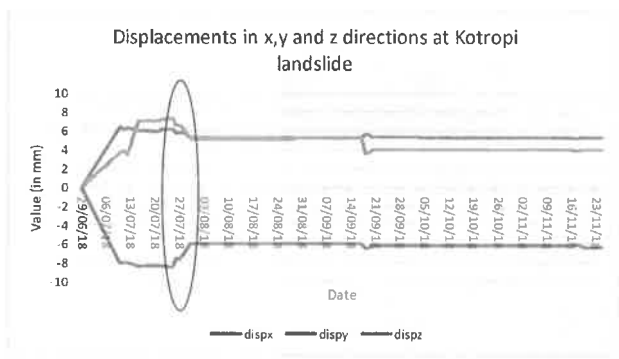
There have been moderate soil movements on hills at Balianala2. Map: <https://bit.ly/2koAzfS>. Please look out for potential landslides. IIoTs IIT Mandi

1 min ago

NAML OR LOGO

A case where our system avoided disaster in Mandi

IIT Mandi develops low-cost landslide monitoring system that can save lives ahead of time



- A tragedy was averted at Kutropi along the Mandi – Jogindarnagar NH due to rains and flash flood by our solution – system issued a warning minutes before the disaster.
- Police stopped traffic before flash flood – Avoided a big disaster!
- About 4-5 vehicles carrying 12-15 people were saved at Kutropi due to the Landslide Monitoring System.

News Coverage



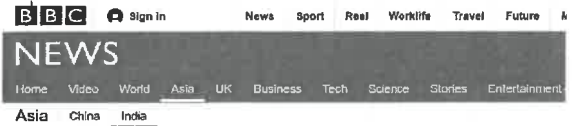
Low cost warning system: IIT Mandi incubator creates a device to sense landslides before they happen

By T.T. Bhatnagar (New Delhi) | Published: August 14, 2019 12:36 AM



Financial Express

<https://www.financialexpress.com/industry/technology/low-cost-warning-system-iit-mandi-incubator-creates-a-device-to-sense-landslides-before-they-happen/1278637/>



The cheap sensor detecting landslides in India

7 November 2019

Share



Waiting for bsw.digitrust...

BBC News

<https://www.bbc.com/news/world-asia-india-50313344>

Recommendation Letter by District Administration Mandi (Himachal Pradesh)

Rugved Thakur, I.A.S.
Deputy Commissioner
Mandi (H.P.)-175001



Tele No. : 01905-225201 (O)
236202 (R)

Fax No. : 01905-225213

D.O. No. : MND-DC-R/DA-50

Dated : 22-07-2020

TO WHOM EVER IT MAY CONCERN

This is to certify that the Landslide monitoring technology developed by team Intiot Services Pvt Ltd. (incubated by IIT Mandi), comprising of faculty from IIT Mandi, has been installed in Mandi district at 14 locations initiated in July, 2018. Since the installation, these sensors have been working fine and providing timely alerts at locations by hooters & blinkers and also to concerned agencies through SMS alerts. This technology also provides predictions for weather and possible chances of landslides ahead of time. Intiot Services Pvt Ltd. also have been providing technical support and maintenance services whenever required.

I wish them good luck in making this technology implemented in large scale.


(Rugved Thakur, IAS)

Awards

Won the 3rd prize in the Development of Innovative Prototypes for Disaster Risk Reduction (DRR), Shimla, Himachal Pradesh.



Intiot team receiving the Award from Chief Secretary, Himachal Pradesh

Patents and Publications

The developed technologies have been filed for patent (2 Indian and 1 International) on landslide monitoring technology and 1 Indian patent on pollution monitoring.

Several publications based on technology, principle and predictions on landslide monitoring have been communicated in refereed conferences, book chapters and journals.

Recent Deployments

Landslide Monitoring Systems have been deployment for the Indian Railways on the Kalka – Shimla Railway Line in Himanchal Pradesh



Machine Learning on Sensed Data

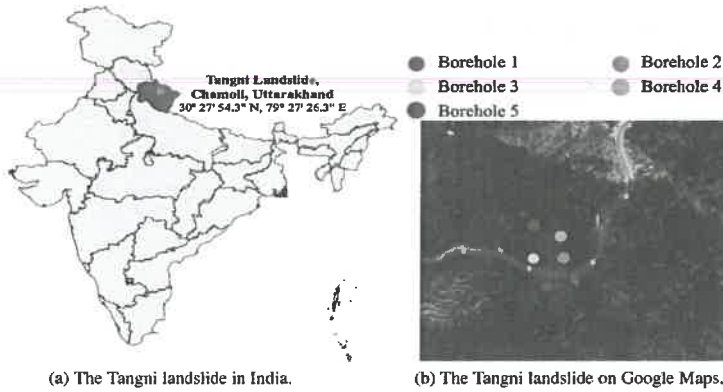


Fig. 8. Location of the study area.

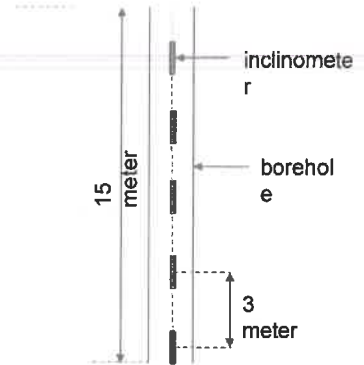


Fig. 9. Inclinometers installed in borehole

Two years time-series data was obtained from Defence Terrain Research Laboratory, Defence Research and Development Organization (DTRL-DRDO) landslide station at Chamoli, Uttarakhand, India.

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Data

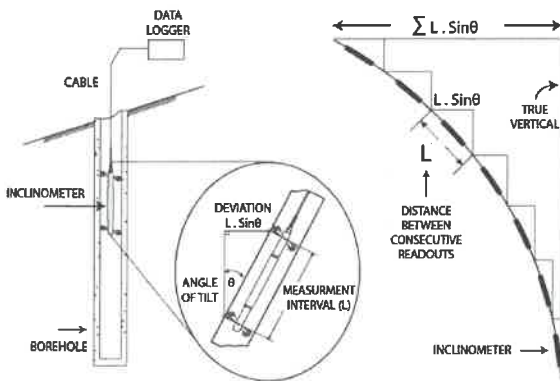


Fig. 10. Inclinometer sensor installed in its casing at a certain depth.

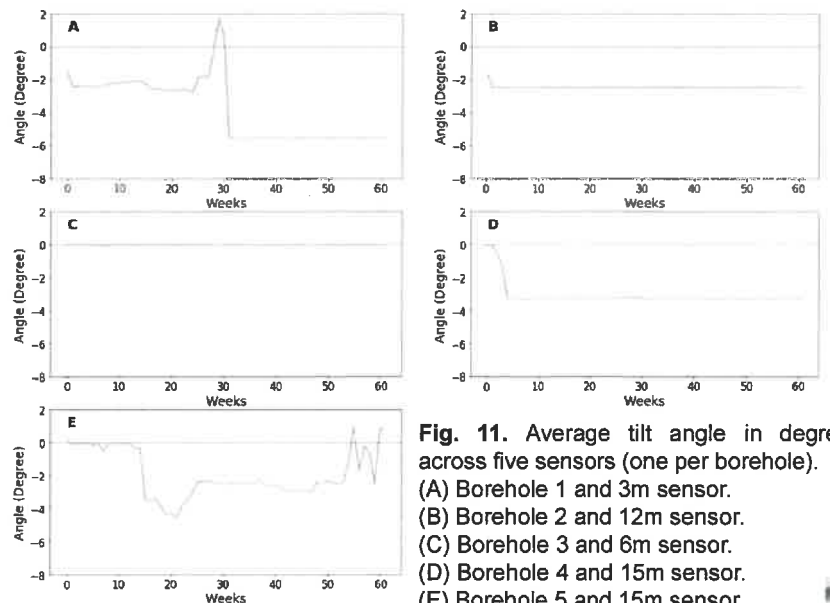
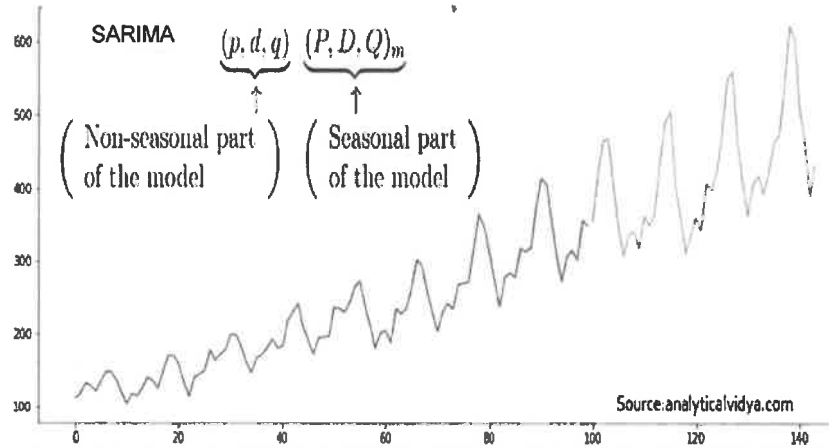


Fig. 11. Average tilt angle in degrees across five sensors (one per borehole). (A) Borehole 1 and 3m sensor. (B) Borehole 2 and 12m sensor. (C) Borehole 3 and 6m sensor. (D) Borehole 4 and 15m sensor. (E) Borehole 5 and 15m sensor.

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Methodology

Moving-Average Model.



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Methodology

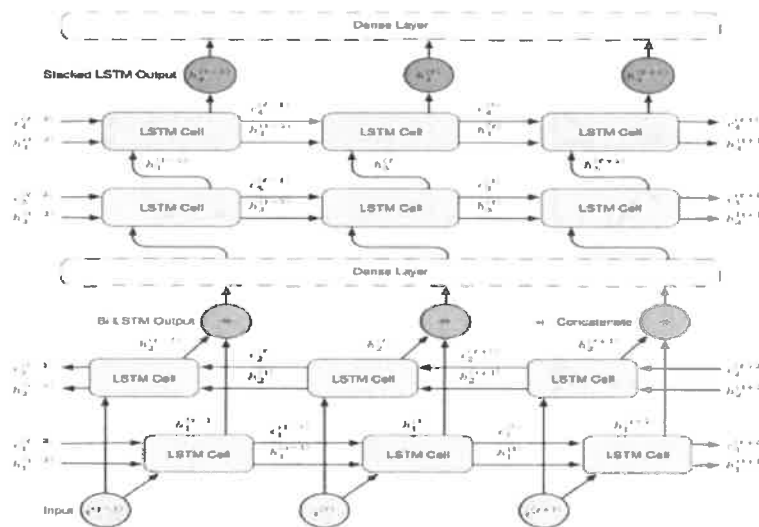


Fig.12. The structure of the BS-LSTM.

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Results for Dharampur

Landslide Monitoring System deployed for the Indian Railways on the Kalka – Shimla Railway Line in Himachal Pradesh

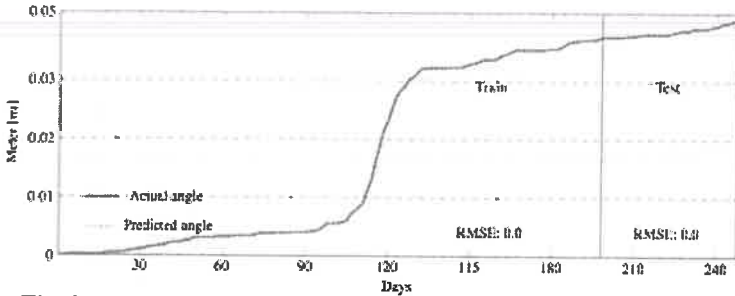


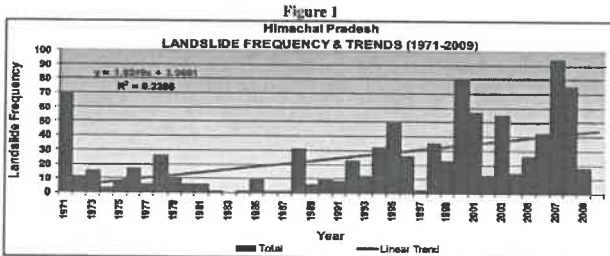
Fig.16. The best performing BS-LSTM model showing the soil movement (in meters) over the Kumarhatti's training and testing dataset.



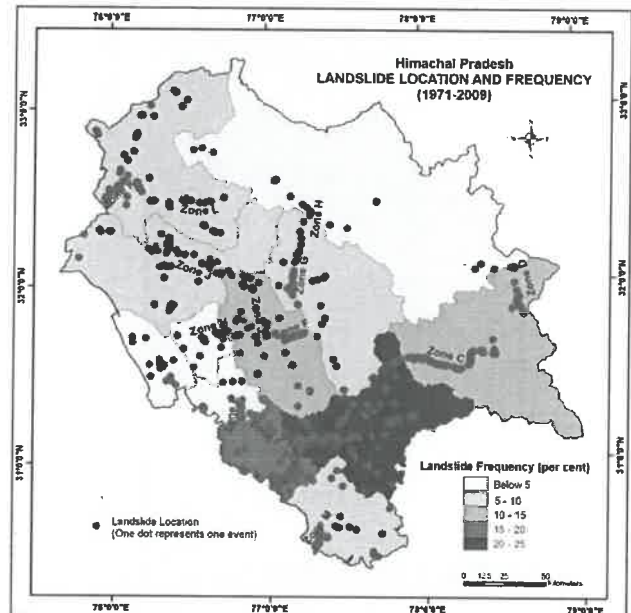
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Landslides in Himachal Pradesh (Kahlon, Chandel, & Brar, 2014)

Figure 2



Source: compiled from The Tribune, 1971-2009



Source: The Tribune, 1971-2009

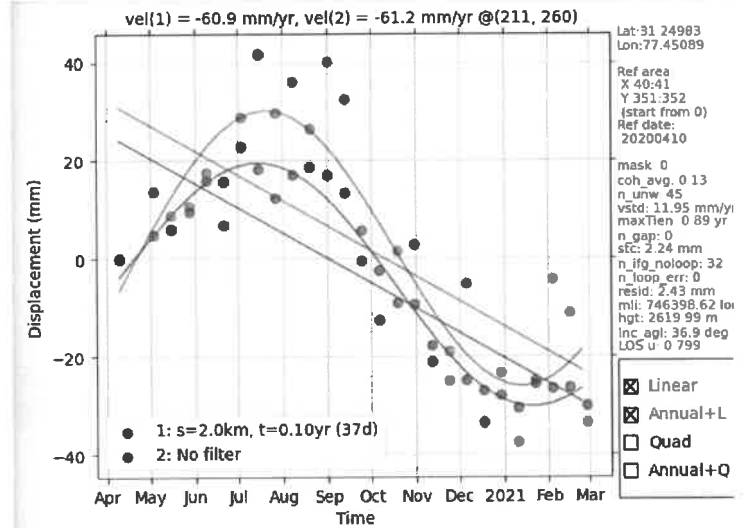
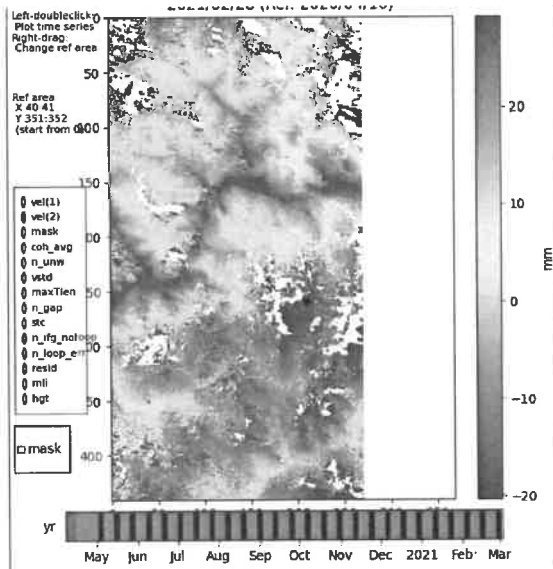
Table 3: District-wise Decadal Distribution of Landslides (1971-2009)

	District	1971-1979	1980-1989	1990-1999	2000-2009	Decadal Total (per cent)
1	Shimla	50 (20.49)	9 (4.52)	55 (25.11)	95 (20.04)	209 (22.74)
2	Solan	38 (23.17)	7 (11.29)	31 (14.15)	62 (13.06)	138 (15.02)
3	Kinnaur	17 (10.37)	3 (4.84)	18 (8.22)	85 (17.93)	123 (13.38)
4	Mandi	20 (12.20)	12 (19.35)	27 (12.33)	40 (8.44)	99 (10.77)
5	Chamba	4 (2.44)	6 (9.68)	26 (11.87)	49 (10.34)	85 (9.26)
6	Sirmaur	7 (4.27)	0	3 (1.37)	54 (11.39)	64 (6.97)
7	Kangra	4 (2.44)	5 (8.06)	10 (4.57)	38 (8.02)	57 (6.20)
8	Kullu	8 (4.88)	3 (4.84)	15 (6.85)	23 (4.85)	49 (5.33)
9	Bilaspur	12 (7.32)	2 (3.23)	19 (8.68)	7 (1.48)	40 (4.35)
10	Lahaul & Spiti	2 (1.22)	1 (1.61)	7 (3.20)	12 (2.53)	22 (2.39)
11	Hamirpur	2 (1.22)	3 (4.84)	6 (2.74)	7 (1.48)	18 (1.96)
12	Una	0	11 (17.74)	2 (0.91)	2 (0.42)	15 (1.63)
	Total (per cent)	164 (100)	62 (100)	219 (100)	474 (100)	919 (100)

Source: compiled from The Tribune, 1971-2009

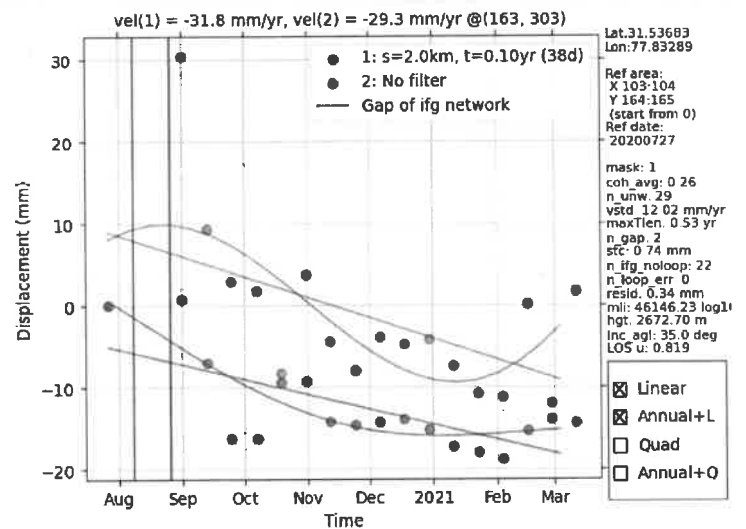
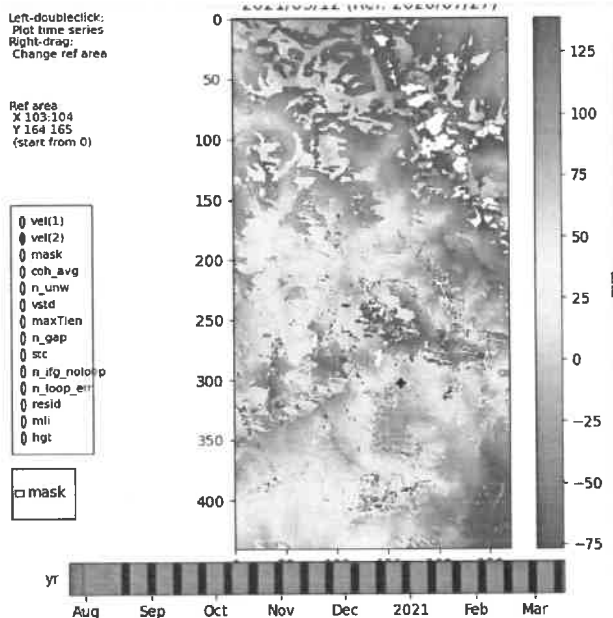
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Sentinel-1 based InSAR (SBAS) Analyses of Shimla Area Between April 2020 and March 2021 (+ is Narkanda)



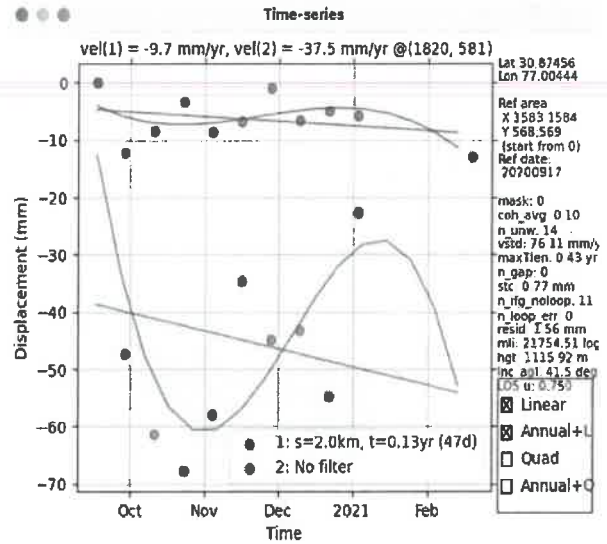
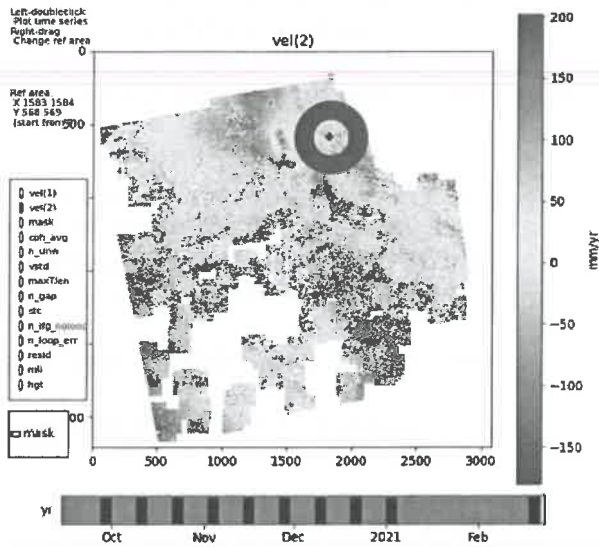
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Sentinel-1 based InSAR (SBAS) Analyses of Kinnaur Area Between July 2020 and March 2021 (+ is Jeeri)



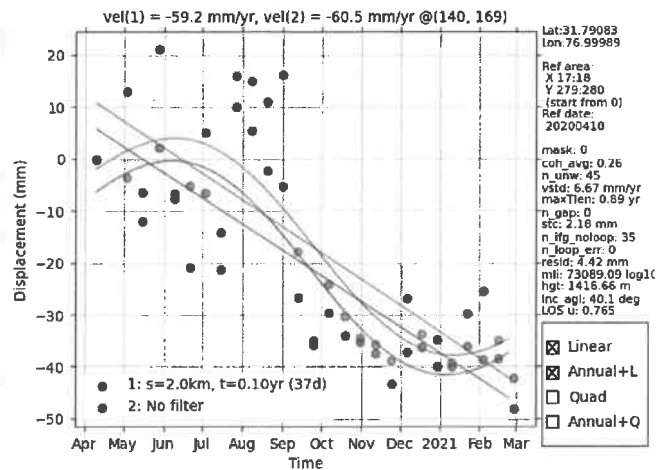
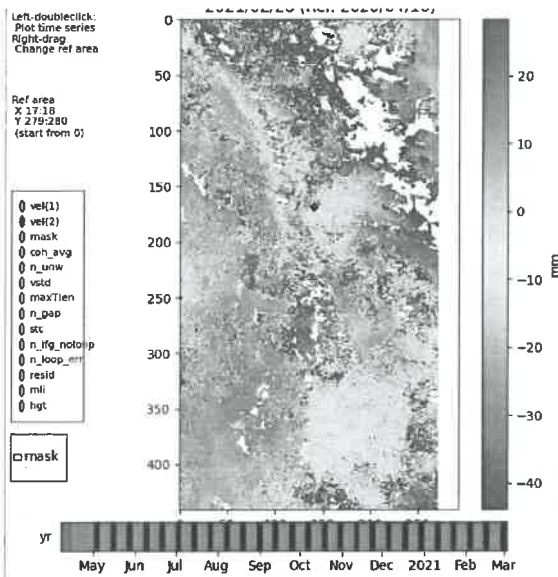
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Sentinel-1 based InSAR (SBAS) Analyses of Solan Area Between September 2020 and March 2021 (+ is Dharampur)



NAML OR LOGO

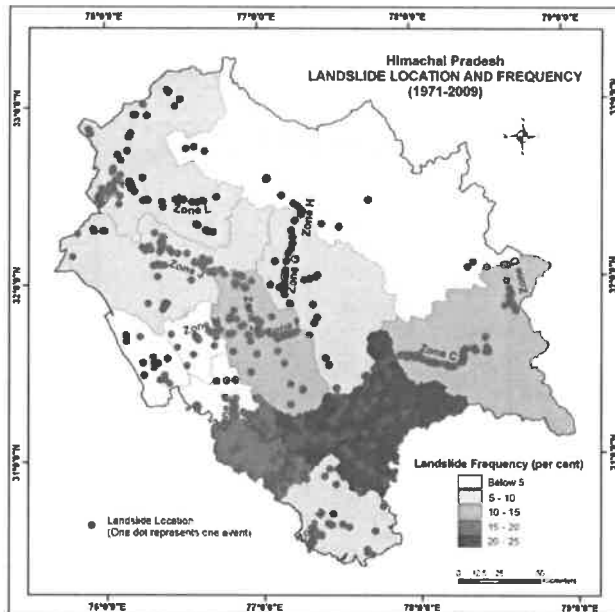
Sentinel-1 based InSAR (SBAS) Analyses of Mandi Area Between July 2020 and March 2021 (+ is Kamand Valley)



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Proposal for HP State for landslide monitoring and warning systems

Figure 2



Source: The Tribune, 1971-2009

- Deploy up to 20-25 systems per district totaling to 150 systems at critical landslide sites in Kinnaur, Shimla, Kangra, Chamba, and Mandi etc.
- 70% deployments are based upon sites identified by DDMA of the district and 30% of the sites are identified based upon satellite analyses.
- Deployment cost: INR 1.0 lakh per site
- Maintenance cost: INR 25,000 per year per site

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Thank you!

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