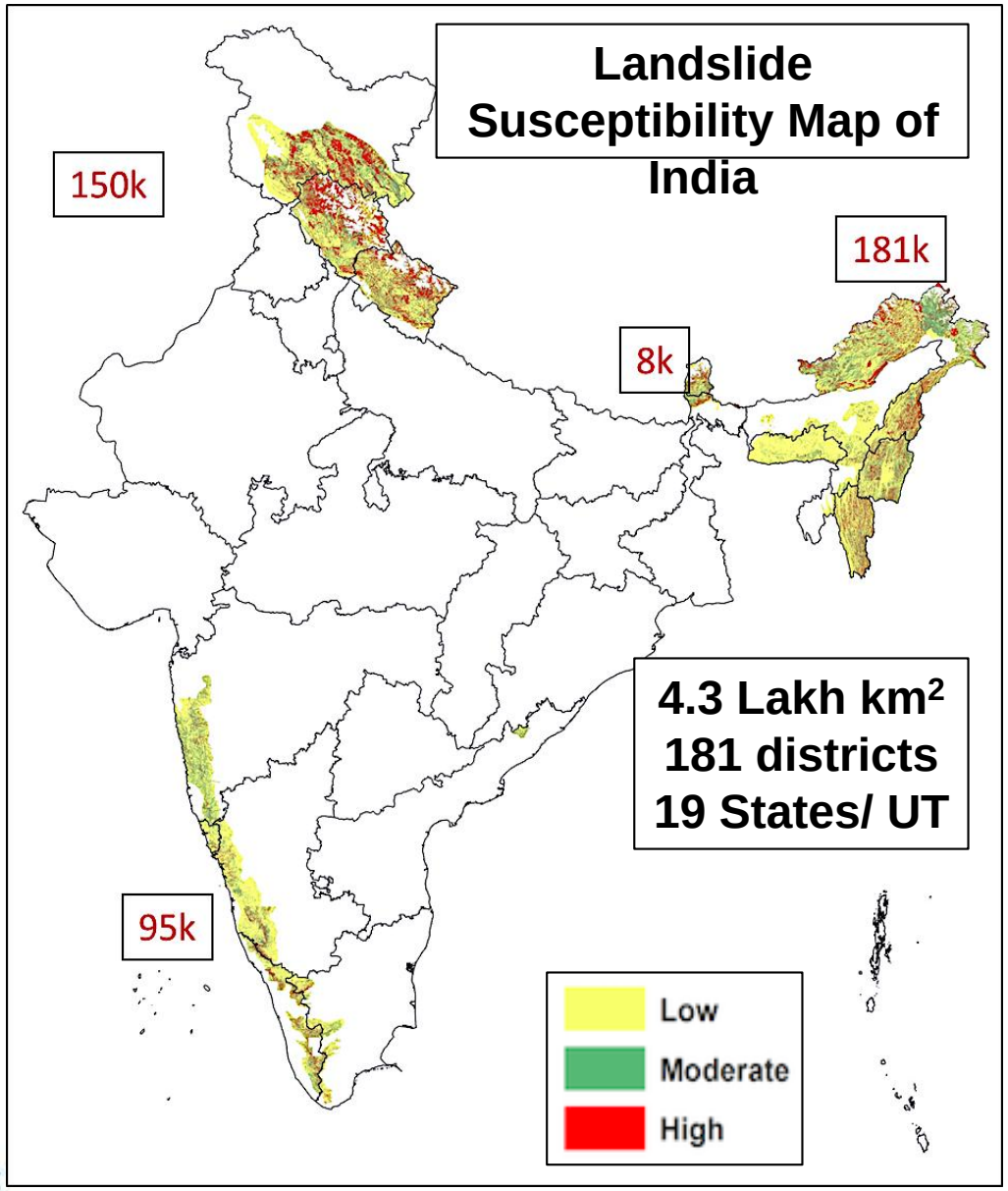
भारतीय भूवैज्ञानिक सर्वेक्षण

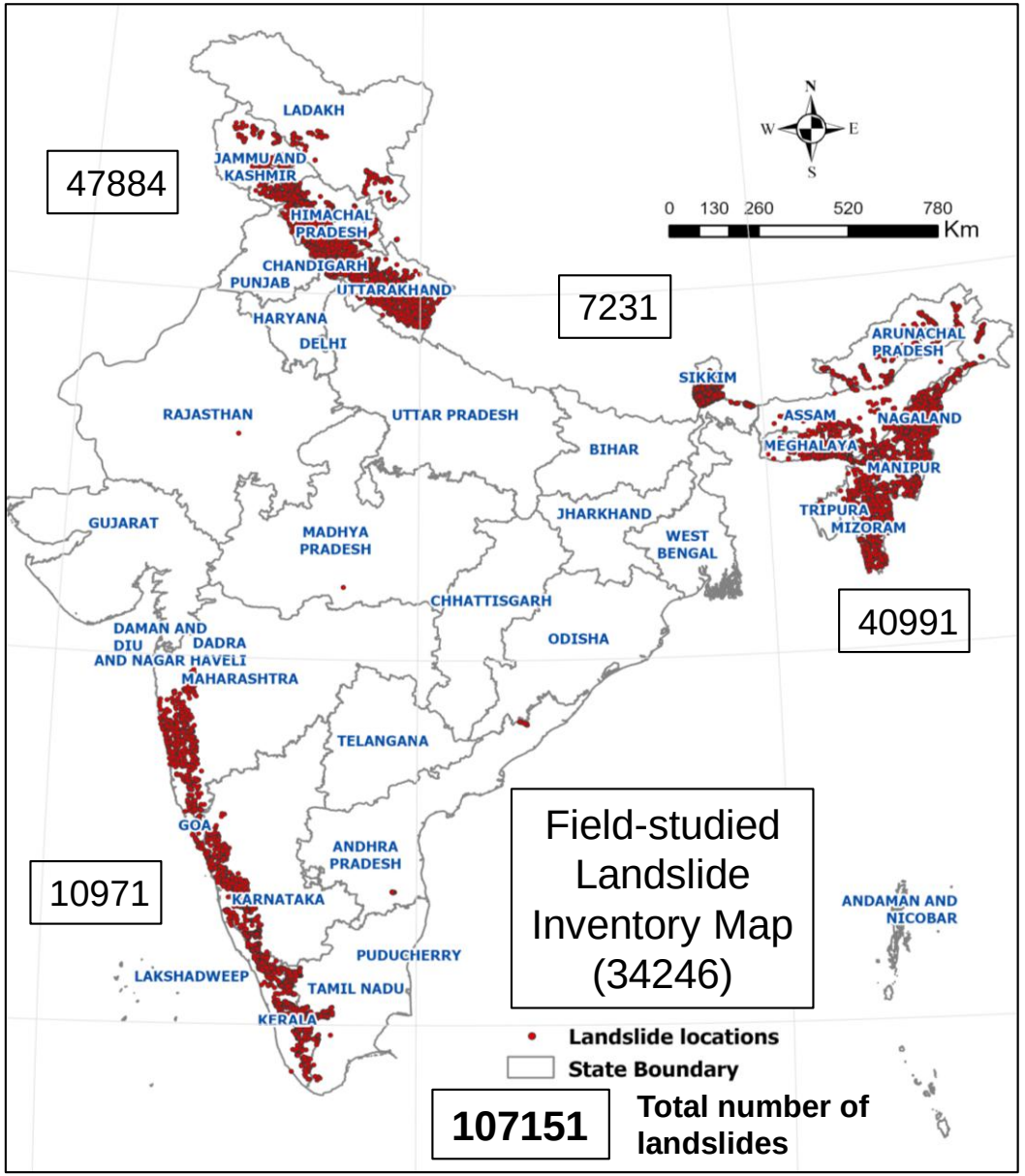
GEOLOGICAL SURVEY OF INDIA

Regional Landslide Forecasting System

Dr. Harish Bahuguna
Dy. Director General

Landslide Hazard Scenario in India

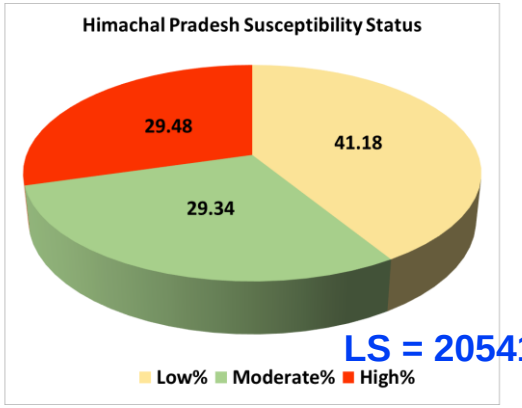




Landslide Susceptibility Scenario in India (High-risk landslide-prone States)

NW Himalayas

LS = 47884



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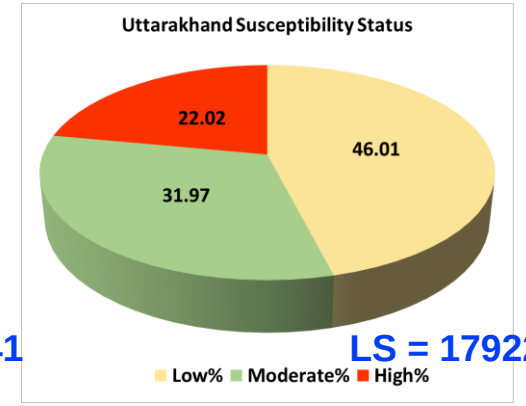

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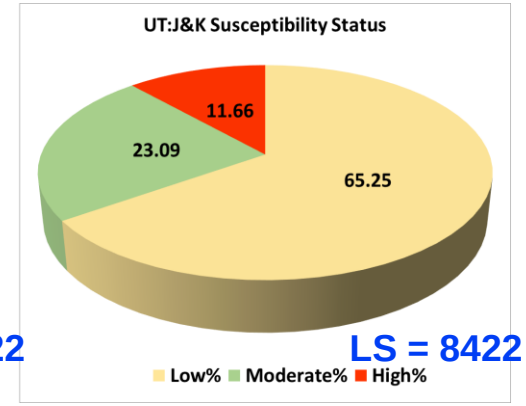

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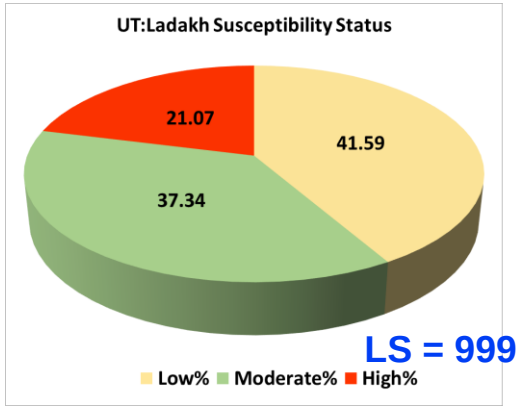
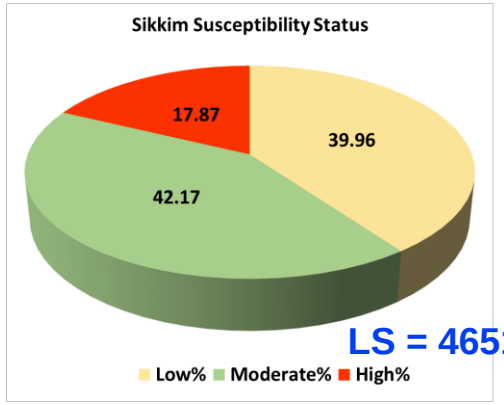


LS = 999

Darjeeling-Sikkim Himalayas

LS = 7231



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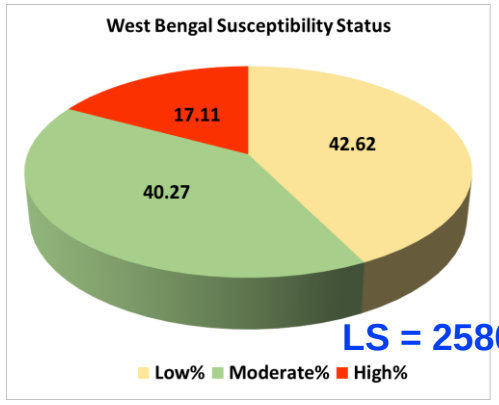
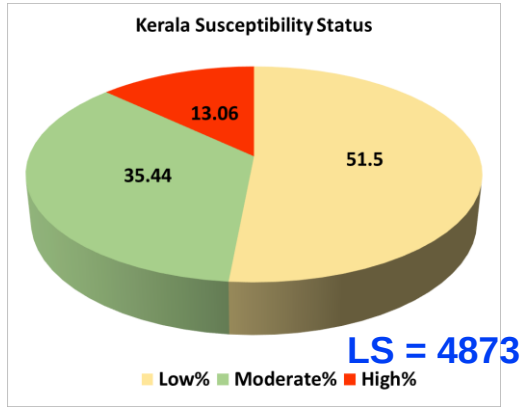


LS = 2580

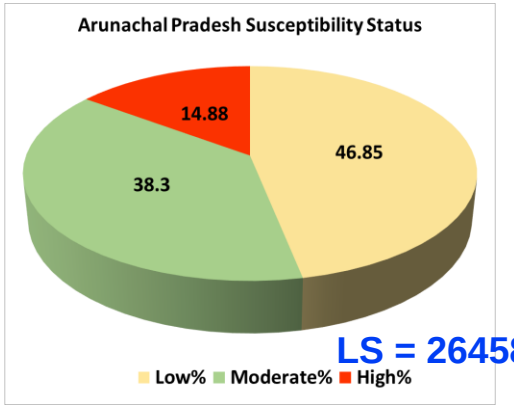
Western Ghats



LS = 4873

North-eastern Region

LS = 40991



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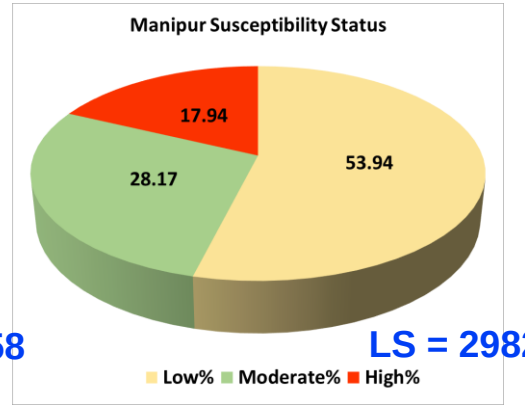

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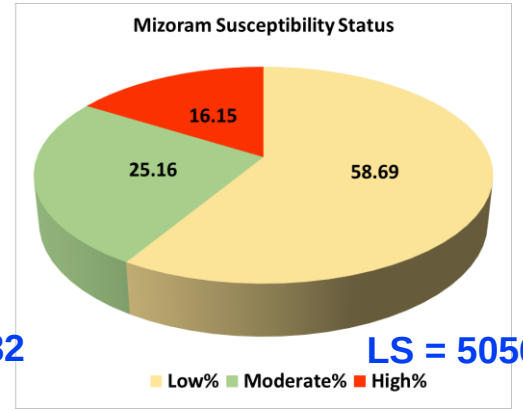

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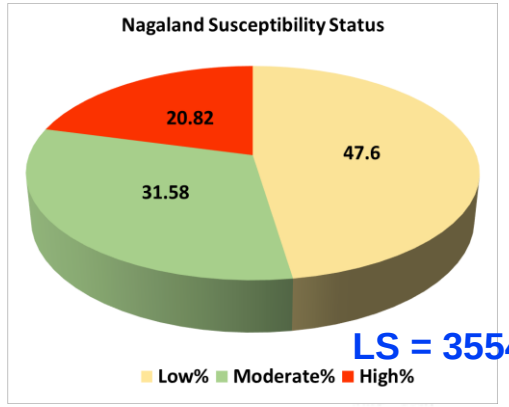


LS = 3554

Follow us on:

Landslide Early Warning Systems (L-EWS)

Landslide forecasting

Regional scale (for multiple slope)

Regional thresholds, Susceptibility conditions, other static information's, Multi institutional

For District/State/Region

Regional Scale – Many slides

Landslide monitoring

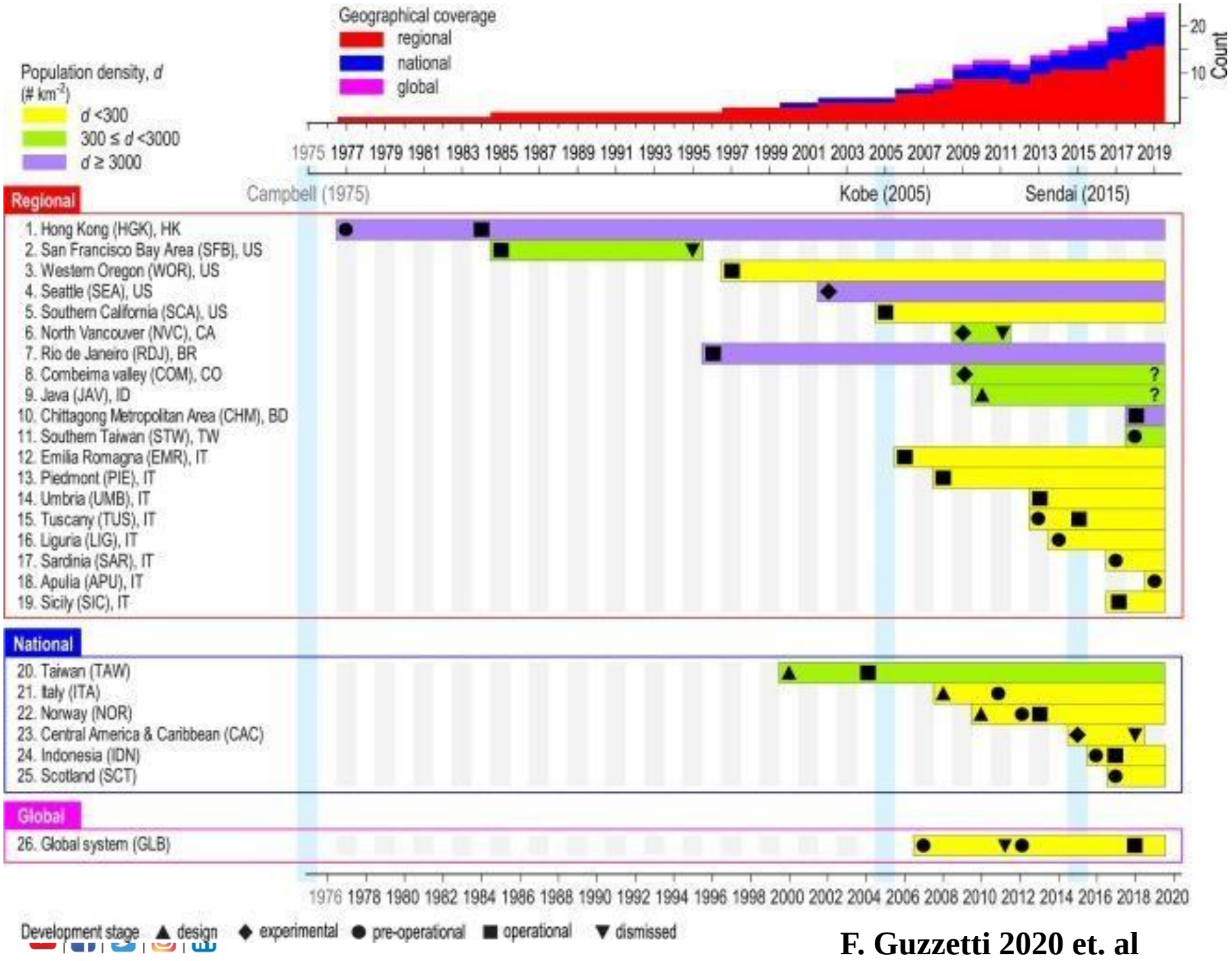
Slope scale (for single slope)

Creep, reactivated, **slow moving**

Sensors, data and cost intensive, instrumentation

Slope Scale – Single slide

Global Scenario Regional LEWS

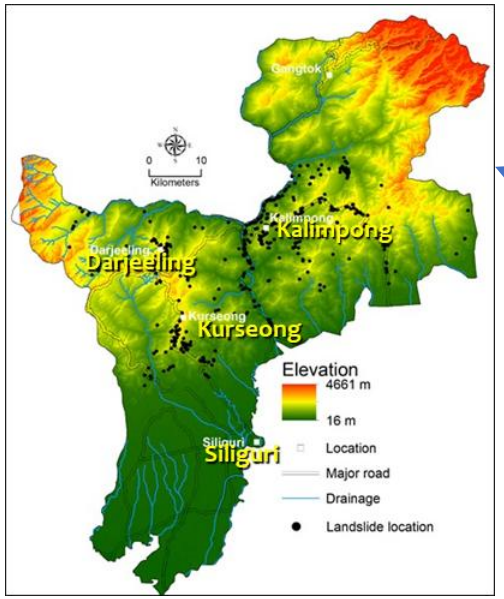


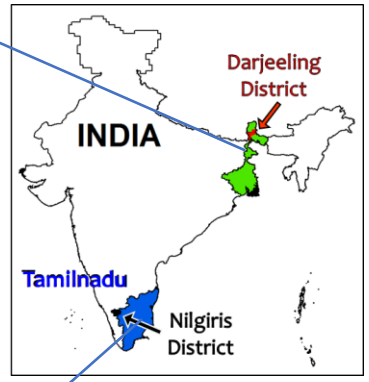
Country	Nos.
Italy	8
US	4
Colombia	1
Indonesia	1
Canada	1
Taiwan	1
Hong Kong	1
Brazil	1
Bangladesh	1

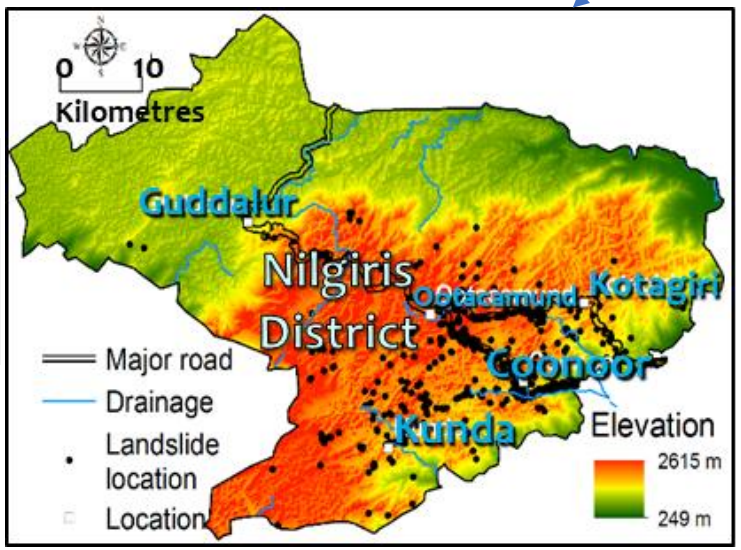
Operational	14
Pre-operational	7
Experimental	2
Developmental	1
Dismissed	2

F. Guzzetti 2020 et. al

Development of Regional LEWS "LANDSLIP Project" (2017-2020)







- Develop a **Prototype** LEWS

- Combines **meteorological, landscape and Social dynamics** information in the test case areas

- **Test case areas:**

1. Nilgiris District, Tamil Nadu
2. Darjeeling District, West Bengal

- **Spatial Scale**: Catchment & Region
- **Temporal scale**: Daily

- ❑ Terrain (Geol/tectonics)
- ❑ Topography (Maturity)
- ❑ Meteorology (Monsoon)
- ❑ Landslide (type/distribution)

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FORECAST BULLETIN: Short Range Landslide Forecast (24 hr & 48 hr)

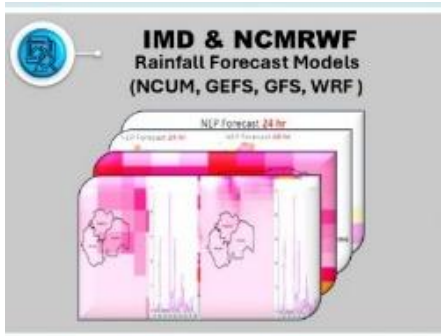
Input Data

1. Meteorological Dynamics (Rainfall forecast models**)**

MME and GFS model of IMD

NCUM (global/ regional) of NCMRWF

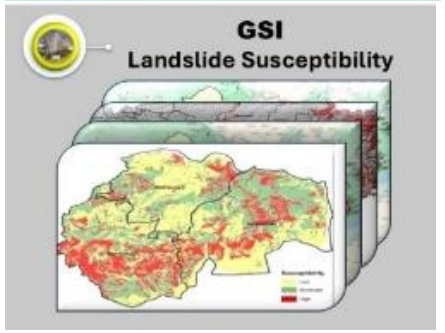
BFS of IITM



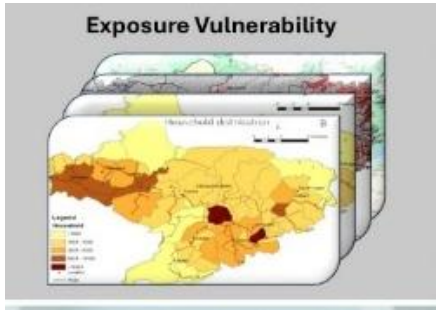
2. Landscape Dynamics: Geo-factor maps,

landslide density/events,

Initiation/ Runout susceptibility**)**



3. Social Dynamics: Exposure Vulnerability



भारतीय भूवैज्ञानिक सर्वेक्षण
Geological Survey of India

खान मंत्रालय, भारत सरकार
Ministry of Mines, Govt. of India

सत्यमेव जयते

REGIONAL LANDSLIDE FORECASTING SYSTEM

DATA & INPUTS

GSI, IMD, DDMA, SDMA, Crowd Source
- Historical Rainfall
- Historical Landslide

IMD & NCMRWF
Rainfall Forecast Models (NCUM, GEFS, GFS, WRF)

NCMRWF
Weather Pattern

GSI
Landslide Susceptibility

Exposure Vulnerability

PROCESSES & ALGORITHM

RAINFALL THRESHOLD

SHORT RANGE LANDSLIDE FORECAST
48 hrs lead
24 hrs lead

MEDIUM RANGE FORECAST
10 days lead

LANDSCAPE DYNAMICS
Static Maps

DECISION SUPPORT SYSTEM

BHUSANKET-DASHBOARD

Forecast

FORECAST BULLETIN

NATIONAL LANDSLIDE FORECASTING CENTRE

BHUSANKET PORTAL

National Landslide Forecasting Centre
राष्ट्रीय भूस्खलन पूर्वानुमान केंद्र

The SENDAI Framework for Disaster Risk Reduction 2015-2030

Bulletin Report

Project Status

Landslide Inventory
31545

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MOBILE APP

BHUSKHALAN
LOGIN
REGISTER
Register as Public
Register as Expert
Username
Email ID
Mobile number
Organization
Password
Confirm password

DISSEMINATION

- EMAIL
- SMS
- WEB PORTAL
- MOBILE APP

NDMA/SDMA/DDMA/PUBLIC

- Prototype models developed under International collaboration (*LANDSLIP* www.landslip.org.)
- National and international collaborators, BGS, Kings College, CNR-IRPI, Met Office, Amrita University, PA India & UK, Newcastle University, IMD, NCMRWF, KSDMA, WBSDMA, TNSDMA, USDMA, HPSDMA, KSNDMC, ASDMA, NSDMA & SSDMA

GSI Awareness & Preparedness
Safety of public is our top priority

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Forecast Bulletin

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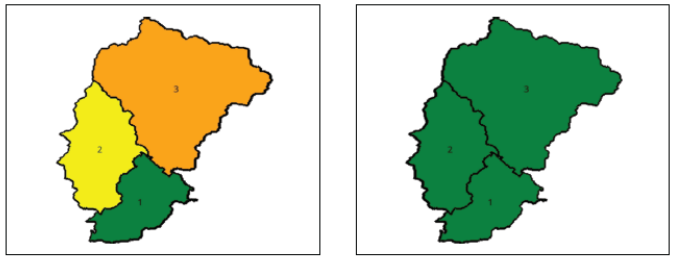
Experimental Rainfall Induced Landslide Forecast Bulletin
Rudraprayag, Uttarakhand

Date of Issue: 2 September 2025 (Not for public use) Time of Issue: 14:00 IST

Day 1 (valid from 2 September 2025 14:30 to 3 September 2025 14:30)

Day 2 (valid from 3 September 2025 14:30 to 4 September 2025 14:30)

Short-Range



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	Medium possibility of occurrences of landslides.Isolated landslide events may occur.
Low	Low possibility of occurrences of landslides, a few small landslides may occur

Administrative Index (Sub-Divisions)

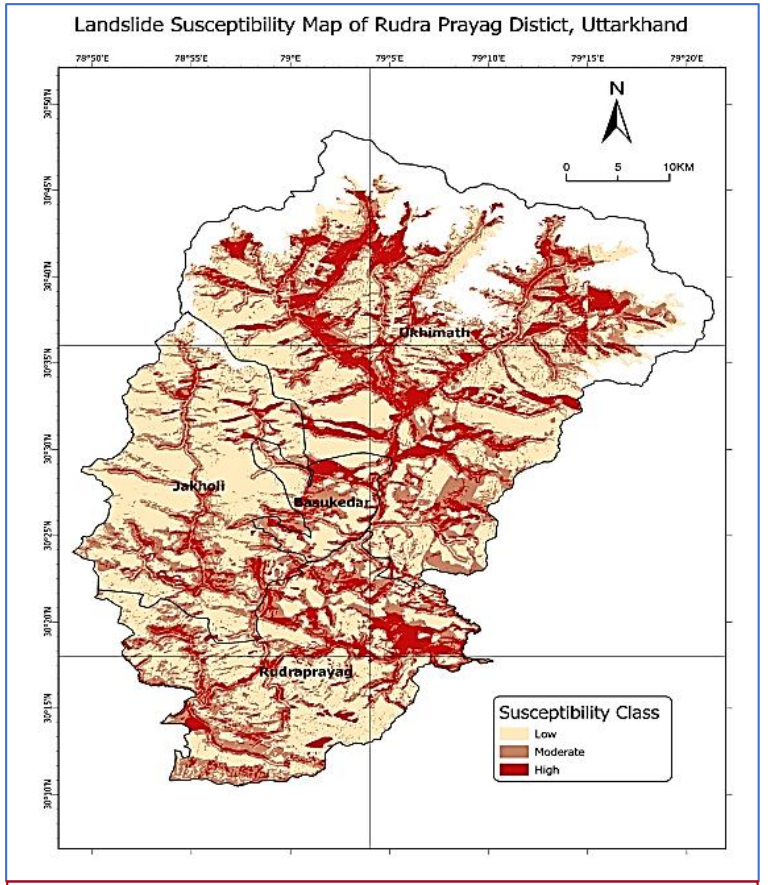
1. Rudraprayag
2. Jakholi
3. Ukhimath

Day 1: High possibility of landslideoccurrences in Ukhimath Sub-Division. Multiple landslides may occur in the above Sub-Divisions. Moderate possibility of landslide occurrences in Jakholi Sub-Division. Isolated landslide may occur in the above Sub-Divisions. Low possibility of landslideoccurrences in Rudraprayag Sub-Division. However untreated modified slopes (road/settlement cuts) are prone to failure.

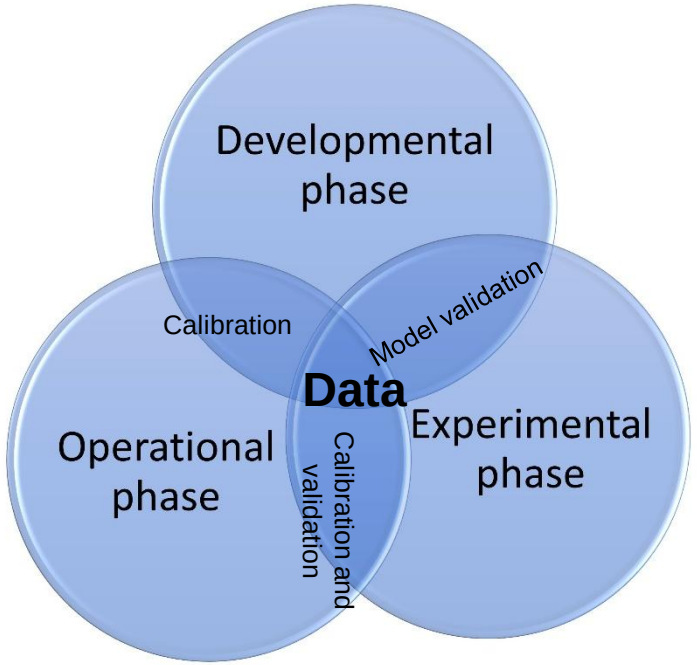
Day 2: Low possibility of landslide occurrences in Rudraprayag, Jakholi and Ukhimath Sub-Divisions. However untreated modified slopes (road/ settlement cuts) are prone to failure.

- Forecast for any day is valid from 14:30 IST of day till 14:30 IST of next day.
- For more details kindly visit bhusanket.gsi.gov.in. Phone: 033-22520137

Page-2



2nd page contains landslide Susceptibility Map



From developmental phase to experimental to operational phase, data is required for model validation, and calibration of the model.

Technical formalities for Integration of Operational Forecast Bulletins with SACHET on CAP platform completed

Forecast/Warning will be issued from the onset of Monsoon 2026

1st page contains landslide forecast information, updated daily. Forecast maps show the 24 hour and 48 hour landslide forecasts for the District.

Regional Landslide Forecasting (2020 to 2025)

State/ UT (No. of Districts)	District Name (s)
Operational forecast (Shared in public domain & State/ District Administrations) – 04 districts	
West Bengal (02)	Darjeeling, Kalimpong (since 19th July 2024)
Tamil Nadu (01)	Nilgiris (since 19th July 2024)
Uttarakhand (01)	Rudraprayag (since 04th September 2025)
Experimental forecast for ground testing (shared with State/ District Administrations) – 17 districts	
Sikkim (06)	Soreng, Pakyong, Mangan, Gyalshing, Gangtok, Namchi
Kerala (02)	Wayanad, Idukki
Karnataka (01)	Kodagu
Uttarakhand (03)	Chamoli, Uttarkashi, Tehri Garhwal
Himachal Pradesh (02)	Shimla, Kinnaur
Nagaland (03)	Peren, Dimapur, Kohima

Status of Experimental and Operational Bulletin -2025

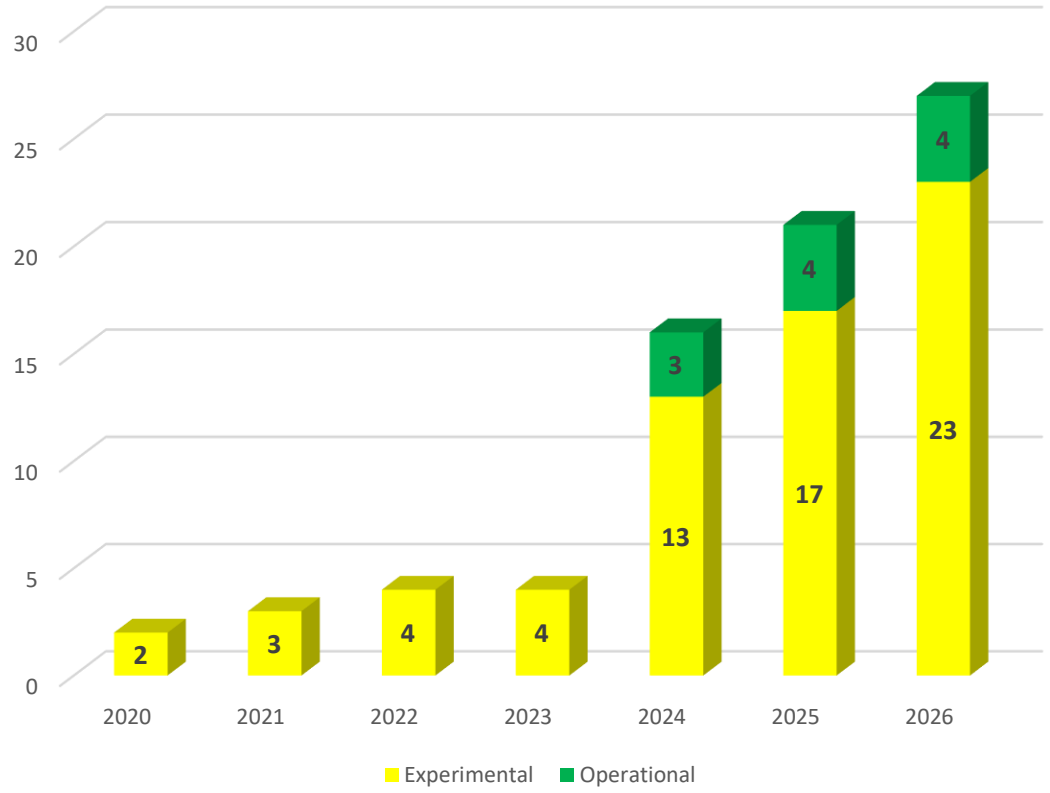
S. No	State	District		Stage	Total
1	West Bengal	i	Darjeeling	Operational	166
		ii	Kalimpong	Operational	166
2	Sikkim	i	Mangan	Experimental	165
		ii	Gyalshing	Experimental	165
		iii	Soreng	Experimental	165
		iv	Namchi	Experimental	165
		v	Gangtok	Experimental	165
		vi	Pakyong	Experimental	165
3	Tamil Nadu	i	The Nilgiris	Operational	240
4	Karnataka	i	Kodagu	Experimental	233
5	Kerala	i	Wayanad	Experimental	241
		ii	Idukki	Experimental	233
6	Uttarakhand	i	Rudraprayag	Experimental/ Operational	93/ 71
		ii	Chamoli	Experimental	164
		iii	Tehri Garhwal	Experimental	164
		iv	Uttarkashi	Experimental	164
7	Himachal Pradesh	i	Shimla	Experimental	164
		ii	Kinnaur	Experimental	164
8	Nagaland	i	Dimapur	Experimental	164
		ii	Peren	Experimental	164
		iii	Kohima	Experimental	164

2025 Monsoon

Total Bulletins issued : 21 districts

Operational Bulletins: 4 nos

Experimental Bulletins: 17 nos



Progress Since 2020……..

Perspective plan

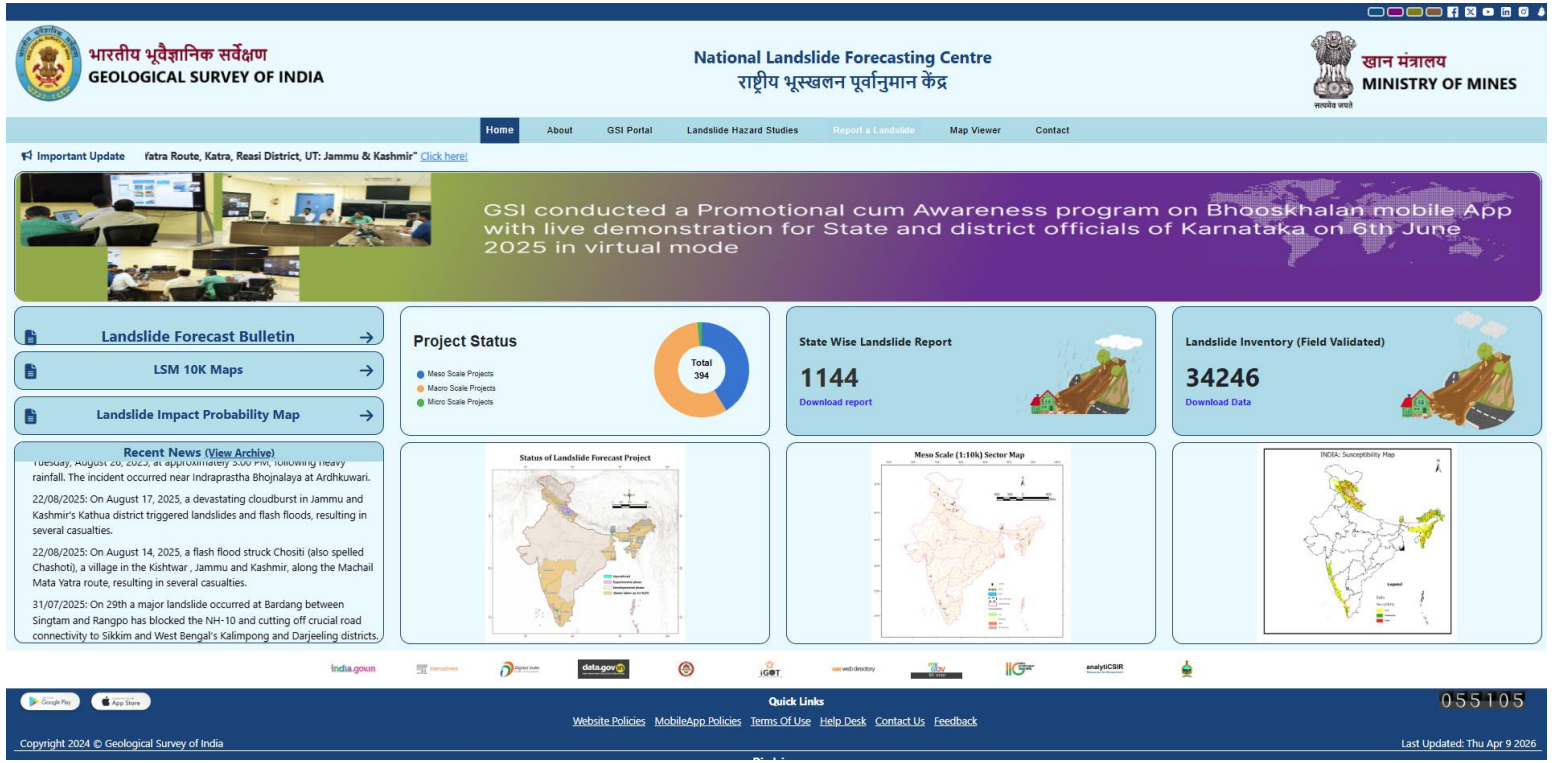
S. No.	State	Districts	2026	2027	2028	2029	2030
1	West Bengal	Darjeeling	Operational				
		Kalimpong	Operational				
2	Tamil Nadu	Nilgiris	Operational				
3	Uttarakhand	Rudraprayag	Operational				
		Chamoli	Experimental	Operational			
		Tehri Garhwal	Experimental	Operational			
		Uttarkashi	Experimental	Operational			
		Nainital	Developmental			Experimental	
4	Sikkim	Mangan	Experimental		Operational		
		Gangtok	Experimental		Operational		
		Namchi	Experimental		Operational		
		Gyalshing	Experimental		Operational		
		Soreng	Experimental		Operational		
		Pakyong	Experimental		Operational		
5	Himachal Pradesh	Shimla	Experimental	Operational			
		Kinnaur	Experimental	Operational			
		Sirmaur	Developmental	Experimental			Operational
6	Kerala	Wayanad	Experimental			Operational	
		Idukki	Experimental				Operational
7	Nagaland	Kohima (Old)	Experimental			Operational	
		Dimapur (Old)	Experimental			Operational	
		Peren	Experimental			Operational	
8	Arunachal	Itanagar	Developmental	Experimental			Operational
9	Karnataka	Kodagu	Experimental				Operational
10	Maharashtra	Raigarh	Developmental	Experimental			Operational
11	Mizoram	Kolasib	Experimental				Operational
		Aizawl	Experimental				Operational
12	Meghalaya	East Khasi hills (Old)	Developmental	Experimental			Operational
		West Khasi hills (Old)	Developmental	Experimental			Operational
		West Jaintia (Old)	Developmental	Experimental			Operational
		Ri-Bhoi	Developmental	Experimental			Operational
13	Assam	Dima Hasao	Experimental				Operational
		Cachar	Experimental				Operational
		Kamrup M	Developmental		Experimental		
		Kamrup R	Developmental		Experimental		
14	Goa	North Goa	Developmental			Experimental	
		South Goa	Developmental			Experimental	
15	Andhra Pradesh	Vizag		Developmental			Experimental
16	J &K	Ramban	Developmental		Experimental		
17	Ladakh	Kargil	Developmental				Experimental
18	Manipur	Senapati	Developmental			Experimental	
		Ukhrul	Developmental			Experimental	
19	Tripura	North Tripura	Developmental			Experimental	
		Dhalai	Developmental			Experimental	

Experimental

Operational

Developmental

Bhusanket Web Portal



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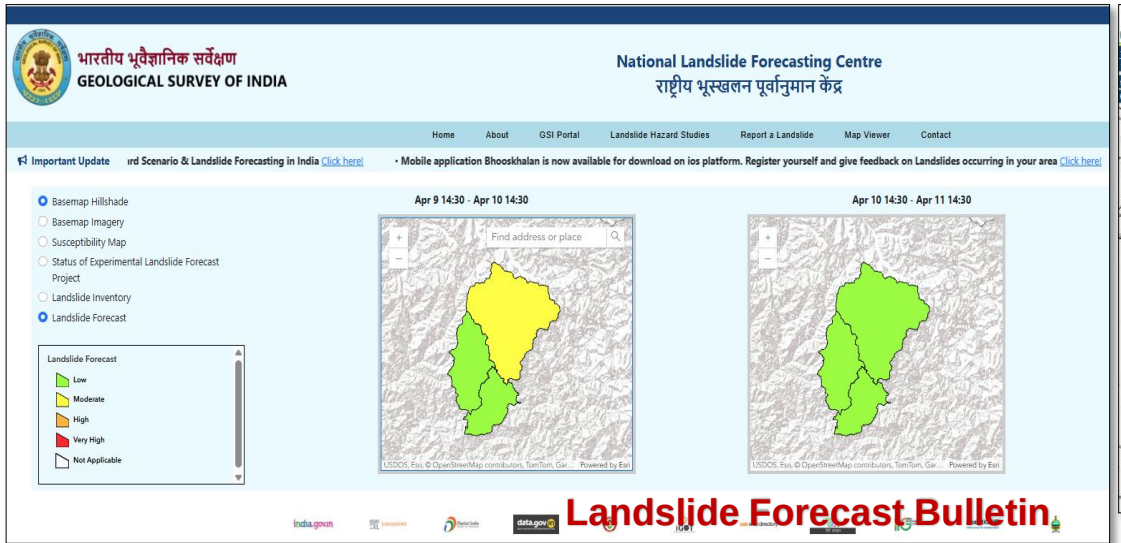
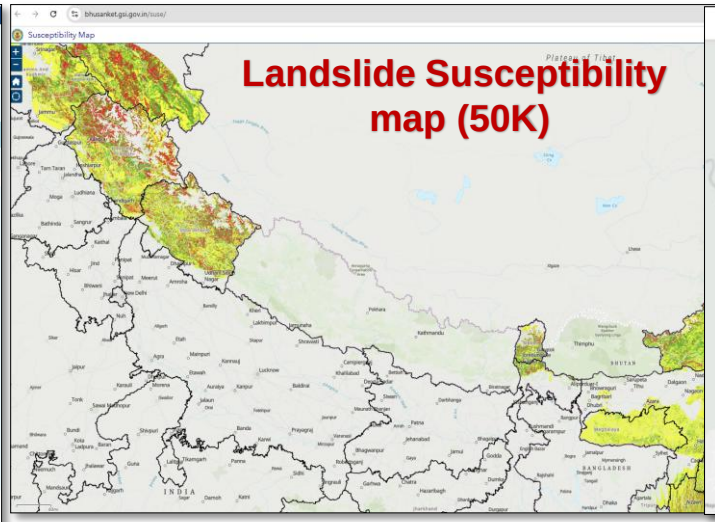
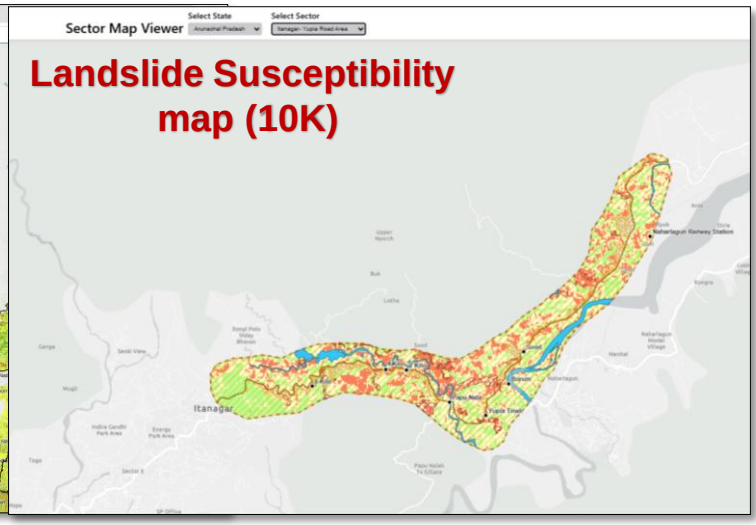




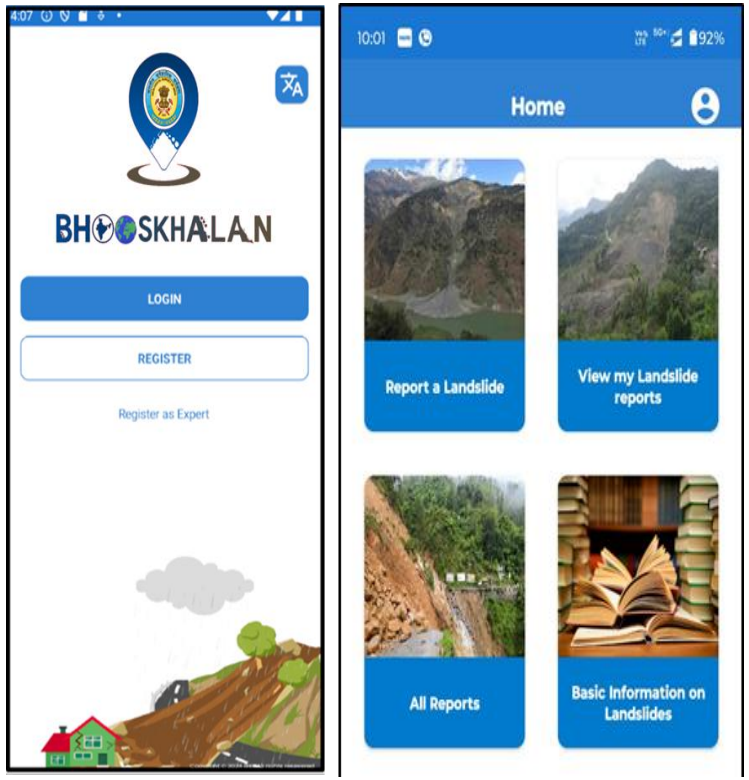


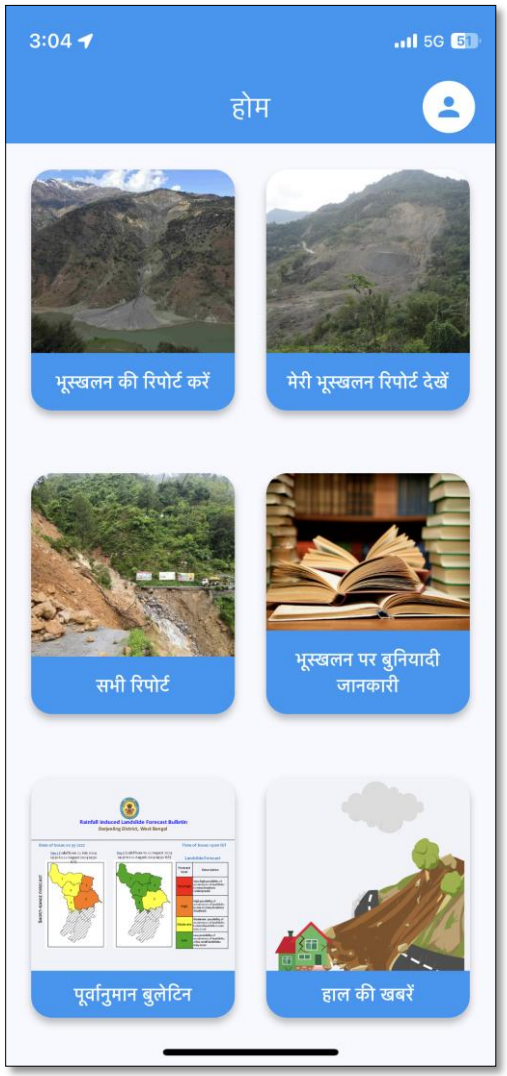
Bhooskhalan Mobile App

(Available on Play and App Store)

A crowd sourced application for enriching the national landslide inventory

1st Version





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- **Landslide Inventory**
- **LSM Maps**
- **Recent News**
- **Projects status**
- **Landslide Reports**

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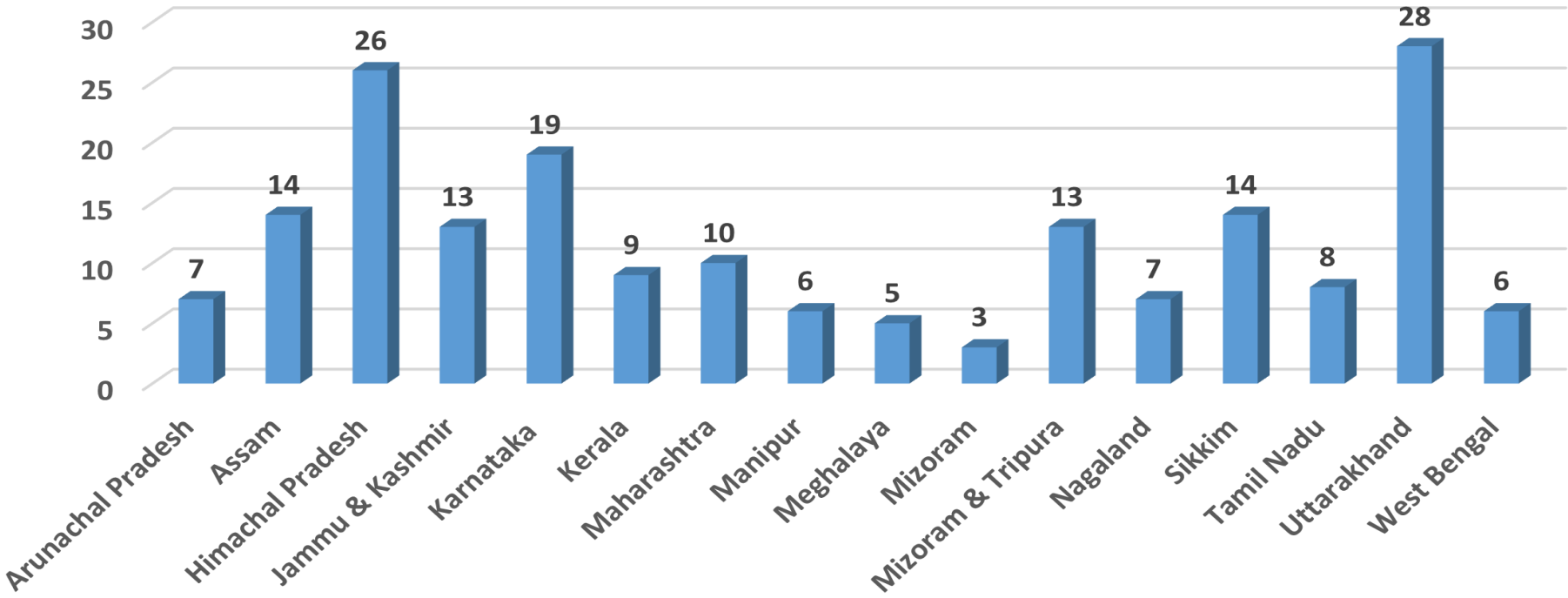


28 projects completed in FS 2025-26

Post NLSM 200 critical Sectors were identified for Meso-scale 1: 10k

188 projects completed in 17 states by 2025-2026

Another 30 projects to be completed by 2028 – Covering all 19 affected states/UT

GSI Maps & Data - Availability

Product/ Tool	Availability in Public domain
Macroscale (1:50k) National Landslide Susceptibility Map of **4.3 lakh km²** in parts of 19 States; **Source**: NLSM; **Year:** 2014-2022	**Yes** (GSI, NDEM and NGDR Portal); also shared with NDMA through WMS;
Field-studied National Landslide Inventory; Total landslides inventoried so far **34246**; **Year:** 2014 - Continuing	**Yes** (GSI, Bhusanket, NDEM and NGDR Portal); also shared with NDMA through WMS;
Mesoscale (1:10k/ 5k) Landslide Susceptibility Map of **160 critical sectors**; **Year:** 2018-2025	**Yes** (Reports till 2023-24 already uploaded in GSI's Bhusanket Web Portal; Also shared with respective State Governments (https://bhusanket.gsi.gov.in/statewiseLandslideReport.html)
Site-specific (1:2k/ 1k) landslide studies of **53 critical landslides**; Year: 2018-2025	
Post-Disaster Landslide Studies (PDLS) in all landslide-prone States/ UT – 300 reports/ notes	

Advancement Initiatives: Landslide management and forecasting

1. Transition of districts from Development to Experimental/ Operational stage

2. **Integration of multiple NWP models into NLFC infrastructure.**

3. Updating Landslide Susceptibility Maps **using latest LU/LC and landslide datasets with** inclusion of **landslide impacts** on elements at risk.

4. **Debris flow impact modelling** by prioritizing districts and identification of all **vulnerable Elements at risk**.

5. Integration of AI/ML as a decision-support layer in the existing landslide early warning system

6.: **Installation of AWS**

Automatic Weather Station (Existing & Proposed)

State	Existing AWS	AWS in Hilly Area	Required AWS
ANDHRA_PRADESH	91	1	20
ARUNACHAL_PRADESH	78	73	536
ASSAM	104	27	267
GOA	10	9	36
HIMACHAL_PRADESH	92	88	394
JAMMU_AND_KASHMIR	43	20	265
KARNATAKA	81	13	340
KERALA	57	20	178
LADAKH	12	6	337
MAHARASHTRA	172	23	345
MANIPUR	17	17	171
MEGHALAYA	24	24	143
MIZORAM	14	14	116
NAGALAND	19	18	93
SIKKIM	9	9	39
TAMIL_NADU	123	7	124
TRIPURA	21	1	18
UTTARAKHAND	184	144	282
WEST_BENGAL	79	4	70
TOTAL	1230	518	3774

Source : aws.imd

Global Best Practices Example

Hongkong in about 1108 sq. km 80 AWS - 1 AWS/14 sq. km

Italy = 2500+ AWS in 3 lakh sq km areas (1 AWS/120sq.km)

India's landslide prone areas = 4.3 lakh sq. km.
Existing AWS availability 1/350 sq. km

We only have 518 AWS in hilly areas 1 AWS/830 sq. km

Challenges in Landslide management and forecasting

1. **Scarcity of Automatic Weather Stations (AWS), Automatic Rain Gauges (ARGs), and ground sensors in landslide prone areas.**

2. The use of tools like Interferometric Synthetic Aperture Radar (InSAR) for near real-time monitoring is still limited.

3. Data sharing remains a challenge among different agencies.

Way Forward – for GSI

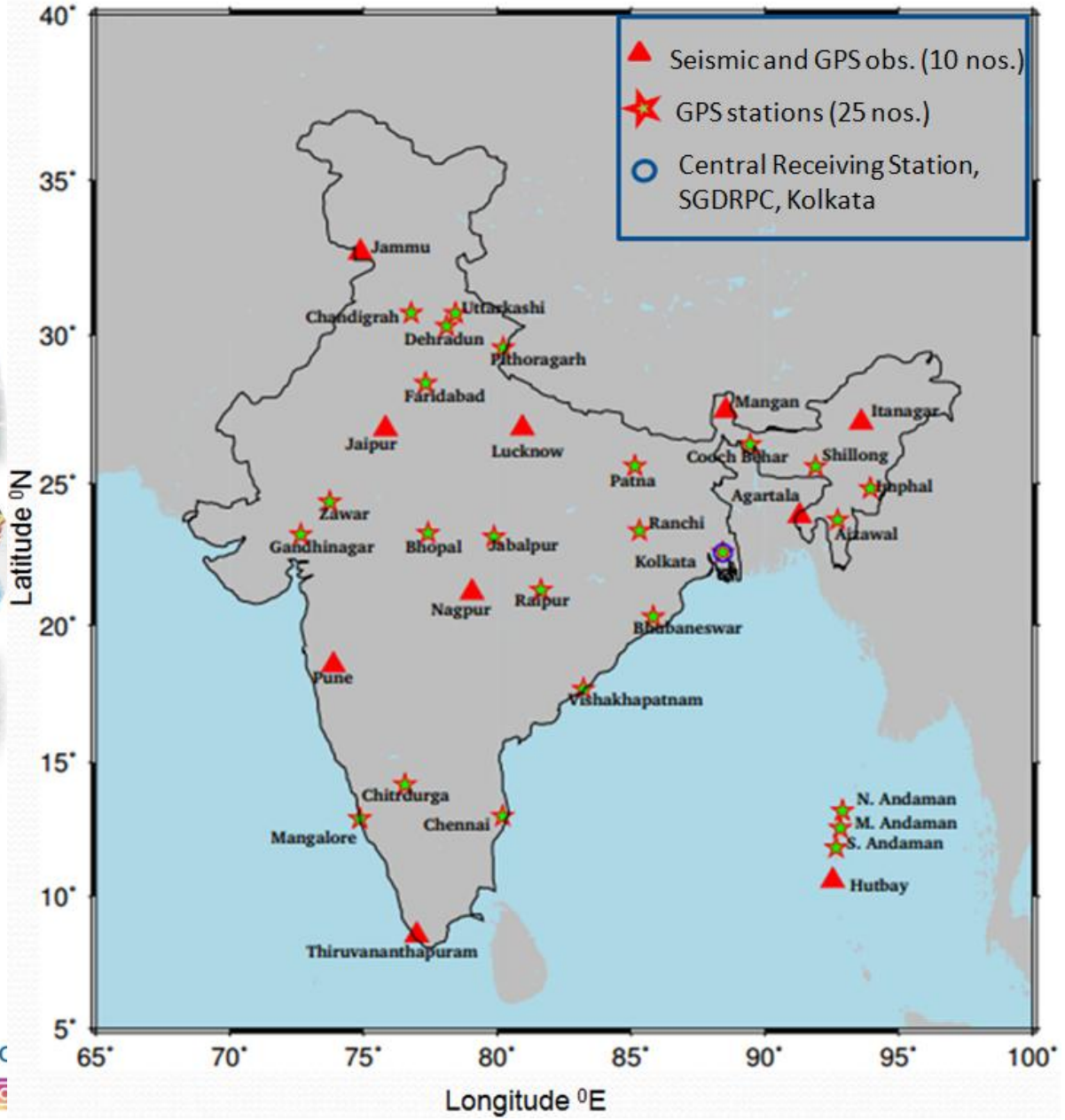
1. **Updating existing 1:50k landslide susceptibility maps** with latest land use/ cover, landslide incidence data,
2. **Debris flow impact modelling in prioritized districts**
3. **Intensifying the meso-scale (1:10K/5K) landslide studies** along Yatra Corridors and vulnerable townships. These maps can be used for landuse zoning.
4. **Strengthening GSI's Regional Landslide Forecasting System** (RLFS) to cover all prioritised landslide risk-prone districts and to make it **granular down to Gram Panchayat level**
5. Use of space-based, **near real-time monitoring through ground deformation mapping by InSAR** / Integration of **MT-InSAR** to monitor vulnerable slopes.

THANK YOU

Sl. No.	City	Sl. No.	City	Sl. No.	City	Sl. No.	City	Sl. No.	City
1	Agartala	11	Chandigarh	21	Gorakhpur	31	Kochi	41	Patna
2	Ahmedabad	12	Chennai	22	Guwahati	32	Kohima	42	Port Blair
3	Aizawl	13	Cuttack	23	Imphal	33	Kozhikode	43	Puducherry
4	Alwar	14	Darbhanga	24	Indore	34	Mangalore	44	Pune
5	Amritsar	15	Dehradun	25	Itanagar	35	Meerut	45	Puri-Konark
6	Bharuch	16	Delhi	26	Jabalpur	36	Moradabad	46	Satara-Koyna-Warna
7	Bhavnagar	17	Dharmanagar	27	Jalandhar	37	Mumbai	47	Silchar
8	Bhubaneswar	18	Dibrugarh	28	Jammu	38	Nashik	48	Siliguri
9	Bikanir	19	Dombivli-Kalyan-Badlapur	29	Jamnagar	39	Panchkula	49	Shillong
10	Champhai	20	Gangtok	30	Jorhat	40	Pasighat	50	Srinagar

Sl. No.	City		
51	Surat		
52	Tinsukia		
53	Tiruchirappalli		
54	Trichur		
55	Vadodara		
56	Vijaywada		
57	Visakhapatnam		
58	Amaravati (AP)		
59	Ongole (AP)	2024 - 2026	
60	Udaipur (Tripura)	2023-2025	
61	Kolasib (Mizoram)	2024-2025	
62	Muzaffarpur (Bihar)	2024- 2026	

LOCATION OF SEISMO-GEODETIC OBSERVATORIES and GNSS GPS Stations



INSTRUMENTATIONS AND INFRUSTRUCTURE

Instruments: The observatories are equipped with

i. Broadband seismograph (Trillium 240),

ii. Accellerograph and

iii. High precision GPS instruments.