

National Workshop on

Disaster Resilient Infrastructure in the Himalayas: Opportunities and Challenges

21-22 November 2017, Dehradun

Highway Slope Management

Key to Disaster Resistance Highway Infrastructure

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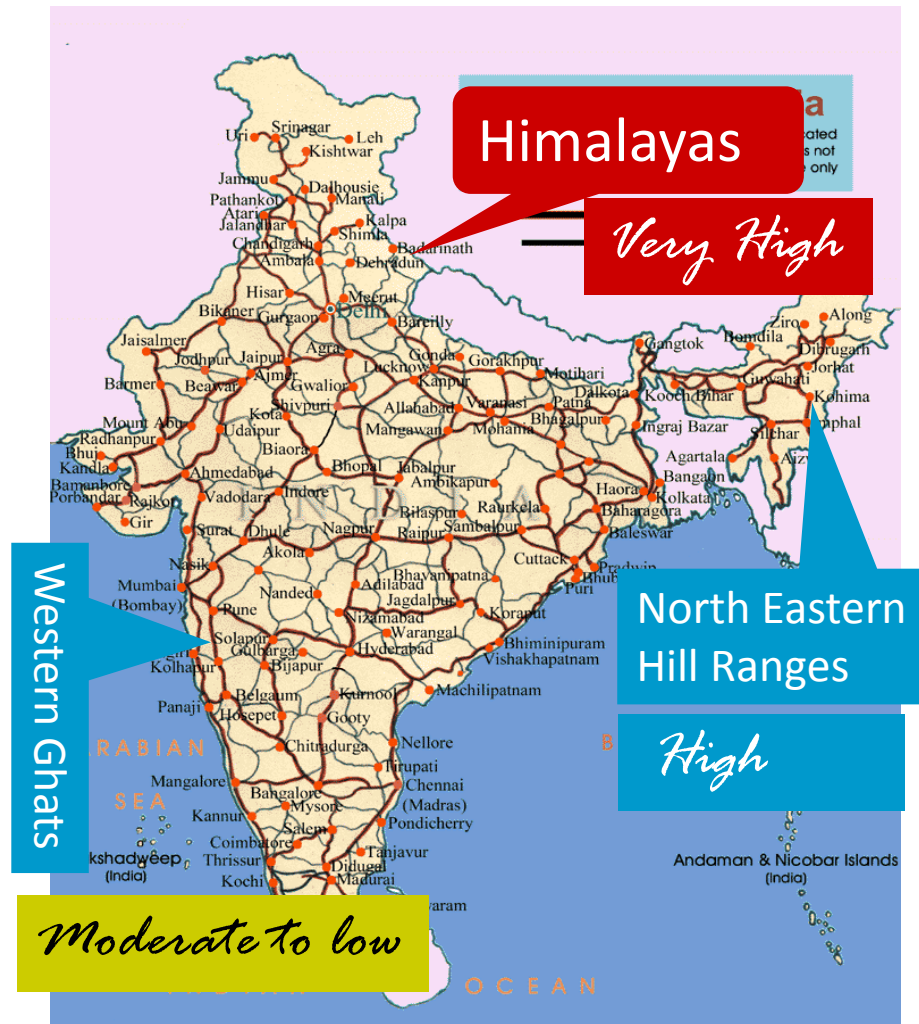
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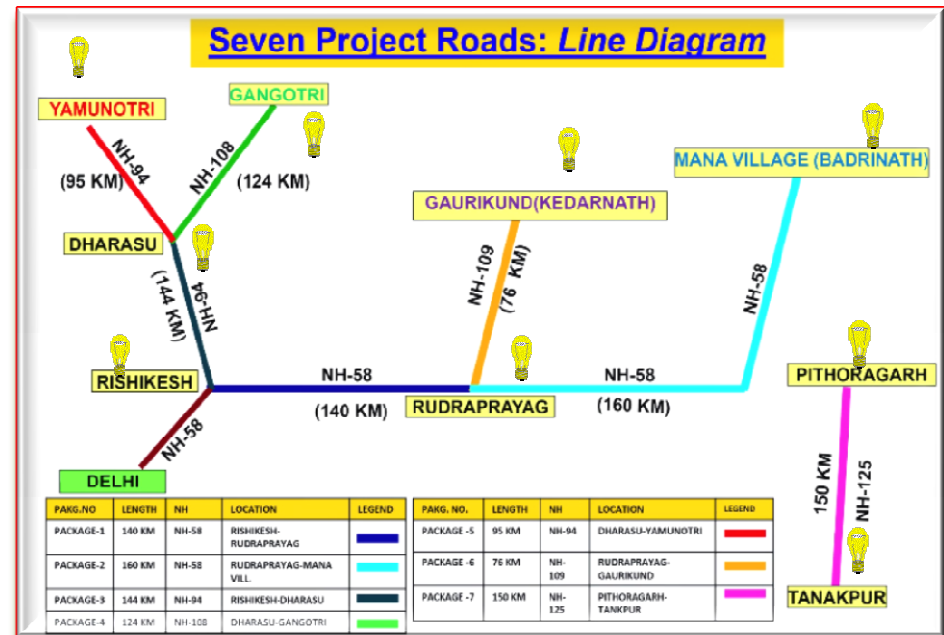
Based on broad distribution of Landslide Hazards, propensity of Hilly regions . Himalya are the most vulnerable.



India has vast network of roads, over 3 million kilometres, and is the 2nd largest in the world.

On hilly regions, roads extend's for over large length of 161000 km which includes Himalayan roads which runs over 60,000 kms across the length and breadth of the IHR.

The total length of only metalled roads in Uttarakhand is 29,939 km



Bharat mala scheme aims to construct approx. 83,677kms of roads in entire country at an investment of 6.92lakh crores by 2022 under which 34,800kms of National highways will be constructed at cost of 5.5lakh crore.

Char Dham Maha Marg Vikas Pariyojna is launched by PM Narendra Modi, total length of 900 km road investing more than 12 thousand crore will connect all four Dham present in the state amking it all season road.

Since Uttarakhand state was formed in 2000, it has been on a path of massive growth

● In first decade alone, over 15,000 hectares (37,066 acres) of forestland has been legally diverted in the state for various projects.

● Over 1,600 ha of riverbed mining was given legal sanction in the same period and Tourism in the state has gone up by up to 380%.

● Uttarakhand 45 hydropower projects with a total capacity of 3,164 MW are operational in Uttarakhand. The state plans to build 199 big and small projects.

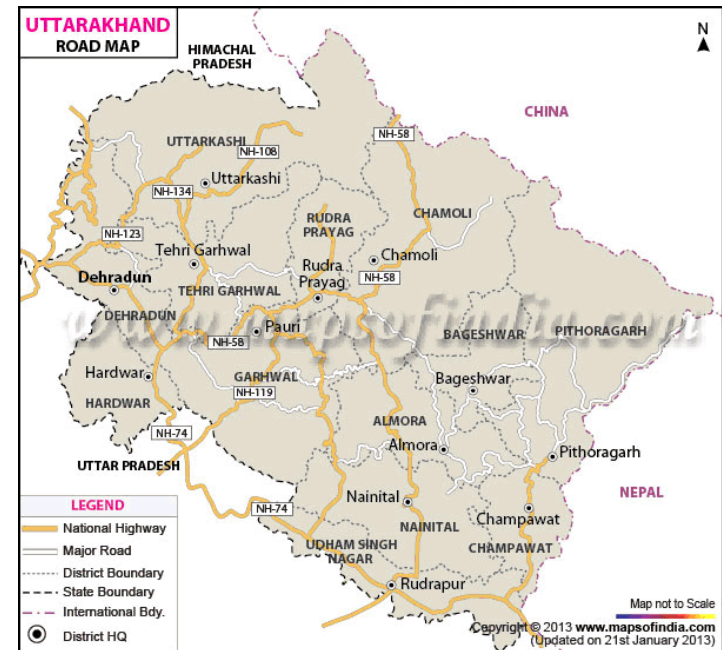
● Under recently announced Bharatmala scheme, some roads will be constructed in Uttarakhand

● Char Dham Maha Marg Vikas Pariyojna, 900 km road

● The ambitious Rishikesh-Karnaprayag railway now to be extended up to Sonprayag, near Kedarnath,

● PMGSY and Other Roads

DEVELOPMENT GROWTH HISTORY OF UTTARAKHAND



'Acting on scientific studies could have reduced losses'



Uttarakhand forest fire: Disaster management teams deployed across region

30 Apr 2016



Fresh forest fire

Earthquake hits Himachal Pradesh

08 Oct 2015

Unlearnt lessons of 2013, as PM Modi promises new Kedarnath

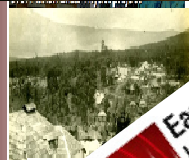
Several elements of the PM's speech tells us that they have shown that the current unscientific and indis have contributed to significantly increasing disaster

In India, disaster preparedness still has a long way to go

Keeping environment risks in mind, involving locals in decision-making is the key to sustainable development in vulnerable areas.



Prosperity or disaster? over Maneri Bhal-



Earthquake of 5.8 magnitude jolts Kashmir
An earthquake of 5.8 magnitude on the Richter scale jolted Kashmir today, forcing panicky residents in various cities and their homes onto the streets.
Asian News Service | Monday September 20, 2010

YET WE ARE STILL FACING THE PROBLEM!!!!

reach danger mark, 63 killed in Uttarakhand

Asian News Service | Monday September 20, 2010

Frequent landslides in Uttarakhand worry scientists

Landslides are common in this Himalayan state of Uttarakhand, especially following heavy monsoon rains. But what has left scientists worried is increase in the number of such phenomena in recent years

Uttarakhand: In the shadow of the quake Bhagirathi eco zone faces quiet burial

strict has been jolted as many times by quakes of magnitude 4 to 5.1. In 2012 d hundreds and left thousands homeless.

killed in landslides in Uttarakhand, 2 in inachal



Sleeping labourers killed in Uttarakhand as boulder thunde

23 May 2016
Dehradun:

Chakrata area of the district in th



Mild tremors felt in Uttarakhand

29 Sep 2015

Dehradun: Mild tremors were felt in parts of Uttarakhand this afternoon as an earthquake measuring 4.8 on the Richter Scale hit Pithoragarh district on India-Nepal border and adjoining areas.

after shock me
avalanche in
struck India an
ing an avalanche



02 Jul 2016

New Delhi: At least twelve people were killed in torrential rains and landslides in Uttarakhand, while two persons were swept away by rain-fed muddy waters in Arunachal Pradesh even as Rajasthan reeled under heat wave conditions with Sri Ganganagar simmering at 45 degrees Celsius.

fear of a

Earthquake induced landslides in the Sikkim-Darjeeling Himalayas

Over 20 Killed, Many Missing After Cloudburst Trigger Landslides In Uttarakhand

India News | Written by Tania Saili Bakshi | Saturday July 2, 2016



At least 29 people have died and over 15 are missing after cloudbursts and landslides triggered by heavy rain in Uttarakhand, bringing back memories of the deadly floods which killed nearly 6,000 people three years ago.



November 25, 2011 Last update November 25, 2011 19:37 By Armand Vervaeck and Dr. ell

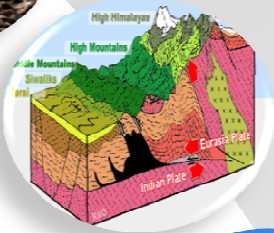
th of the 18th September 2011 Sikkim earthquake

II Chakraborty, Dr. Saibal Ghosh, Debasish Bhattacharya & Anjan Bora, Engineering Geology

KEY FEATURES OF HIMALAYA



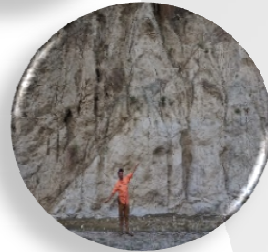
SEISMICALLY ACTIVE



ACTIVE TECTONICS



GEOMORPHOLOGY



**STRUCTURAL COMPLEXITY
WITH STEEP SLOPES**



PECULIAR CLIMATIC CONDITION

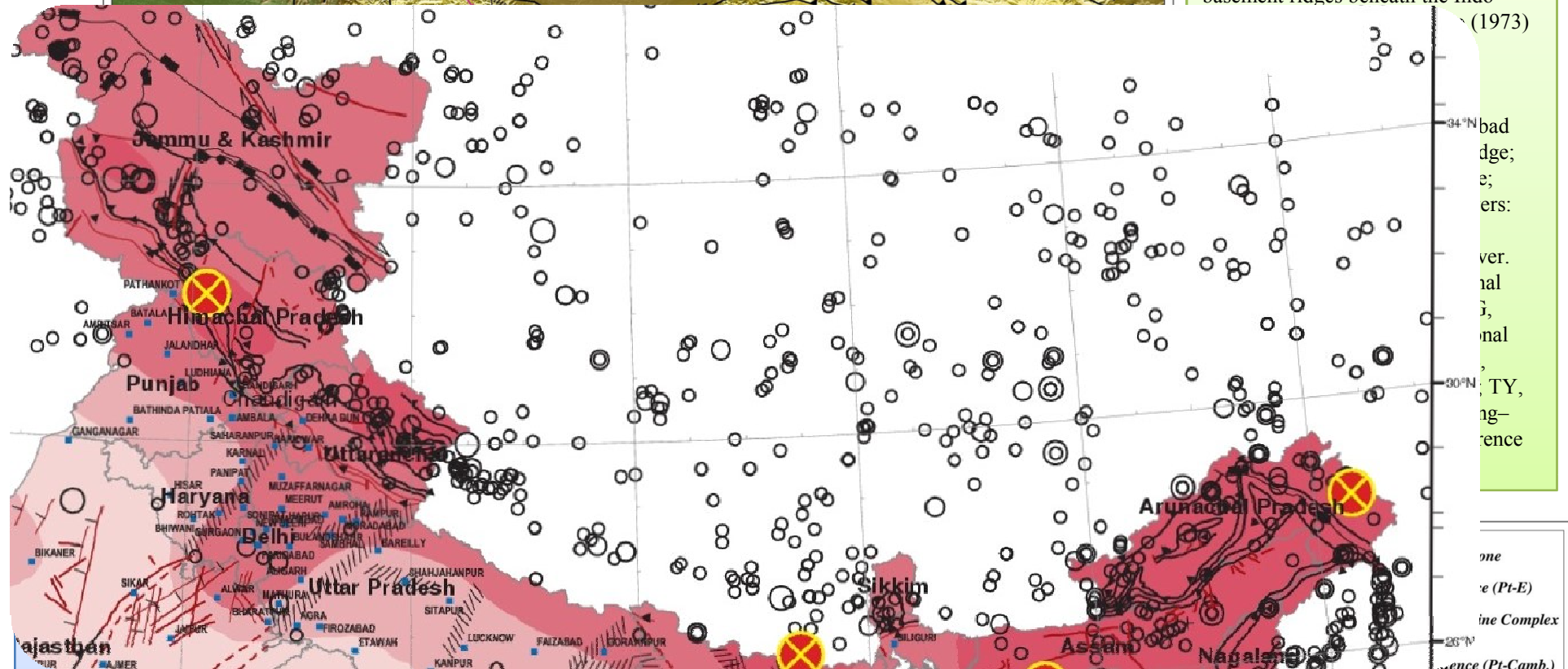


ANTHROPOGENIC EFFECTS

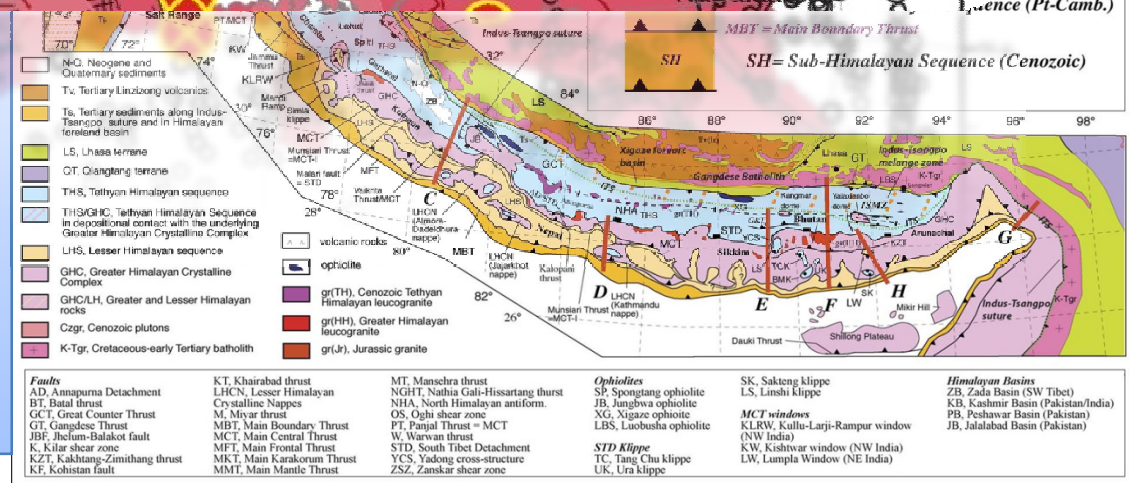
(A)
40°N



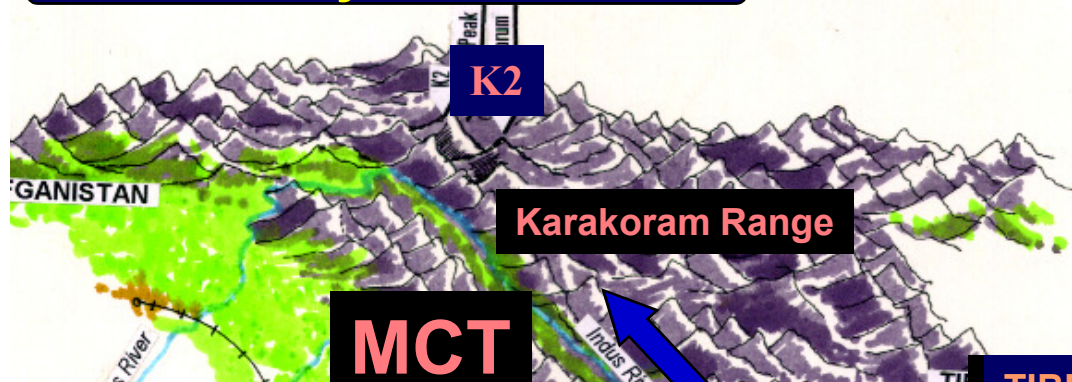
Regions outlined by yellow lines are basement ridges beneath the Indo- (1973)



- The tectonic activity has effected morphotectonic changes due to uplift, tilting of drainage basins, shifting or diversion of rivers and their tributary channels.
- Seismicity is mainly due to activity along numerous active faults, which trend parallel or transverse to the Himalayan mountain belt.



The Himalayan Landslides



The uniqueness and vulnerability of the mountain system necessitates due consideration prior to planning, construction &

The most disturbing fact is that the phenomena keeps repeating every year and the costs on only restoration works increase exorbitantly high.

Highways, across the fragile Himalayan terrain face severe landslide problems during every monsoon on recurring basis.

Even the best constructed highways keep suffering from onslaught of landslide and like processes.

The status of developed highways so far portrays just the contrary as almost all these highway infrastructures suffer from frequent slope failures/ landslides.

Most of the landslide occurrences, especially those that have caused extensive damage to life and property, are recorded along the highways /roads of the hilly terrain of the country.



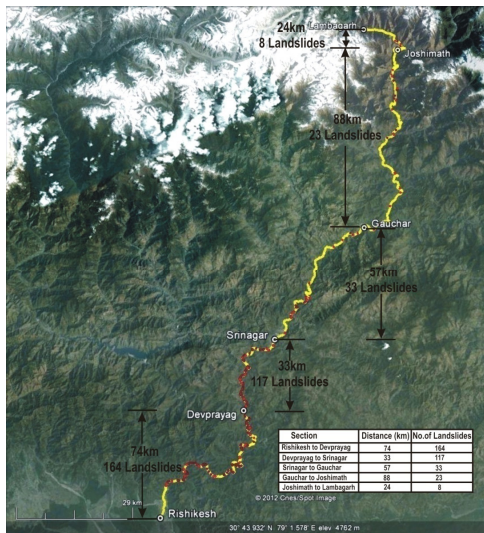
Along Highways, a large population and their economic activities are settled. Frequent landslides present a threat to life and livelihood, ranging from minor disruption to social and economic and environmental catastrophe.



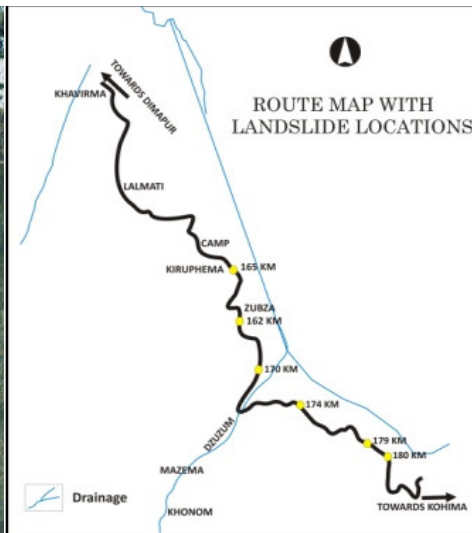
It impacts the Socio- economic, Environmental, Spatial, Cultural and Political Development



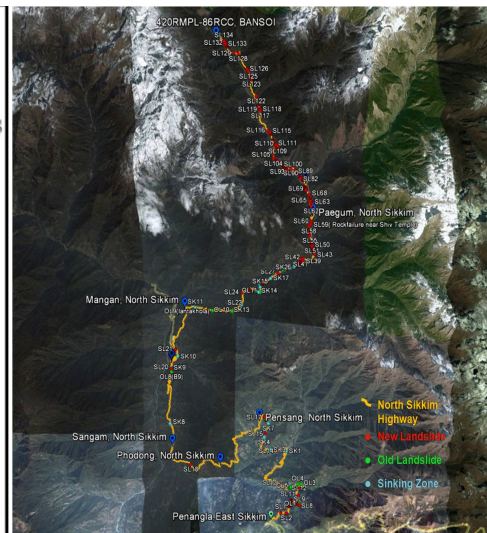
Road side farmlands, agricultural production, agro-forest, other economic activities are also influenced



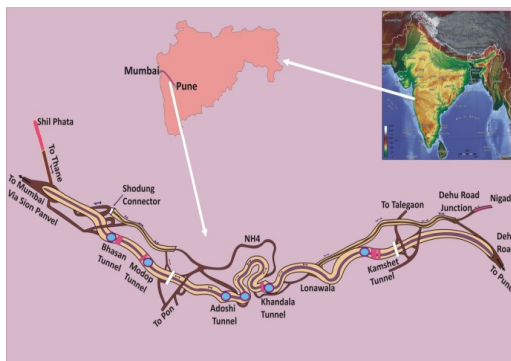
Landslide incidences on NH-58



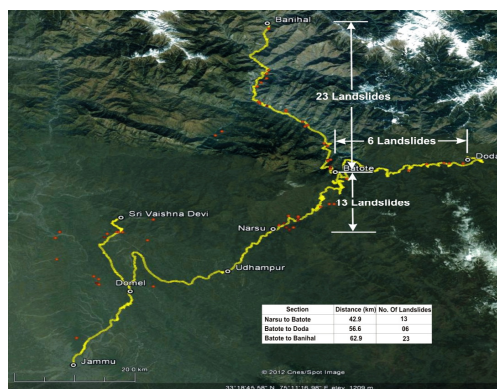
Trouble areas on nh-39 Nagaland



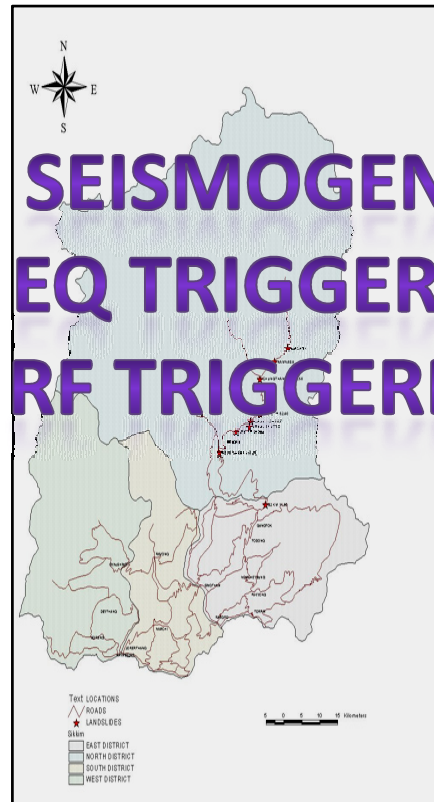
Landslides on NSH Sikkim



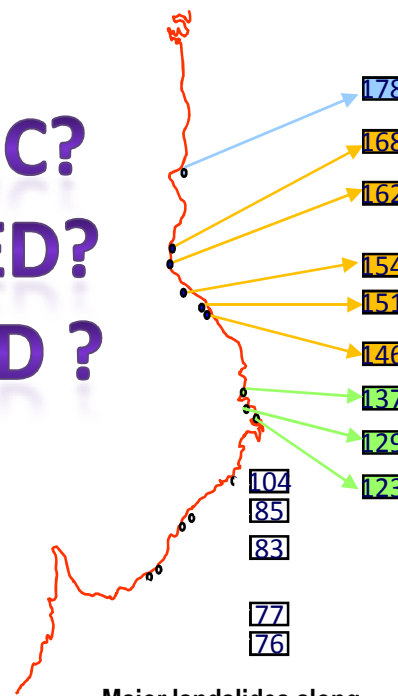
Trouble areas on expressway



Landslide incidences on NH1A



**SEISMOGENIC?
EQ TRIGGERED?
RF TRIGGERED ?**

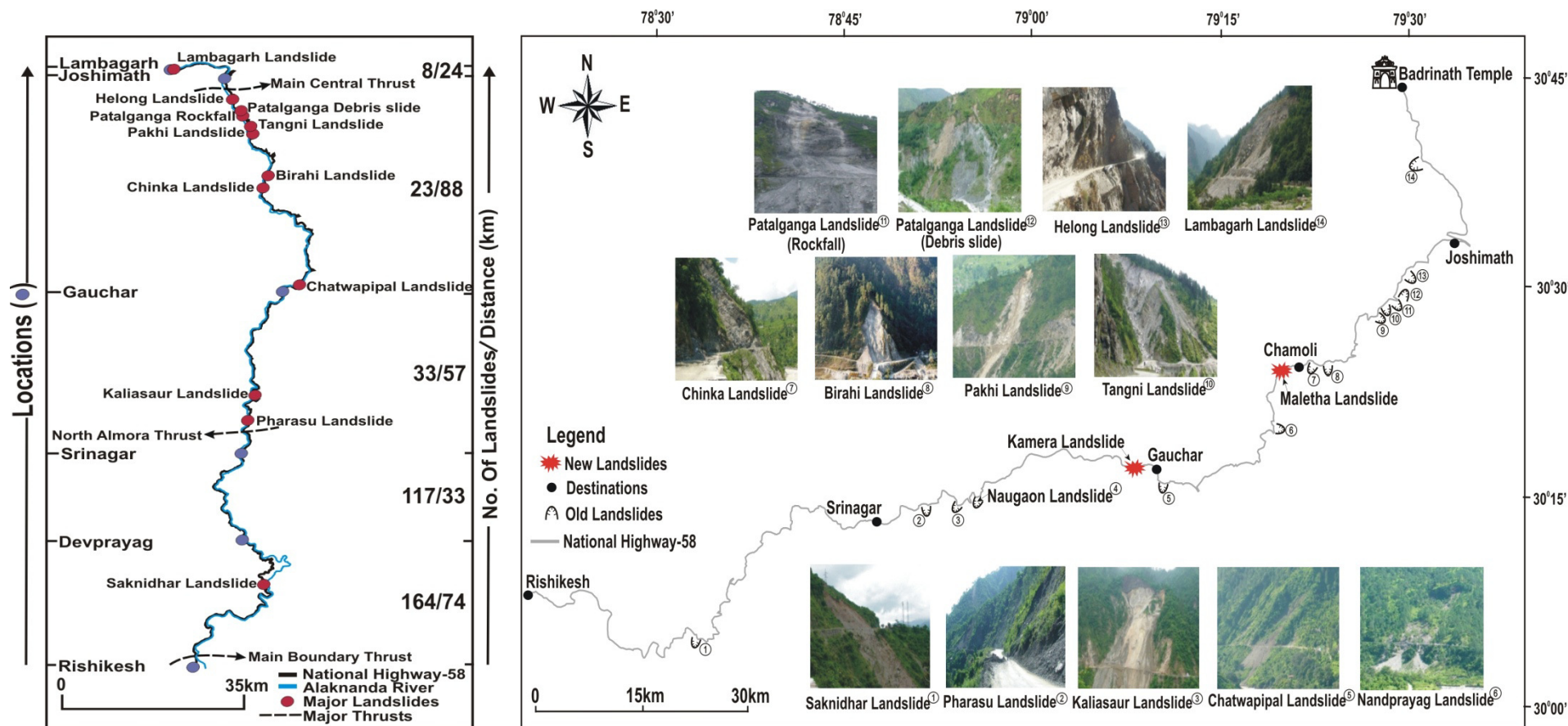


Major landslides along NH-1A

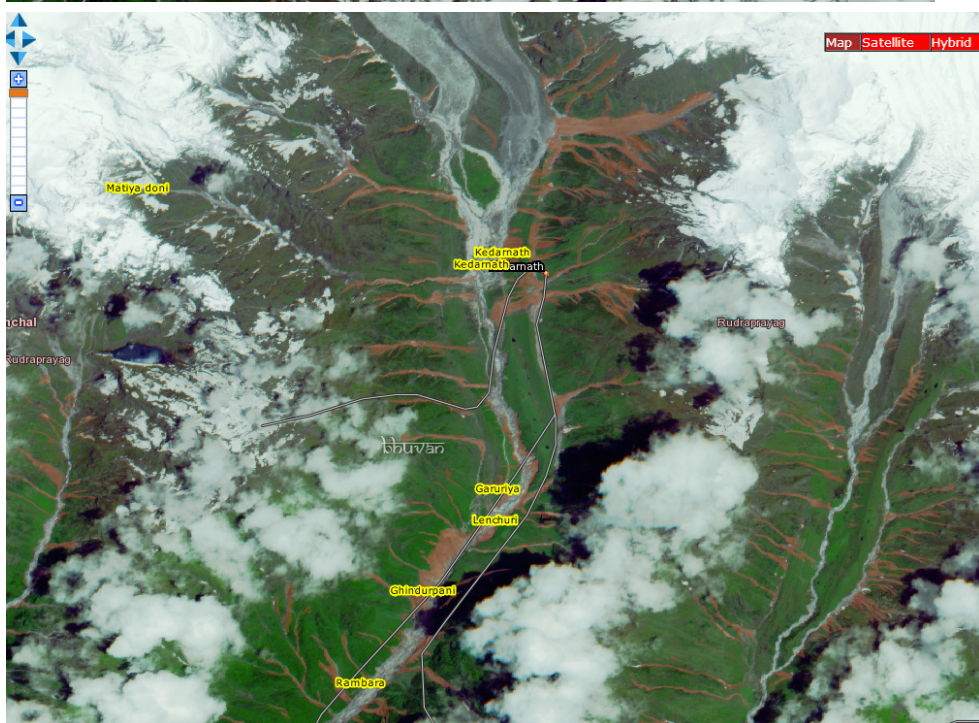


Landslide incidences on NH-58

Locations of Landslide on National Highway 58



Some of the most critical and recurring landslides are the source of the draining out of badly needed revenue for maintenance of roads and are source of hardship, loss of life and loss of property worth billions. **Preventing obligatory rescue and rehabilitation works at the time of need during disasters.**





Sili



Sumari



Augustyamuni



Sonprayag (DAM)



Sitapur (DAM)



Kund (DAM)



Kotma



Jaltala (DAM)



Gaurikund



Earthquake triggered landslides







Challenges in snowbound high altitude areas



Challenges in selecting a suitable alignment with minimal from risk



At km 38.90,

Rockfall investigation and prevention on Mumbai- Pune Expressway



at km 42.36



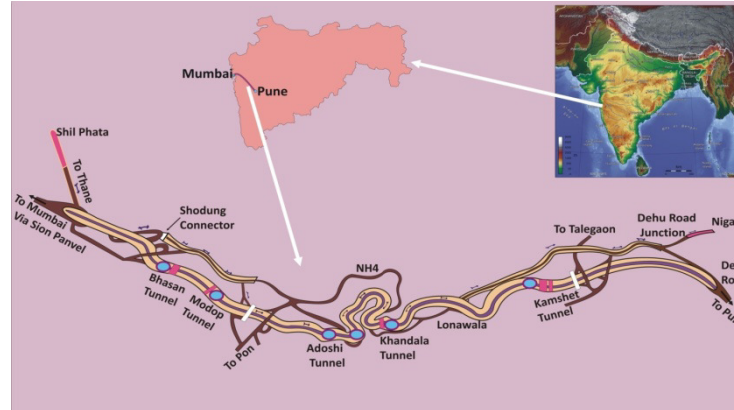
At km 16



At km 70



The rock mass at km 68



← TROUBLE AREAS ON EXPRESSWAY → subsidence at km 41,



Amritanjan Bridge site
at km 45



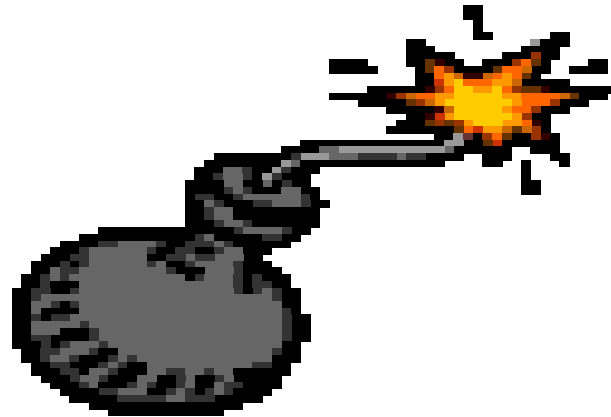
At km 41.70



At Khandala tunnel



The landslide seems to be a small tiny topic in the crowd of numerous disasters but this tiny topic is like a bomb with a timer clicking every second and we are losing precious time to deal with it.

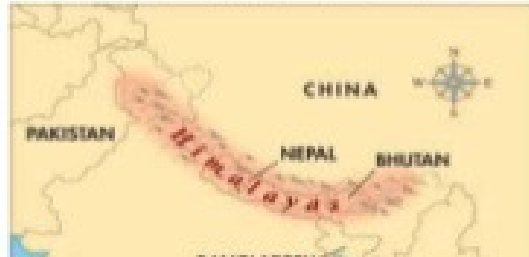




Serious destruction to the traditions, culture, overall habitation and environment . Hills are drying out of humans lived for long but full of , somehow, poorly conceive infrastructures, including highways - **Way forward ?**

Geo-environmental setup of hills/Himalaya will not change – its dynamic in nature and may pose more surprises in coming time

The **Himalayas** are a mountain range in Asia separating the plains of the Indian subcontinent from the Tibetan Plateau.



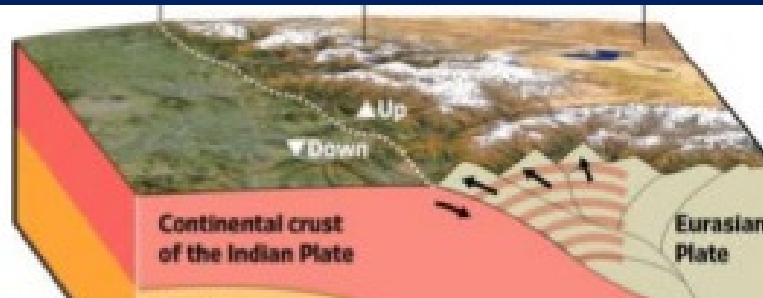
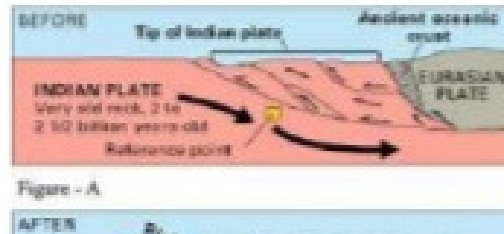
CONTINENTAL COLLISION

As the Indian subcontinent pushes against Eurasia, pressure is released in the form of earthquakes. The constant crashing of the two plates formed the



◆ Proneness to floods, Earthquakes, cloudbursts, landslides etc

FIGURE 7: MAP SHOWING THE HIMALAYAN MOUNTAIN RANGE



◆ More land may be acquired for road development in future posing more challenges

FIGURE 8: SECTION OF THE TECTONIC PLATE MOVEMENT

SOURCE: www.jabalpur.nic.in

FIGURE 9: FIGURE SHOWING THE CONTINENTAL COLLISION OF INDIAN AND EURASIAN PLATE CAUSING THE HIMALAYAS TO FORM.

SOURCE: USGS; GOOGLE EARTH, THE WALL STREET JOURNAL

FIGURE 10: MIGRATION OF INDIA
SOURCE: FROM *THIS DYNAMIC EARTH* BY KIDUS AND TILLING, COURTESY OF THE US GEOLOGICAL SURVEY

14

SOURCE: THE GEOLOGICAL SOCIETY- PLATE TECTONICS.
www.geol.soc.org.uk

SERIOUS CONSIDERATIONS

◆ Entering into the Challenging/inaccessible areas/land

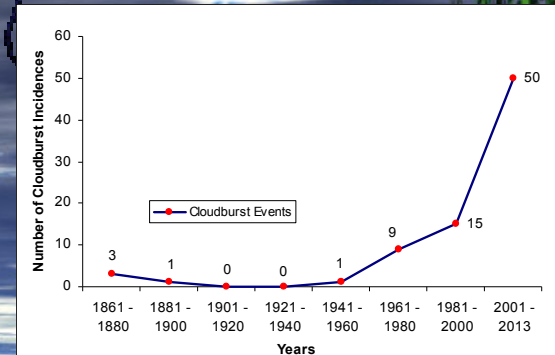
Heavy rainfall is one of the climate challenges that Himalayan range face due to its steep topography



Kedarnath

Leh cloud burst

Okhimath



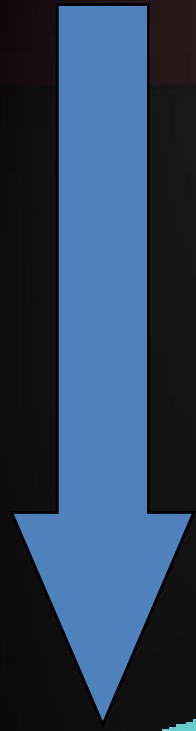
Frequency of Cloudburst from year 1860 to year 2013

Impact of climate change will be more prominent in future & the connection is already established

✦ **Rainfall intensity/ frequency/ amount and Duration will also increase and extreme events are likely to increased**

1901-2009- AMT has risen by 0.56°C over the period. Global warming due to increase in greenhouse gases- an increase in Mgn. & Fr. of extreme precipitation events. The frequency of extreme rainfall shows increasing trend over the Indian monsoon region during the southwest monsoon season from June to September and is significant at 98% level

Extreme rainfall within short time period in the form of cloud burst in such regions can multifold the mayhem by breaching such dams



**Melting of glaciers
Formation of Glacial lakes
Bursting of glacial lakes
Sudden Flooding**



A New Challenge in Landslide Management

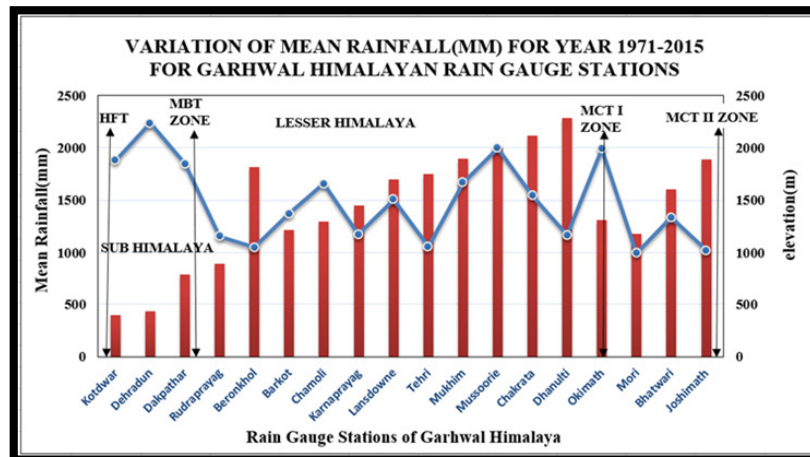




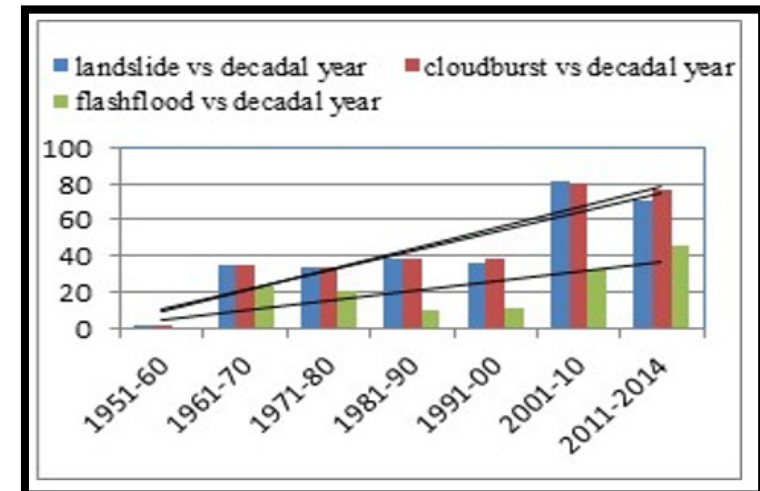
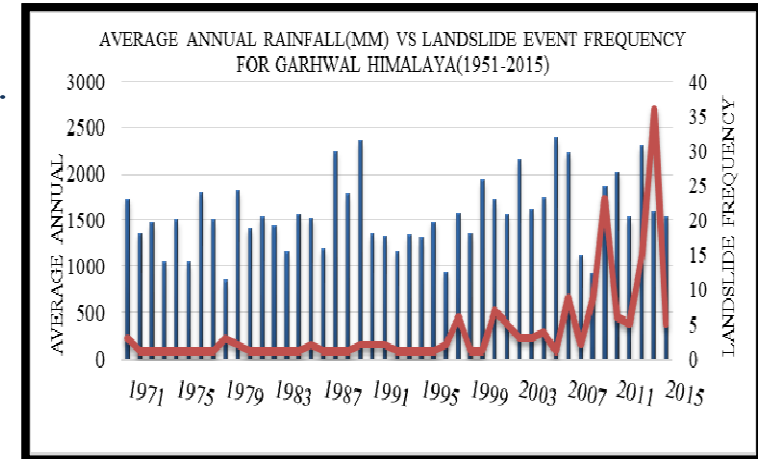
Changing climate perspective in Himalaya



- Over the last 4-5 decades, the rainfall in Indian Himalayan region is showing an increasing trend.
- Extreme events like landslides, cloudbursts, flash floods etc. in recent decades show increasing trend as well.



- Work on Intensity-duration of rainfall to determine the threshold for landslide in Himalaya still needs a lot of consideration and work
- Most of the landslides in Himalaya are concentrated near weak /thrust zones as they are geologically fragile, lithologically fractured and slope wise unstable.
- With the given scenario,



Increasing Rainfall+Vulnerable Topography+Fragile Lithology+ Road Construction & other Anthropogenic activities+ Inadequate policies - LOSS OF LIVES & ECONOMY

NEED CHANGE OF APPROACH



Geology of Himalaya will not change – its dynamic in nature and may pose more surprises

Affects of climate change will show in future more prominence

Rainfall intensity/ frequency/ amount and Duration will also increase.

Prone to floods, Earthquakes, cloudbursts, landslides will also increase etc.



**PONDER OVER EACH FACTORS AND THINK
WHERE WE ARE LACKING AND WHAT OPTIONS
WE HAVE TO CONTRUCT A DISASTER
RESILIENT INFRASTRUCTURE**

There is a link between the disaster and the manner in which development has been carried out in this

IN GIVEN SITUATION
WHAT NEED TO BE DONE TO INSURE THE FOLLOWING

To ensure that the safety of the Highway slopes/infrastructure is adequately managed and their stability maintained

To ensure that the common people/commuters/the user agencies/the planners/the disaster management people and other stakeholders are well informed about the risk during the recurrence period of landslide/slope failure so that they can take appropriate steps to avoid loss of life and infrastructure

To provide, **understandable**, mitigation and management strategies and guidelines to avoid the risk, to reduce the likelihood of the risk, reduction of consequences of risk, Monitoring of risk and transfer of risk etc.

To ensure year round operability of highway network which has strong bearing on socio-economic development of the region and also on strategic needs in the border areas through online forecasting system of the critical disastrous areas.

In a given situation of the inherent and external conditions of the hills , we should have answers of the following.

Why only few slope fail, why not all?

Which are the slopes which failed/not failed and why?

Which are the slopes which can further fail?

Which are the slopes which may not fail in future

The scientific and not vague answers to these questions lead to robust slope management system

This may be possible when we have a slope management system in place

FACTS

- Most of the roads are built without much consideration of the probability of landslides and like processes and consideration for environmental and ecological consequences
- No proper slope maintenance practices are followed
- Though good roads are constructed they do suffer miserably because of slope failure, landslide, sinking, subsidence, collapse, flow etc.
- Most of the hill roads and highways suffer from landslides
- Majority of the landslides occur on the road/highways

Road construction and maintenance issues

- ★ Pre- construction consideration of landslide hazard situation – use of modern technology – **inadequate**
- ★ Pre-planned budget for landslide prevention/ control measures and restoration work – **NIL or inadequate**
- ★ Proper economic and environmental impact analysis – **missing**
- ★ Specific maintenance practices in landslide hazard prone areas – consider slope as a part Road Infrastructure - **missing**

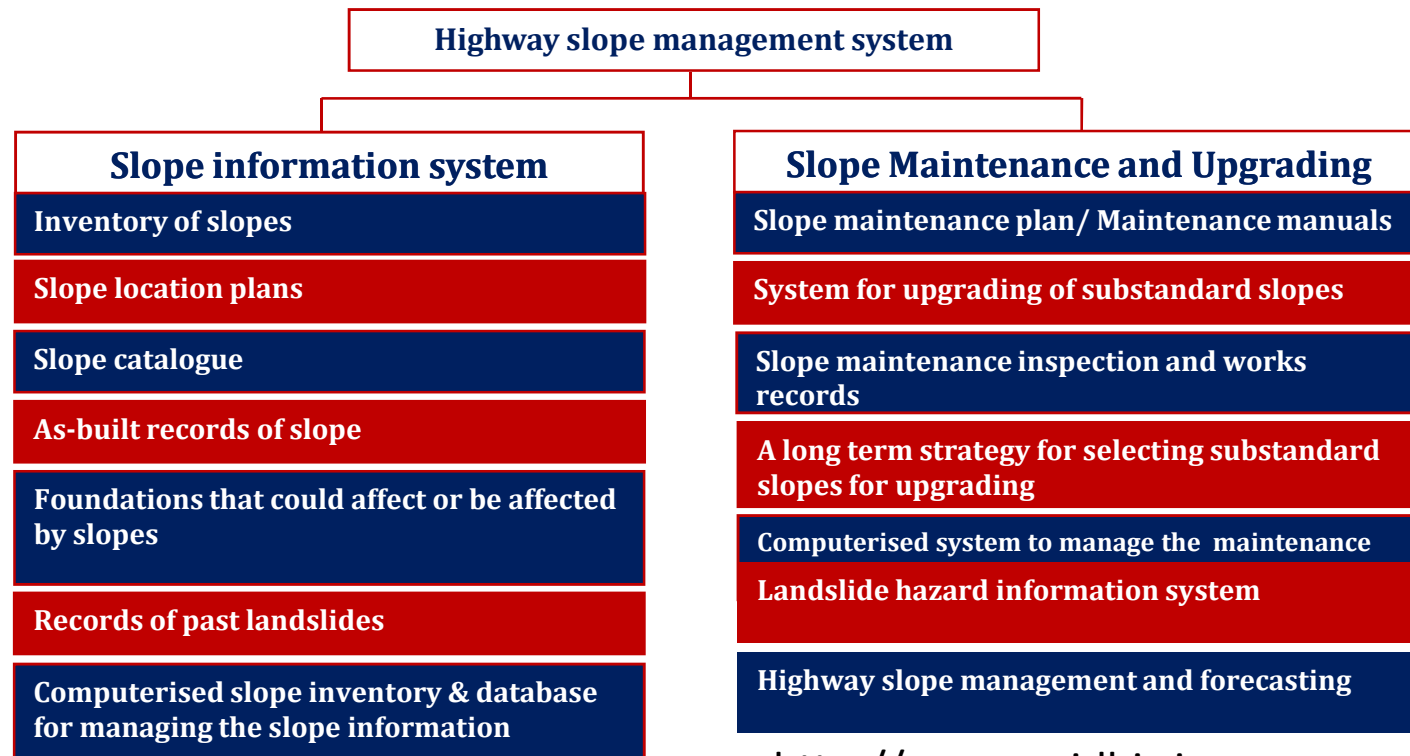
Key – Possible Solution

Highway slopes ----- Part of Road Infrastructure? Yes or No?

Highway slopes ----- Just a Natural Asset ?, part of Infrastructure asset? HAM - HSAM?

Can we maintain highways or any other infrastructure without maintaining Highway slopes ?

Is there any Highway slope management system in the country sofar?



<http://www.crri-lhis.in>

What may come out from here

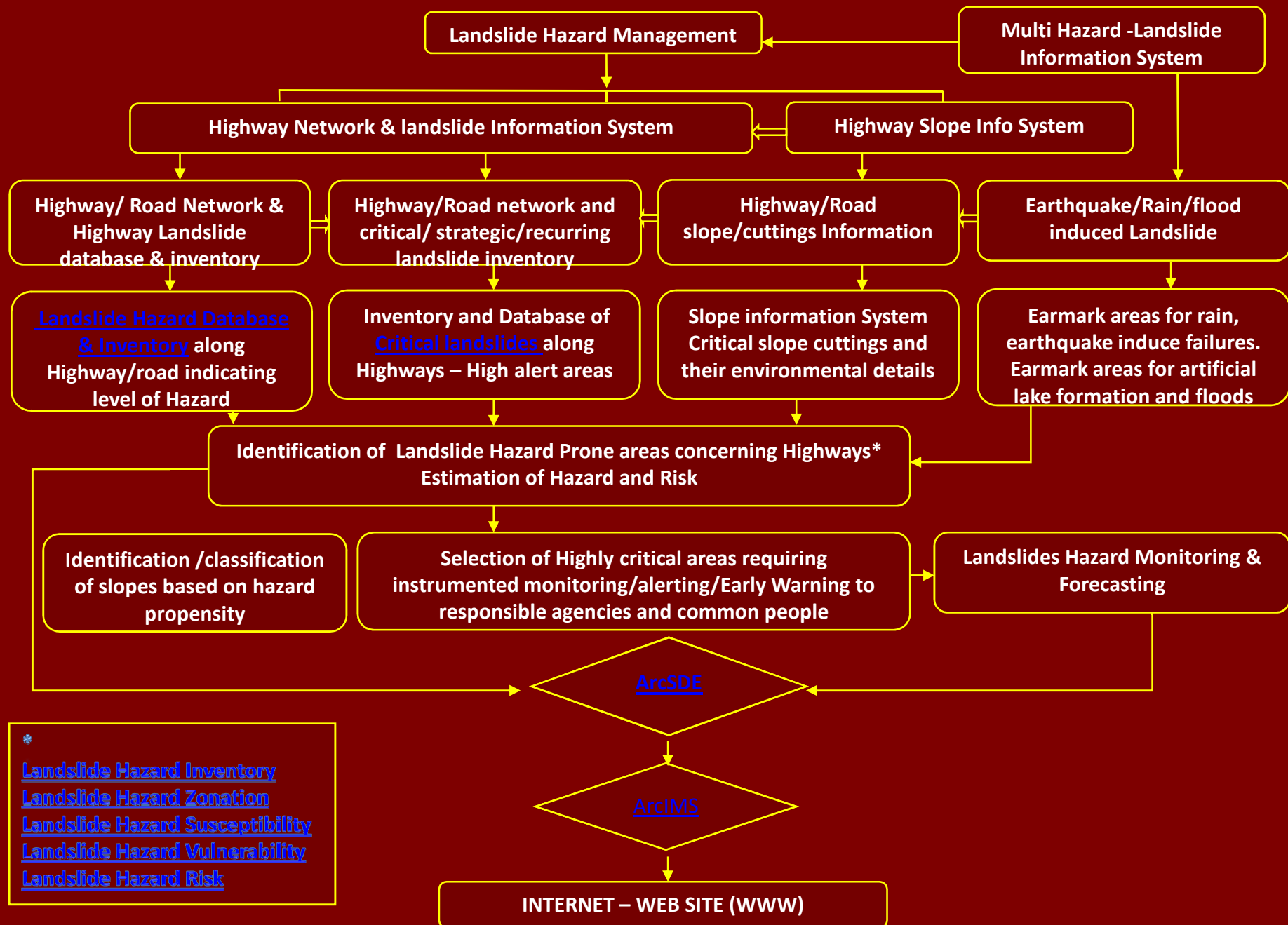
- **Development of digital Highway Slope Management and Forecasting / Warning System**
- **Guidelines/modules/Manuals on management strategies for risk-free and environmental-friendly maintenance practices on slopes.**
- **Methodology that will provide advance information system and management strategies for risk less, safe and environment friendly highway infrastructure network.**
- **Development of public awareness modules for awareness of the common citizen based on the outcome of the project.**

- **The proposed landslide hazard management system may be utilized to drastically reduce:** Loss of life, Loss of property and assets, Loss of infrastructure and lifeline facilities, Loss of Resources, Loss of farmland, Loss of places of cultural importance etc.
- **Indirect losses which could be avoided are:** Loss in productivity of agricultural or forest lands, Reduced property values, Loss of revenue, Increased cost, Adverse effect on water quality, Loss of human productivity, Reduction in quality of life, Impact on emotional wellbeing etc.
- **The economic losses expected to be reduced to the tune of at least 30 to 40% during the initial years of implementation which can further be increased.**

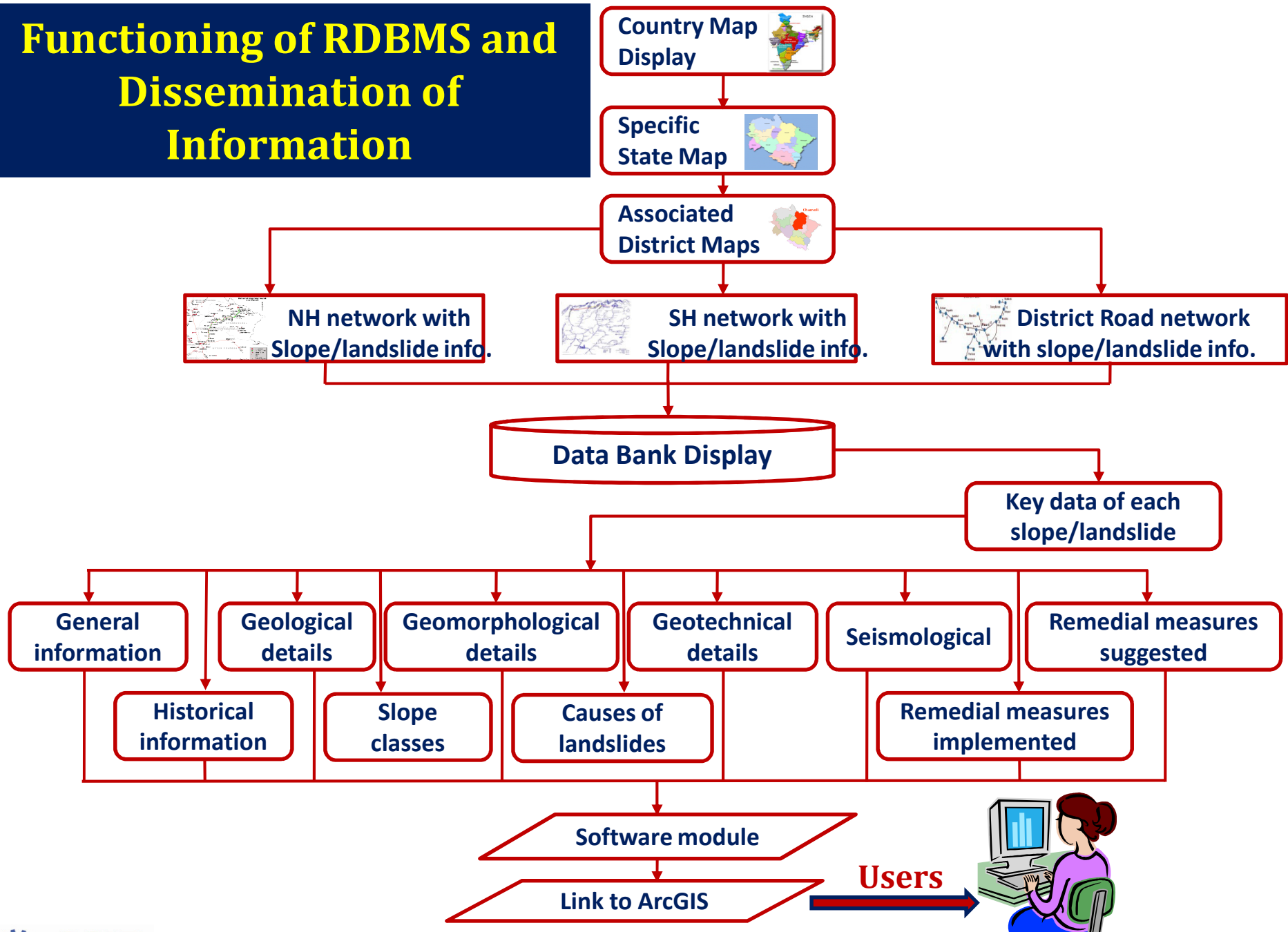
HOW THE SYSTEM BENEFITS US

- **The proposed system provides information to educate the public living in disaster prone areas about landslides & related hazard and risk from these events.**
- **It will forewarn the public about the impending hazard/disaster due to such events in specific risk prone areas so that they can get into alert mode and ready for appropriate action for their safety**
- **It will forewarn and update concerned agencies such as manager of communication, road construction and maintenance units (BRO, PWD's) so that timely action can be taken to save the people and property from the disasters.**

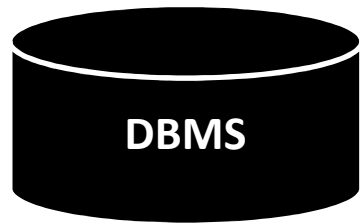
Sustainable Highway/Road Infrastructure against Landslide Hazards



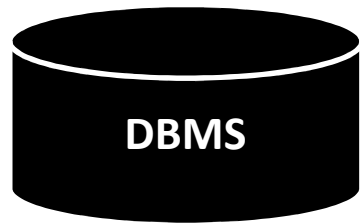
Functioning of RDBMS and Dissemination of Information



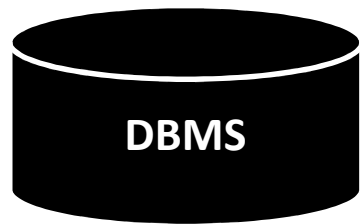
Geodatabases are maintained in different DBMS



Planning



Geotechnical Engineering



Public Safety

User work with one unified object view of geodatabase



ArcSDE Gateway

Geodatabases utilized by user for different applications



Road Maintenance



Landslide Hazard Mitigation & Management



Infrastructure Planning



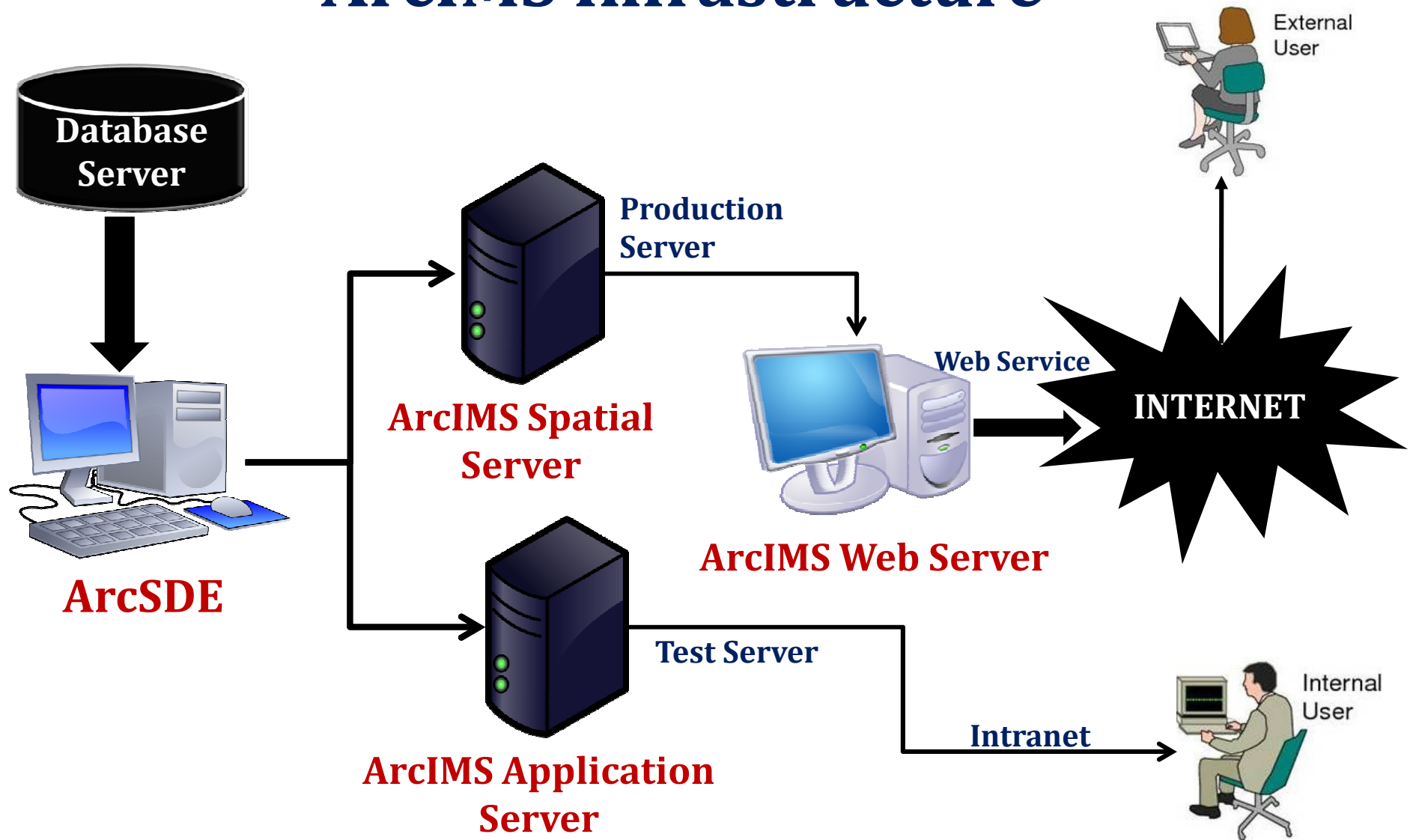
Property Management



Emergency Response

INTERACTIVE ACTIONS

ArcIMS Infrastructure





BEFORE Planning, Construction and maintenance

Always been the points of discussion

???

- Large scale Topographic Maps- How Large? – How to prepare?
- Multi hazard vulnerability Maps- Large scale, workable on the ground
- Existing Landslide/Infrastructure map in large scale
- Other detail maps of drainage pattern, road network and LandUse-Land Cover pattern. Large scale
- Large scale Landslide hazard/susceptibility/risk maps
- Selection of Right Alignment.- use modern technology
- DPR



LET US THINK A FRESH
SLOPE MANAGEMENT CAN BE A BETTER IDEA?



- Collaborative projects
- Bilateral Exchange
- Workshop/conf/seminar



- Regular Training Courses
- 1-3 week Training to students
- 1-3 week Training to Executives
- Knowledge Networking



- For immediate action after an event or hazard
- For Long-term action
- For expert advice



- Investigation
- Mapping
- Instrumentation
- Monitoring
- Analysis
- Remediation/Prevention/Correction



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Th a n k s