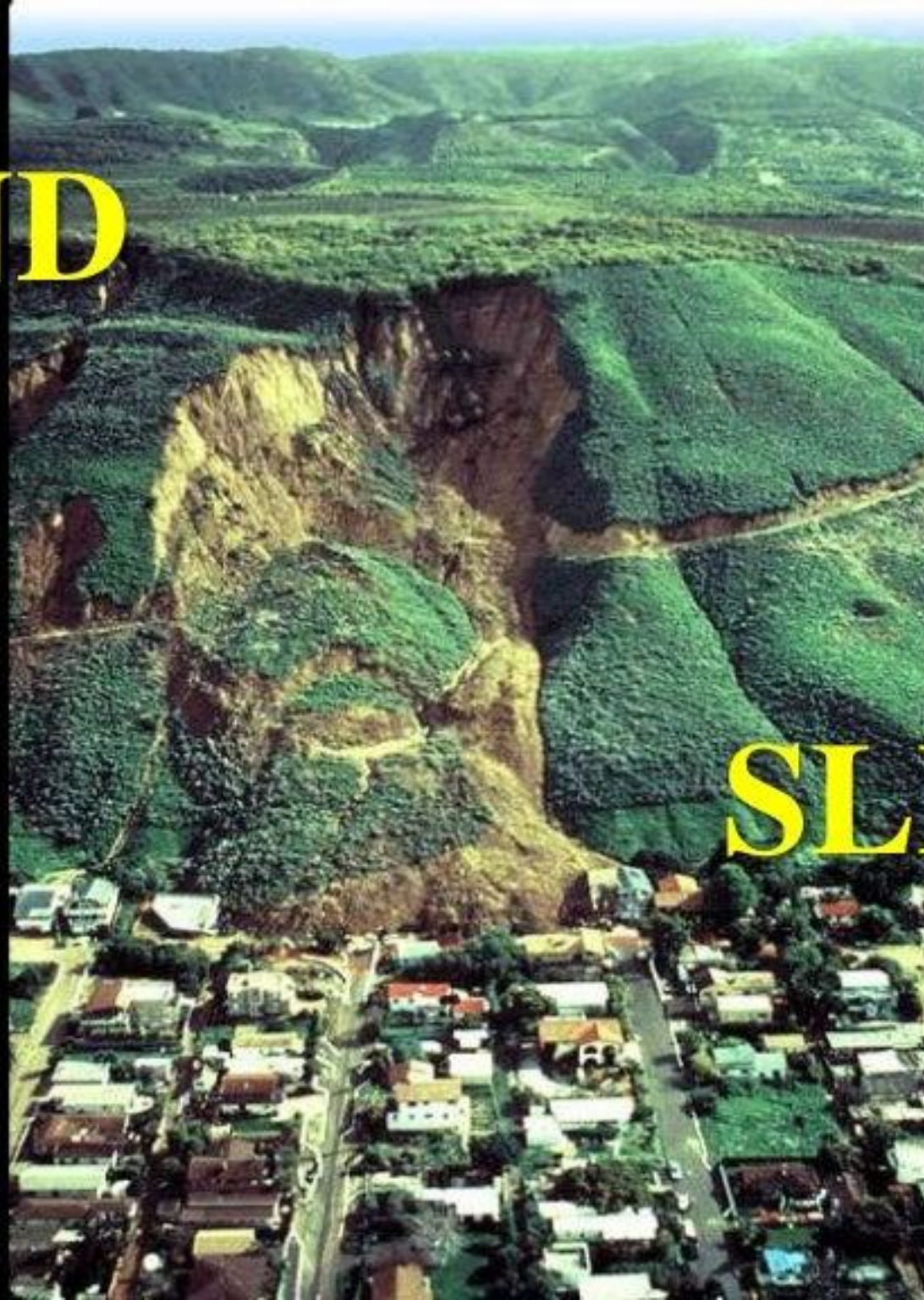


LAND



SLIDES

Alex K George
2014-17-115

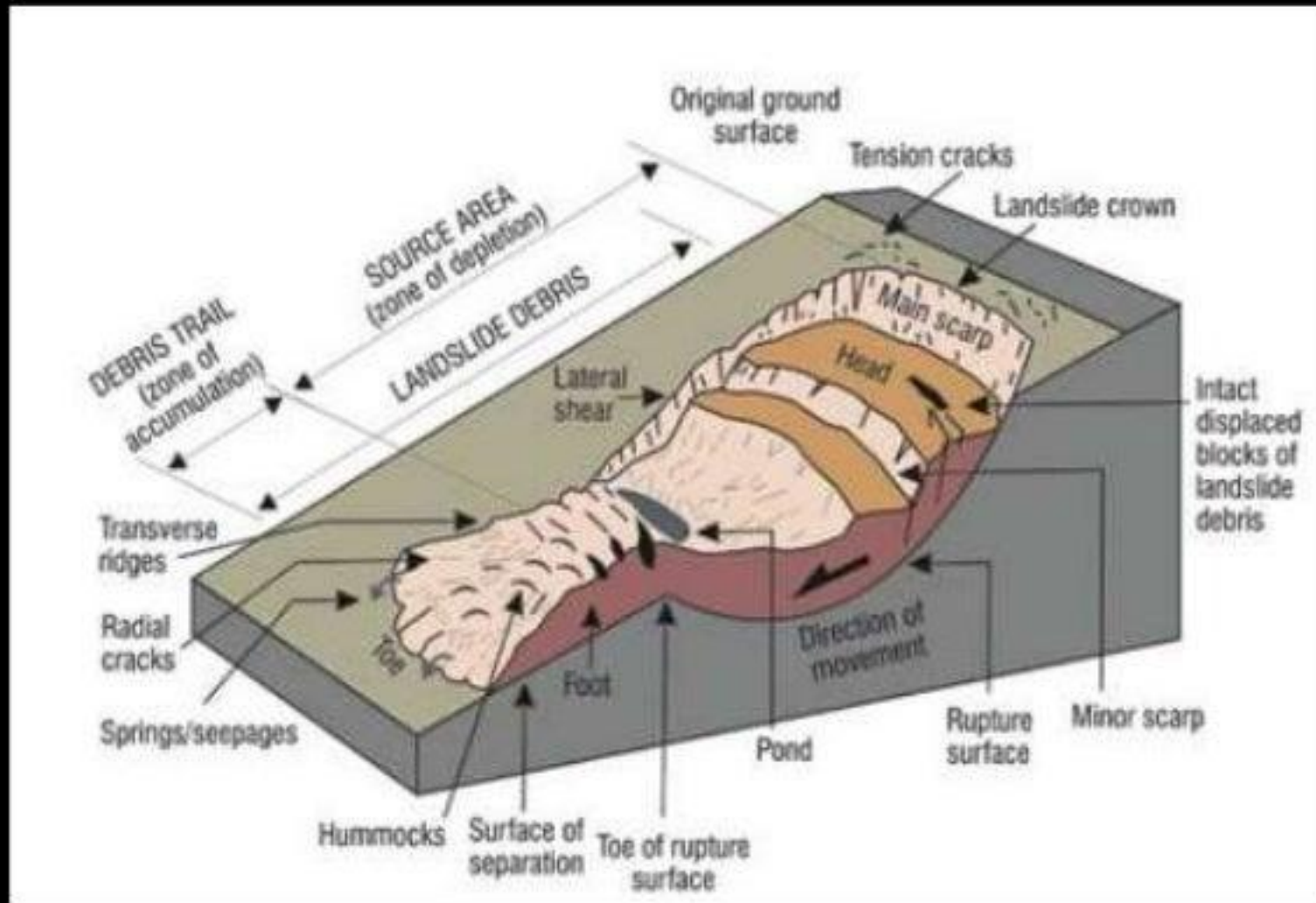
LANDSLIDES

- Landslides are defined as mass movement of rock, debris or earth down a slope and have come to include broad range of motions whereby falling, sliding and flowing under the influence of gravity dislodges earth material.

- Khanna, B.K and Khanna, N., 2011.

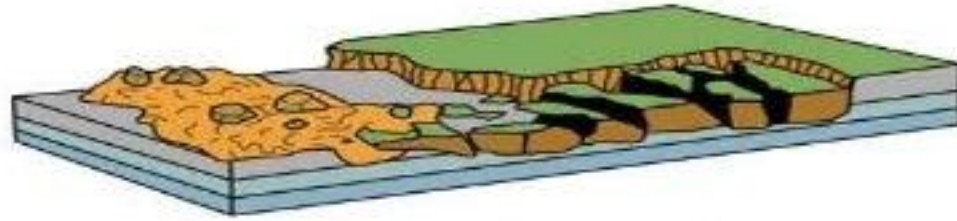
- Take place in conjunction with
 - I. Earthquakes
 - II. Floods/ prolonged rainfall
 - III. Volcanoes
- Hilly terrain is highly sensitive to landslides – Himalayas and Western Ghats

LANDSLIDE FEATURES



Types of landslides

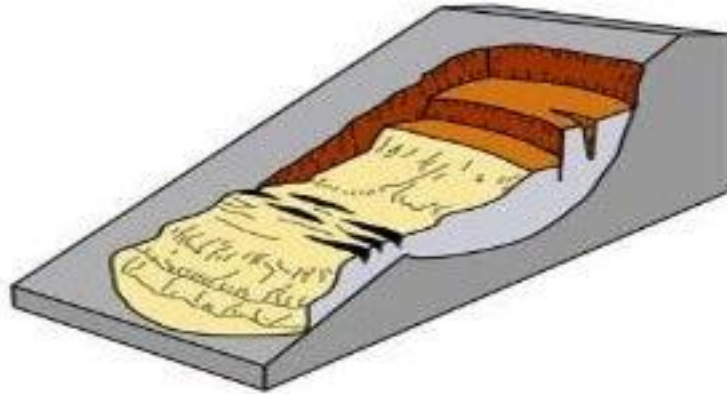
-Varnes, D. J., 1978



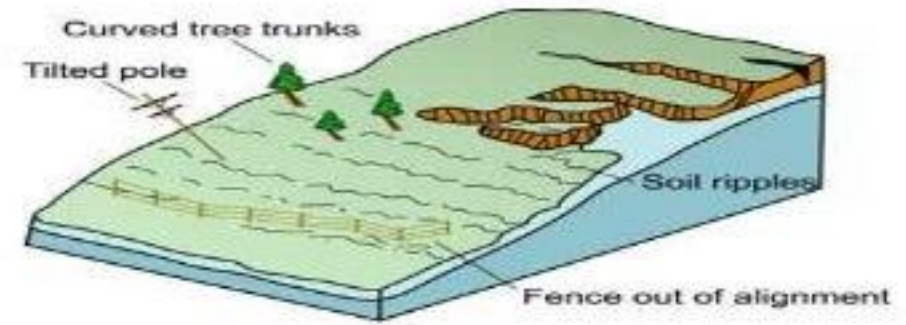
Lateral spread



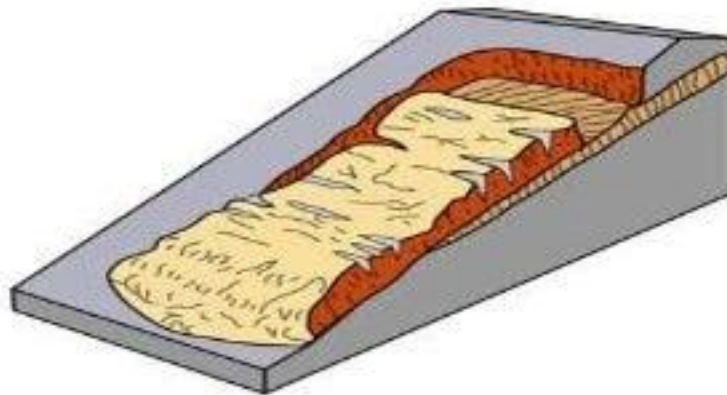
Topple



Rotational Landslide



Creep



Translational Landslide



Rockfall

CAUSES OF LANDSLIDES

Landslides occurs when several factors converge,

A. Natural Factors

- Gravity – works more effectively on steeper slopes
- Geological factors – weak, sensitive or weathered materials
- Heavy and prolonged rainfall – rapid rise in water level and saturation
- Earthquakes – plate tectonic moves the soil that covers it also moves
- Forest fire – causes erosion and induce floods and landslides
- Volcanoes – kill vegetation over extensive area and spreads volcanic rocks, subsequent rainy season will trigger landslides
- Waves – can erode the beach or the toe of a bluff, cutting into slope
- Freezing and Thawing

CAUSES OF LANDSLIDES

Landslides occurs when several factors converge,

B. Anthropogenic Factors

- Inappropriate drainage system – natural drainage lines on slopes are blocked by terracing/ contour bounding
- Cutting and deep excavations on slopes for buildings, roads, canals and mining – modification of natural slopes, blocking of surface drainage, loading of critical slopes and withdrawal to toe support
- Change in slope/ land use pattern, deforestation, settlements, agricultural practices on steep slope

ELEMENTS AT RISK

Settlements built

- ✓ on the steep slopes
- ✓ at the toe of slopes
- ✓ at the mouth of the streams emerging from mountain valley



LANDSLIDE PRONE AREAS



- IIT, Bombay.

EFFECTS

- Landslides destroys everything and anything that comes in their path.
 - Roads
 - Rail lines
 - Lines of communication
 - Settlements
 - River flows/ Damming
 - Agricultural production
 - Land area
 - Flooding
 - Water availability, quality and quantity
 - Flora and Fauna
- Fatalities depends on the place and time of occurrence.
- Estimated casualties per year, world-wide: **600 - 1000** persons



LANDSLIDE LOSSES

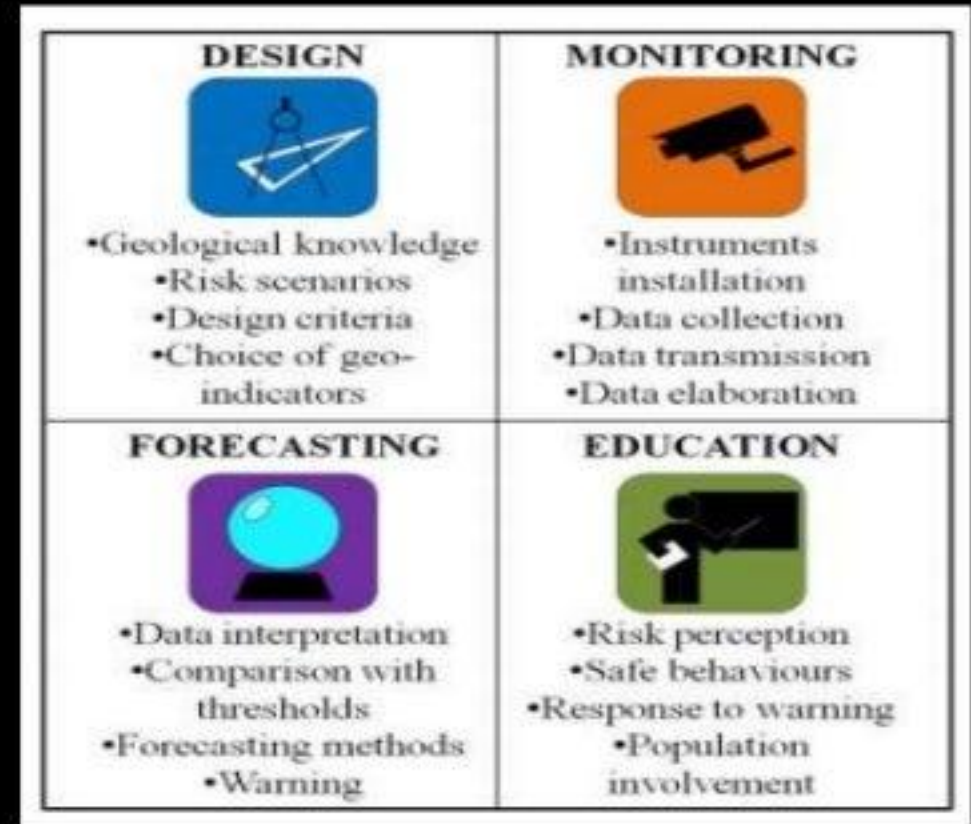
Country	Yearly losses Million US \$
Japan	4.700
Italy	2.600
United States	1.800
India	1.350
China	500
Spain	220
Canada	50
Hong Kong	25
New Zealand	12
Norway	6

- ITC, Netherland

WARNING

- Very difficult to predict the occurrence
- areas of high risk can be determined by
 - Geology
 - Hydrology
 - Vegetation cover
 - Post occurrence

- *System measures the water level in the ground, and then using a geotechnical mathematical model it evaluates the potential for a landslide. A warning message is then send to a website and also to people's smartphones.*



- Landslide Early Warning System, NASA

SIGNS OF LANDSLIDES



- Springs, seeps, or saturated ground in areas that have not typically been wet before.
- New cracks or unusual bulges in the ground, street pavements or sidewalks.
- Soil moving away from foundations, and ancillary structures such as decks and patios tilting and/or moving relative to the house.
- Sticking doors and windows, and visible open spaces.
- Broken water lines and other underground utilities.
- Leaning telephone poles, trees, retaining walls or fences.
- Sunken or dropped-down road beds.
- Rapid increase in a stream or creek water levels, possibly accompanied by increased turbidity (soil content).
- Sudden decrease in creek water levels even though rain is still falling or just recently stopped.

What to do if suspect imminent landslide danger:

- ✓ Contact local fire and police control rooms.
- ✓ Inform neighbours who are likely to be affected. Help them in evacuation.
- ✓ Evacuation out of the likely path of the landslide is the best protection.

What to do during a landslide:

- ✓ Quickly move out of path of the landslide or debris flow.
- ✓ If inside a building, stay inside and take cover under a desk, table or other sturdy furniture.
- ✓ If escape is not possible, curl into tight ball and protect your head.

What to do after a landslide:

- ✓ Check for injured and trapped persons, without entering the slide and direct and assist rescuers.
- ✓ Help vulnerable group persons in neighbourhood for emergency assistance.
- ✓ Listen to local radio or television station.
- ✓ Watch for flooding, which may occur after a landslide or debris flow.
- ✓ Look for and report damaged utility lines to authorities.
- ✓ Replant damaged ground as soon as possible since erosion caused can lead to flash flooding.
- ✓ Seek professional advice for evaluation of landslide hazard and designing corrective techniques to reduce landslide risk.

MAJOR LANDSLIDES

<u>YEAR</u>	<u>PLACE</u>	<u>CASUALTIES</u>
1248	Mount Granier (France)	1000+
1919	Kelud (Indonesia)	5110
1920	Haiyuan (China)	>100000
1933	Diexi (China)	~ 3100
1941	Huaraz (Peru)	4000-6000
1949	Gharm (Tajikistan)	~7200
1962	Ranrahirca (Peru)	4000-5000
1970	Yungay (Peru)	>22000
1985	Armero (Colombia)	23000
1999	Vargas (Venezuela)	30000
2013	Kedarnath (India)	5700



Uttarakhand Floods and Landslides - 2013

- Multi-day cloudburst caused devastating floods and landslides becoming the country's worst natural disaster since the 2004 tsunami
- Unscientific developmental programmes
- Activities for 70 hydro electric power projects lead to ecological imbalance.

MITIGATORY MEASURES

National Core Group for Landslide Mitigation, 2004 (MHA).

- Hazard Mapping: locate areas prone to slope failures – help in planning developmental activities
- Proper Drainage and Drainage Correction: allowing excess water to move without hindrance – deep drainage
- Engineering Structure: slope stabilisation – geogids, nailing, anchors
- Insurance
- Proper Land use Measures
- Afforestation and Reforestation of the Areas
- Developmental Activities: only after detailed study of region, avoid constructions along natural drainage
- Creation of Awareness Among Local People



SETTLEMENT POLICY

- ✓ Avoid permanent settlements in high risk zones.
- ✓ Diversion of stream channel in upper slopes, especially above settlements should be strictly disallowed.
- ✓ Adequate provision for drainage of storm water from high sloping terrain, to reduce saturation.
- ✓ Maintain existing natural drainage channels and hallows, without any blocking, division or modification.

REFERENCES

- Khanna, B.K. and Khanna, N. 2011. *Disasters*. New India Publishing Company, New Delhi, 278p.
- <http://www.csre.iitb.ac.in/rn/resume/landslide/india.html>
- <http://saarc-sdmc.nic.in/pdf/landslide.pdf>
- http://www.adpc.net/casita/Course%20Modules/Landslide%20hazard%20assessment/Landslides_types_and_causes.pdf
- <http://www.civildefence.govt.nz/assets/Uploads/publications/consistent-messages-part-B-landslides.pdf>
- <http://www.idahogeology.org/DrawOnePage.asp?PageID=83>
- http://en.wikipedia.org/wiki/List_of_landslides
- <https://2014.spaceappschallenge.org/project/landslide-ewas--early-warning-system>
- <http://landslides.usgs.gov/learn/prepare.php>
- <http://www.nat-hazards-earth-syst-sci.net/13/85/2013/nhess-13-85-2013.pdf>
- http://www.fao.org/fileadmin/templates/rap/files/NRE/Forestry_Group/Landslide_Policy_Brief.pdf