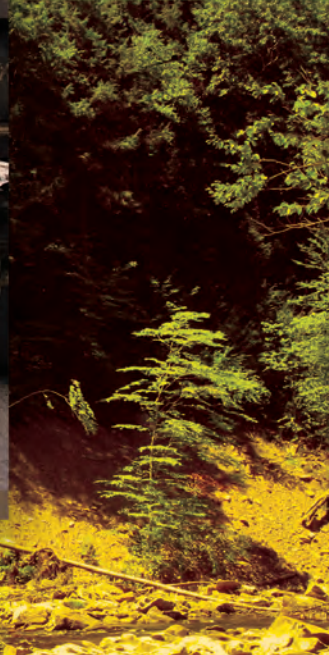
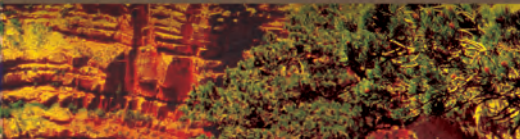
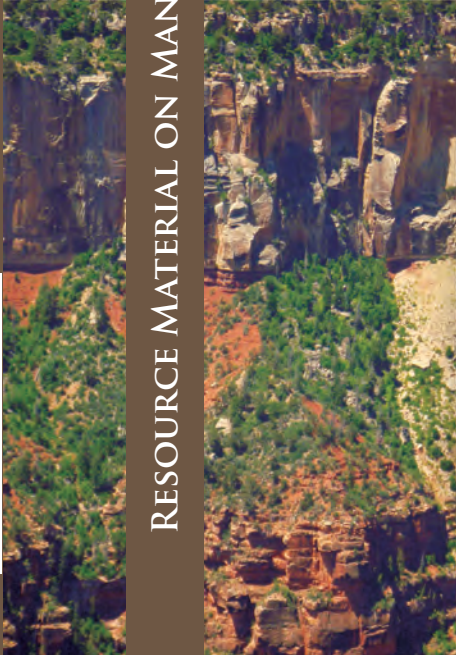
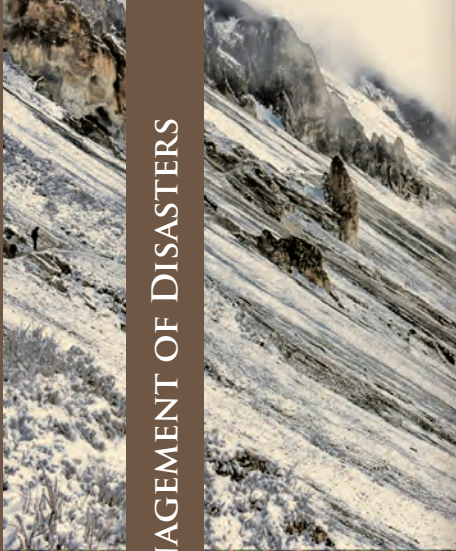


Landslide



First Edition

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In this series, an attempt has been made to raise awareness in order to handle these disastrous situations effectively so as to minimise losses.

This series comprises of ten booklets covering different areas such as earthquake, landslide, tsunami, flood, draught, fire and accidents, chemical hazards, epidemics like swine flu, malaria and dengue, food poisoning and cholera. You will notice that the topics selected here do not include all the issues related to disaster. These are only illustrative cases. This is because the idea is to impart necessary information to develop skills to enable people to prevent disasters or to reduce their impact by efficient handling of such situations.

Simple and communicative language has been used in the entire series so that children in the age group of 10–16 years can understand it effectively. We hope that the readers will benefit from this material and have confidence to handle such kind of situations proving to be smart and responsible citizens.

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Landslide



Rasika



Rasika's Mother



Geologist

विद्यया ऽ मृतमश्नुते



एन सी ई आर टी
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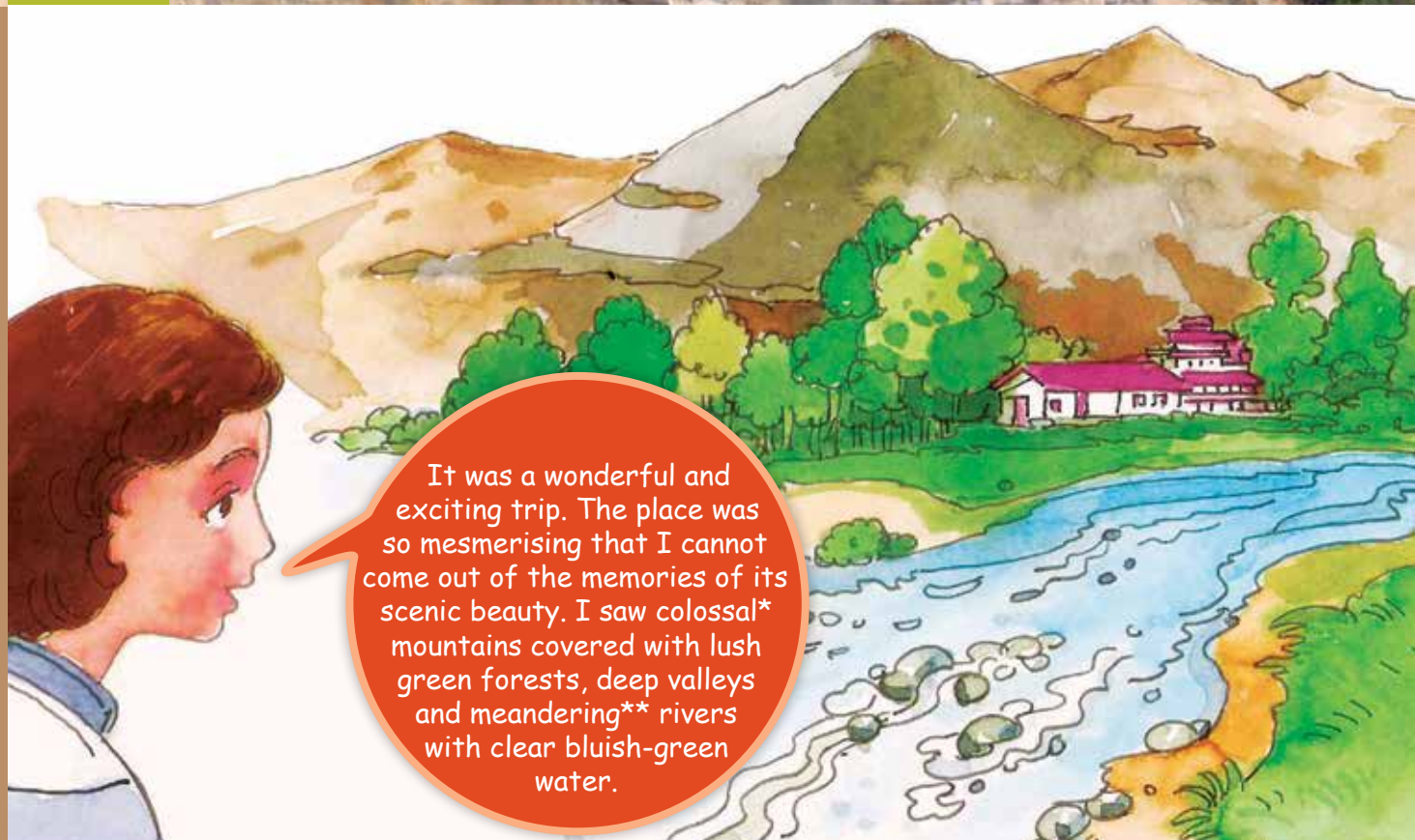
Rasika is eagerly waiting for her school to open the next day. She has just come back from the mountaineering trip organised by the Eco Club.

She got up early, excited that she would soon meet her friends.









It was a wonderful and exciting trip. The place was so mesmerising that I cannot come out of the memories of its scenic beauty. I saw colossal* mountains covered with lush green forests, deep valleys and meandering** rivers with clear bluish-green water.

*COLOSSAL: extremely large.

**MEANDERING: to wander around in a leisurely, aimless manner.



Wow!
Rasika,
that must be
an amazing
experience.

Oh yes,
but we had
other experiences
also which were
adventurous as well
as terrifying. Let
me tell you...

Landslide

...Ours was a 7-day mountaineering trip. As soon as we reached NIM, the Nehru Institute of Mountaineering at Uttarkashi, we were given our first assignment. We were to put up our tents near the bank of the river Bhagirathi, a

tributary of Ganges. Challenging as it was, it was interesting too. We thoroughly enjoyed putting up the tents during the day. We spent a music filled evening around a bonfire...



...Early morning on the next day we left for trekking, backpacks on our shoulders. We were accompanied by a guide from NIM and our Eco-club co-coordinator, Mrs. Archana. We climbed towards Agoda where a major earthquake had occurred on 20th October 1991. We trekked on steep slopes through ridges and crossed the river many times. We were almost touching the peaks of the mountains on our way...





Anaiah immediately asked "But why? Weren't you carrying your umbrellas or raincoats with you?"

Yes,
we had
raincoats but
our guide cautioned
us that there is a
possibility of landslides
on the hills during rains
so it is better to
stay at a safer
location.

So
where did
you stay?



We stayed in tents on a stable, solid rock on the hilltop the whole night. Our teacher told us to use our food and water optimally* till morning as we had limited stock with us. That night was very scary and we were not able to sleep due to the rumbling sound of the thunderstorm.

*OPTIMAL: most effective. In just the desired amount.

Landslide

The next day morning, when the rain stopped, we woke up and resumed our return journey, but on our way back we

found huge queues of vehicles on the road side, stuck due to a major landslide on Varunavat hills in Uttarkashi



A Landslide?
What is that?

We didn't
know
either, till
we saw it
really....



Oh yes, I
remember!
Did we
not have a
discussion
about
landslides
during a mock
drill once?

Yes, Ma'am told us that landslides happen frequently in hills in response to a wide variety conditions and triggering processes like heavy rainstorms, cloudbursts, earthquakes, floods and unsafe developmental activities. In our country,

more than 15% of the territory is prone to various degrees of landslide hazards, frequently causing massive damage to human life, livelihood, livestock, living places, structures, infrastructure, and natural resources.



Landslide

It was actually very horrific. The road was completely covered with the landslide debris* and many tourists and pilgrims were trapped for several hours on both sides of it without any supply of food and water. When we were waiting for the debris to be cleared, the local people told us that

several hotels and other buildings had been buried by the landslide and some people were also missing who may have been trapped under the landslide. Fortunately, most of the people had already left the area as the alert was issued by the Geological Survey of India about the possibility of a landslide.



*DEBRIS: the remains of anything broken down or destroyed



Our teacher asked a geologist why did the landslide happen here? But the geologist was busy attending to the emergent duty. Seeing our curiosity to learn about landslides he asked us about our place of stay. When the teacher told him about NIM guest house, he told us that he was also staying at the same place and would try to meet us after dinner and would explain about the landslides.



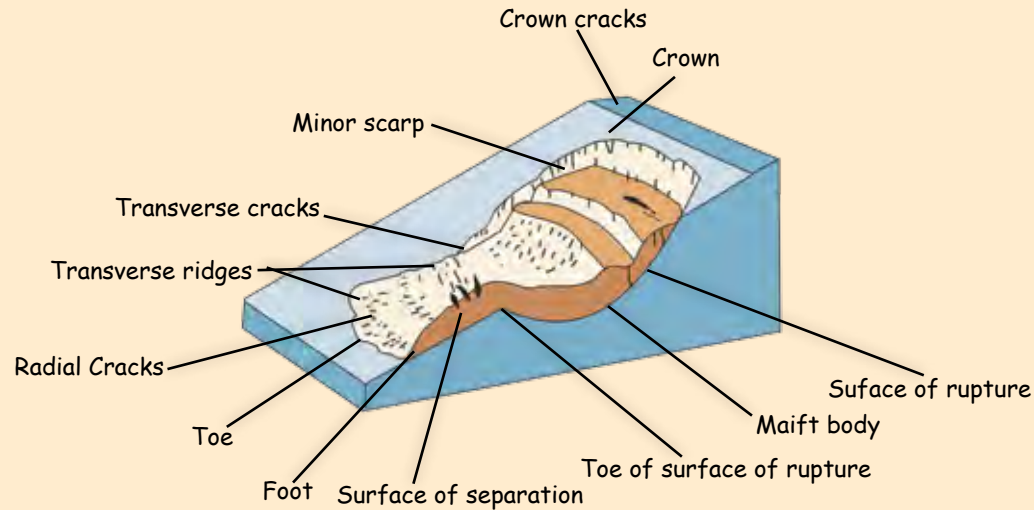
Landslide

Soon after, we were told by the guide to carefully cross the landslide from the upper side to return to our place of stay. On reaching the guest house we were tired and rested till evening. When we went for dinner we met the geologist. After

dinner we went out with him to the adjoining park to talk about the landslide that we had encountered in the morning. He explained to us the real cause of landslide and how it impacted the lives of local people.



WHAT ARE LANDSLIDES?



Landslides are simply downslope movement of rock, debris and/or earth of the massive nature. The active part of the word "landslide" denotes sliding,

whereas, it connotes even movements without sliding like, fall, topple, flow etc.

CAUSES OF LANDSLIDES

A. GROUND CONDITIONS

- Weak, sheared and deformed rocks
- Joint, fissured* or cracked material
- Adversely oriented discontinuities including faults and joints
- Contrasts in stiffness (stiff, dense material over plastic material)

B. GEOMORPHOLOGICAL PROCESSES

- Tectonic uplift
- Glacial Rebound
- Slight erosion by rivers and glaciers
- Subsurface erosion (solution, piping)
- Vegetation removal by erosion, forest fire or drought
- Ground Cracks and subsidence**

*FISSURE: natural division or groove through which separation of parts take place

**SUBSIDENCE: to sink or fall to bottom

C. PHYSICAL PROCESSES

- Intense or prolonged rainfall, melting of snow
- Earthquake or flood
- Breaching of lake or dams
- Contrasts in permeability* of rocks, debris and soils
- Freeze and thaw; shrink and swell of rocks and soils

d. MAN-MADE PROCESSES

- Excavation**
- Drawdown of reservoirs
- Inappropriate irrigation
- Defective maintenance of drainage system
- Water leakage from services, like, water supplies, sewage, storm water drains
- Vegetation removal by deforestation or over grazing
- Mining and quarrying activities
- Waste dumps and reclaimed*** grounds
- Artificial vibration like blasting and explosion
- Poor maintenance of remedial measures

*PERMEABILITY: the capability of a rock or sediment to permit the flow of fluids through its pore spaces

**EXCAVATION: to dig or scoopout (earth, sand etc.)

***RECLAIM: recover

TYPES OF LANDSLIDES

Falls is a very rapid to extremely rapid movement which starts with detachment of material from steep slopes such as cliffs. The material then descends through the air by falling freely, bouncing or rolling onto the slopes below.



Topples involves overturning of material. It involves forward rotation of the detached unblock of matter.



Flows is a landslide in which the soil travels continuously like water flows.

Lateral Spreads is sudden movement of soil on gentle slopes that have rapid movement like a liquid. This landslide is generally observed on slopes



Slides is a downslope movement of material along a recognisable slip surface. There are two types of slip surfaces. A Rotational or Slump slip surface is circular while a Translational or Wedge slip surface is planar.



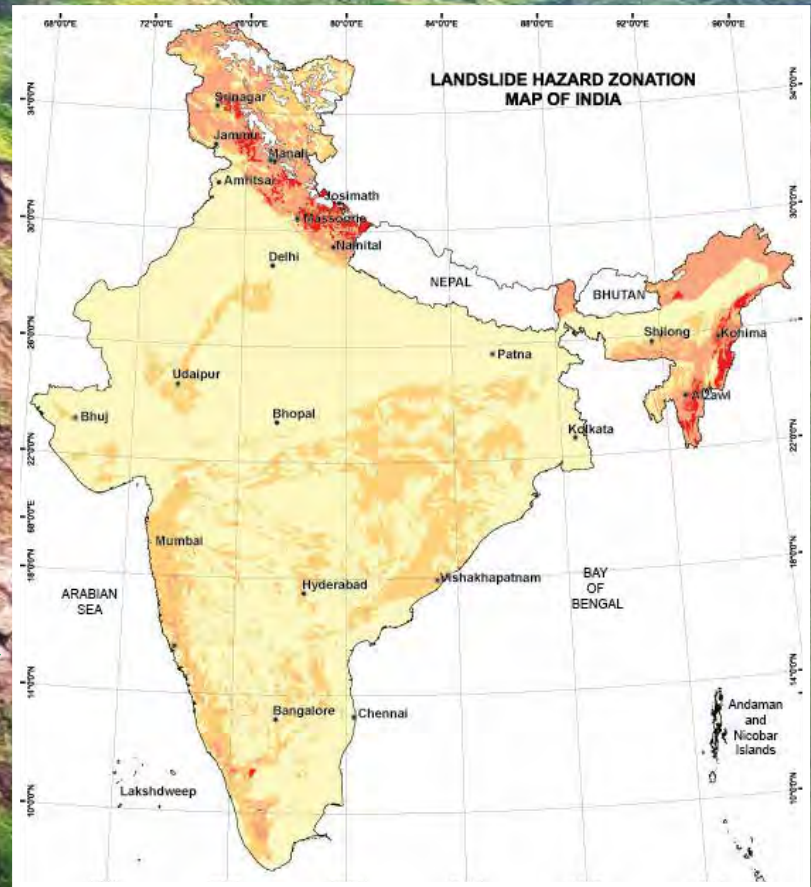
Oh my God! There are so many causes of landslides and so many ways they can occur! Life of people in the hills must be very difficult. Then how do they deal with landslides so often?



"Even we asked the same question from the geologist and he told us that there are different ways in which the landslides are dealt by the people. Before developing any area, the landslide hazard zonation map is used to know the degree of landslide problems. They try to avoid construction and development in high and very high hazard zones.

Landslide

1. Which parts of India are affected by landslides?
2. Is my state vulnerable to landslides?
3. If yes, in which landslide zone am I located?
4. Lets identify the landslide prone areas in our state.



REGULATORY MEASURES FOR REDUCING LANDSLIDE HAZARD

Discouraging new developments in hazardous areas by

- informing and educating the public.
- disclosing the hazard to real estate buyers.
- posting the warnings of potential hazards.
- adopting proper utility and public facility service-area policies.
- making a public record of hazards.

Removing or converting existing development through

- acquiring or exchanging hazardous properties.
- discouraging non-conforming land use.
- reconstructing damaged areas after landslides.
- removing unsafe structures.
- clearing and redeveloping landslides prone areas

Protecting existing developments by

- controlling landslides and slumps.
- controlling mudflows and debris flows.

Landslide

He also told us that in case such zones are unavoidable, then preventive and mitigation

measures are taken to reduce the incidence and impacts of landslides.

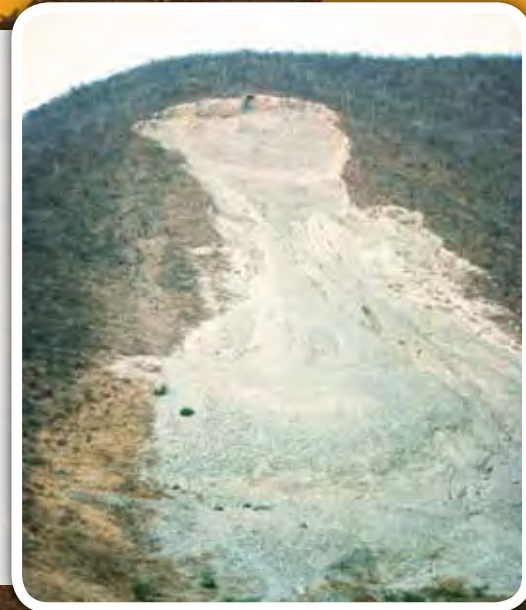
LANDSLIDE PREVENTION AND MITIGATION MEASURES

A. Modification of Slope Geometry

- Benching
- Reducing slope angle and height
- Slope stitching using timber or cement concrete

B. Drainage Management

- Surface drains to divert water from the slide area
- Shallow or deep trench drains
- Boreholes* and wells for subsurface drainage
- Drainage tunnels and galleries
- Vegetation planting



*BOREHOLE: a hole drilled in earth



C. Building Retaining or Restraining Structures

- Earth retaining walls
- Piles, piers* and caissons**
- Reinforced earth retaining structures
- Rock trap ditches, nets and meshes for rock slopes,

D. Internal Slope Reinforcement

- Use of Bolts, Anchors, nails and piles
- Grouting***
- Biotechnical measures like planting vetiver grass or using jute or coir mats

* PIER: an upright support for a structure or super structure

**CAISSON: a large watertight chamber

***GROUT: a coat of plaster for finishing a ceiling

Landslide Alerts and Warnings

Geological Survey of India issues alerts and warnings to all authorities and agencies of the Central Government, State Governments and district administration for landslides in the following categories.

- ❖ Category IV: Landslides of small dimensions that occur away from habitations and do not affect either humans or their possessions. These may occur near infrastructural installations, agricultural and forestlands and may not affect them in a significant manner.
- ❖ Category III: Landslides which are fairly large could cause damage to infrastructural installations like strategic and important highways and roads, rail routes and other civil installations like various important structures of hydroelectric and irrigation projects.
- ❖ Category II: The landslides that may occur on the fringes of inhabited areas and result in limited loss of life and property. Landslides, which result in blockade of courses of relatively smaller natural drainages. If the blockade is of relatively smaller dimensions its impact would be small.
- ❖ Category I: Landslides of large dimensions which are located over or in close vicinity of inhabited areas. Activity on these slides can result in loss of human lives and dwellings on a large scale. These slides may also inflict heavy losses on urban infrastructure. The slides that block busy pilgrimage routes during peak times resulting in hardships to thousands of pilgrims and sometimes resulting in loss of human life. Landslides which result in blockade of courses of relatively large natural drainages.

Despite preventive and mitigation measures taken by people, landslides may affect normalcy of life. Hence, preparedness against the landslide risk

by the communities is considered as an important activity. Local communities prepare themselves for pre, during and post landslide situations

Pre-disaster Preparedness

If one is at risk from landslides, one should

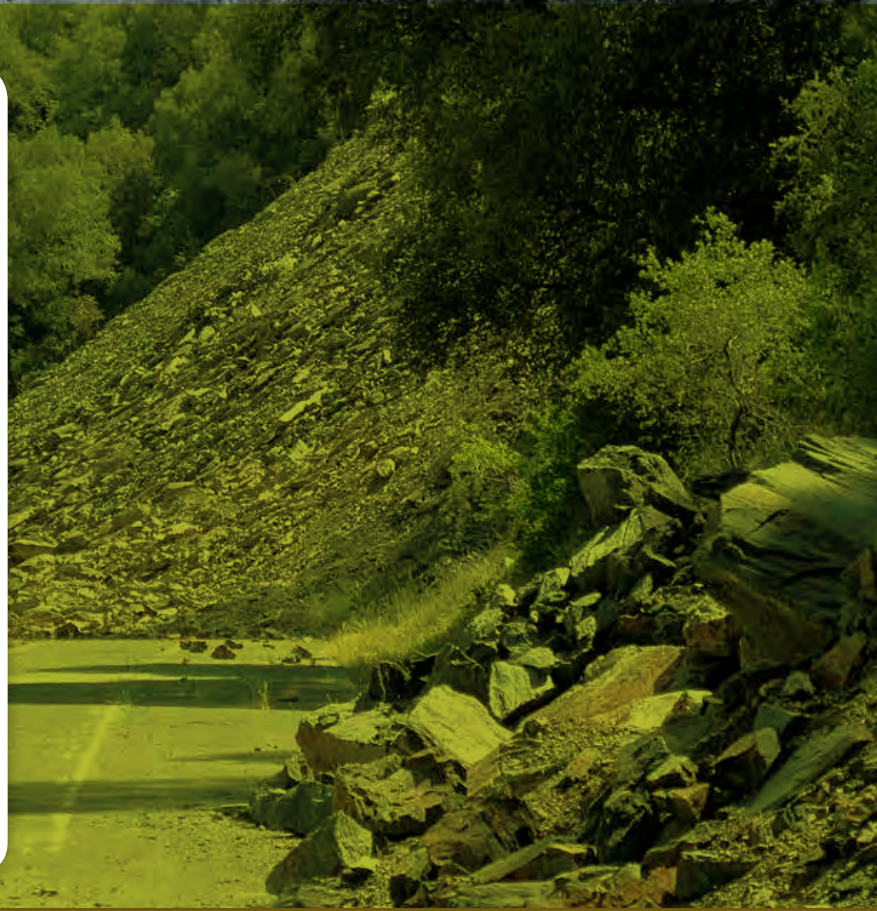
- develop an evacuation plan
- familiarise with your surroundings to assess risk
- watch the patterns of storm-water drainage on slopes near your homes
- watch the hillsides around homes for any signs of land movement, such as small landslides or debris flows, or progressively tilting trees

Noticing small changes could alert you to an increased threat of a landslide

- Discuss landslides and debris flows with members of household. Everyone should know what to do to stay safe if landslide occurs.
- Build away from steep slopes and from the bottoms or mouths of steep ravines and drainage facilities.

Learn to recognise the landslide warning signs

- Doors or windows get stuck or jam for the first time.
- New cracks appear in plaster, tiles, bricks, or foundations
- Outside walls, walks, or stairs begin pulling away from the building
- Slowly developing, widening cracks appear on the ground or on paved areas such as roads or highways.
- A sinkhole occurs when ground water dissolves a vulnerable land surface such as, limestone, causing land surface to collapse due to lack of support.



WHAT TO DO DURING A LANDSLIDE

- ❖ If outside, quickly move out of the path of the landslide and run to the nearest high ground in a direction away from the path of the landslide



- ❖ If escape is not possible, curl into a tight ball and protect your head
- ❖ If rocks or debris are approaching you, run towards the nearest shelter such as, group of trees or big and heavy rock mass that are unlikely to move with slide.

WHAT TO DO AFTER A LANDSLIDE

- ✧ Stay away from the slide area. There may be danger of additional slides.



- ✧ Go to the established meeting point and follow instructions by the assigned responsible person.

- ❖ Be vigilant to locate injured and trapped people in the landslide without entering the slide area directly. Direct rescuers to their locations.



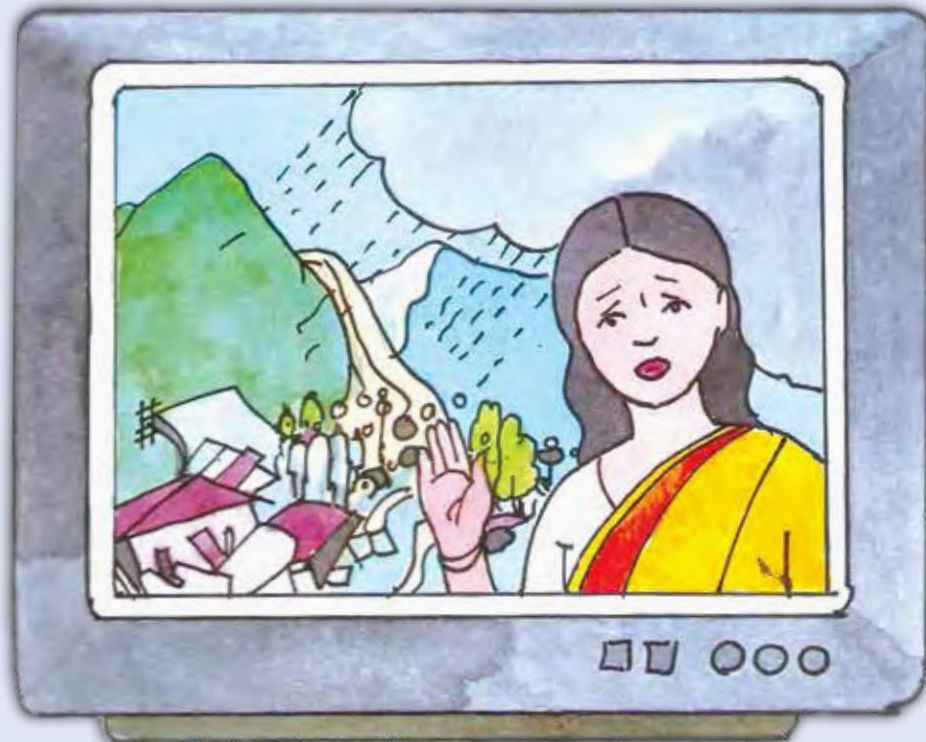
- ❖ Help those who require special assistance, e.g., infants, elderly people; and people with disabilities.

Landslide

- ❖ Give first aid to victim, if you are trained.
- ❖ Listen to the local radio or television for the latest information on the emergency.

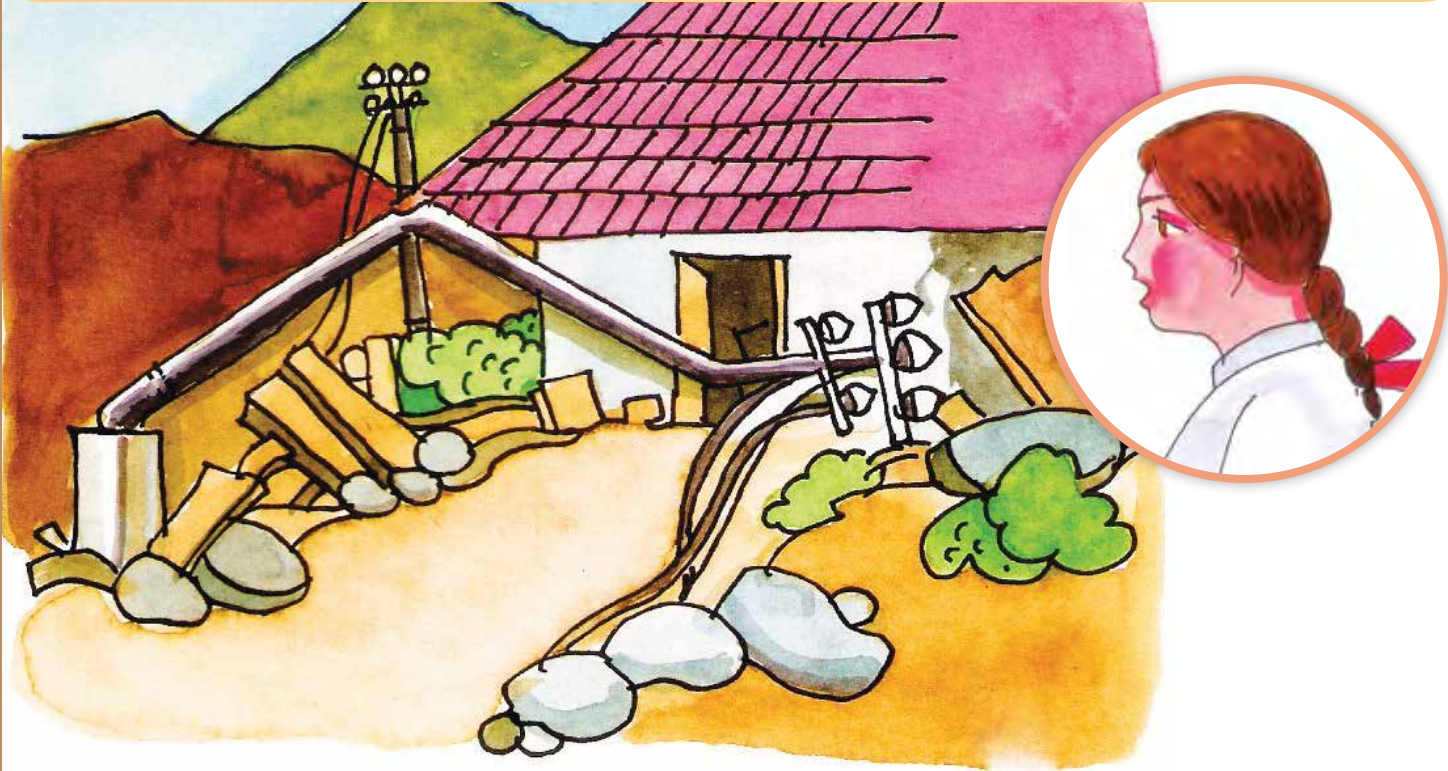


- ❖ Watch for flooding, which may occur after a landslide or debris flow. Floods sometimes follow landslides and debris flows because they may both be started by the same event.
- ❖ Look for and report broken utility lines to appropriate authorities so that they are turned off as quickly as possible, preventing further hazard and injury.



Landslide

After the discussion we all went back to our rooms to sleep as it was already midnight. Next morning again we went to the landslide site and took some pictures. Would you like to see some of these pictures?



Landslide posing risk to multistoried hotels at Uttarkashi
(photograph taken a day before these buildings were buried
under this slide on 26 September 2003)



Photograph after burial of
hotels and other buildings at
Uttarkashi



After seeing the photographs Sakshi said, "hmmm..., these pictures clearly shows what you must have experienced during the landslide. Through your experience we have also learnt a lot about landslides. It was useful information and next time when I will go to any hill station, I will surely go prepared for landslides".



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