KARNATAKA STATE ACTION PLAN:

MANAGEMENT OF LANDSLIDES – 2022

Karnataka State Disaster Management Authority
Revenue Department (Disaster Management)
Government of Karnataka

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

CHAPTER 1
LANDSLIDE

1.1 Introduction:

The term “landslide” describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a combination of these. The materials may move by falling, toppling, sliding, spreading, or flowing. Figure 1.1 shows a graphic illustration of a landslide, with the commonly accepted terminology describing its features. The various types of landslides can be differentiated by the kinds of material involved and the mode of movement. A classification system based on these parameters is shown in Table 1. Other classification systems incorporate additional variables, such as the rate of movement and the water, air, or ice content of the landslide material.

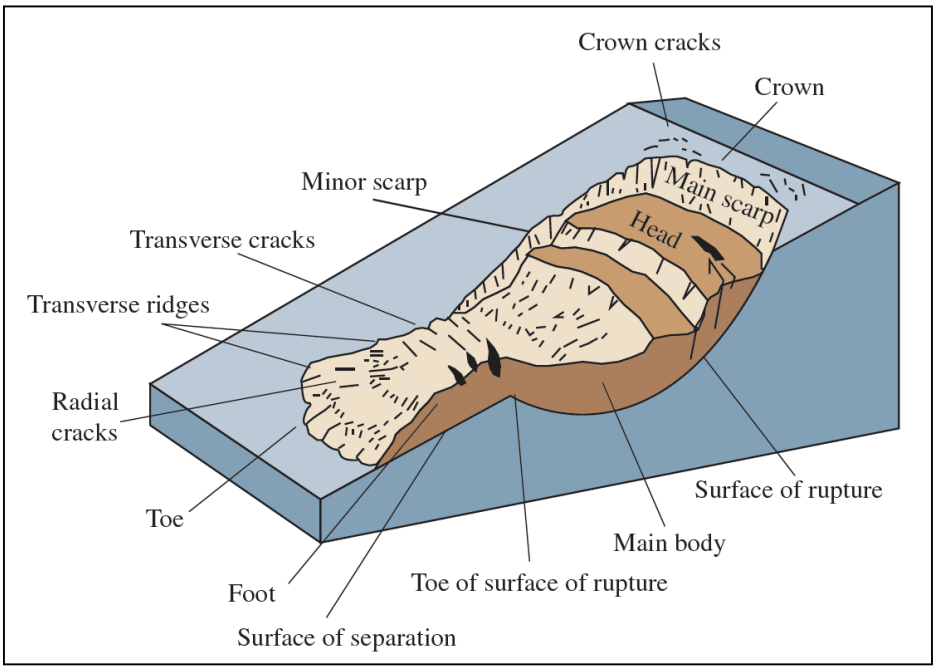

Figure 1.1: An idealized slump-earth flow showing commonly used nomenclature for labeling the parts of a landslide.

1.2 Types of Landslides

Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief. In low-relief areas, landslides occur as cut-and fill failures (roadway and building excavations), river bluff failures, lateral spreading landslides, collapse of mine-

waste piles (especially coal), and a wide variety of slope failures associated with quarries and open-pit mines. The most common types of landslides are described as follows.

Table 1: Types of landslides (Varnes, 1978)

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly coarse	Predominantly fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (deep creep)	Debris flow	Earth flow
			(soil creep)	
COMPLEX Combination of two or more principal types of movement				

1.2.1 FALLS

Falls are abrupt movements of masses of geologic materials, such as rocks and boulders that become detached from steep slopes or cliffs (fig. 1.2A). Separation occurs along discontinuities such as fractures, joints, and bedding planes, and movement occurs by free-fall, bouncing, and rolling. Falls are strongly influenced by gravity, mechanical weathering, and the presence of interstitial water.

1.2.2 TOPPLES

Toppling failures are distinguished by the forward rotation of a unit or units about some pivotal point, below or low in the unit, under the actions of gravity and forces exerted by adjacent units or by fluids in cracks (fig. 1.2B).

1.2.3 SLIDES

Although many types of mass movements are included in the general term “landslide,” the more restrictive use of the term refers only to mass movements, where there is a distinct zone of weakness that separates the slide material from more stable underlying material. The two major types of slides are rotational slides and translational slides.

Rotational slide: This is a slide in which the surface of rupture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface and transverse across the slide (fig. 1.2C).

Translational slide: In this type of slide, the landslide mass moves along a roughly planar surface with little rotation or backward tilting (fig. 1D). A *block slide* is a translational slide in which the moving mass consists of a single unit or a few closely related units that move downslope as a relatively coherent mass (fig. 1.2E).

1.2.4 LATERAL SPREADS

Lateral spreads are distinctive because they usually occur on very gentle slopes or flat terrain (fig. 1.2F). The dominant mode of movement is lateral extension accompanied by shear or tensile fractures. The failure is caused by liquefaction, the process whereby saturated, loose, cohesion-less sediments (usually sands and silts) are transformed from a solid into a liquefied state. Failure is usually triggered by rapid ground motion, such as that experienced during an earthquake, but can also be artificially induced. When coherent material, either bedrock or soil, rests on materials that liquefy, the upper units may undergo fracturing and extension and may then subside, translate, rotate, disintegrate, or liquefy and flow. Lateral spreading in fine-grained materials on shallow slopes is usually progressive. The failure starts suddenly in a small area and spreads rapidly. Often the initial failure is a slump, but in some materials movement occurs for no apparent reason. Combination of two or more of the above types is known as a complex landslide.

1.2.5 FLOWS

There are five basic categories of flows that differ from one another in fundamental ways.

a. Debris flow: A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as a slurry that flows downslope (fig. 1.2G). Debris flows include <50% fines. Debris flows are commonly caused by intense surface-water flow, due to heavy precipitation or rapid snowmelt, that erodes and mobilizes loose soil or rock

on steep slopes. Debris flows also commonly mobilize from other types of landslides that occur on steep slopes, are nearly saturated, and consist of a large proportion of silt- and sand-sized material. Debris-flow source areas are often associated with steep gullies, and debris-flow deposits are usually indicated by the presence of debris fans at the mouths of gullies. Fires that denude slopes of vegetation intensify the susceptibility of slopes to debris flows.

b. Debris avalanche: This is a variety of very rapid to extremely rapid debris flow (fig. 1.2H).

c. Earthflow: Earthflows have a characteristic "hourglass" shape (fig. 1.2I). The slope material liquefies and runs out, forming a bowl or depression at the head. The flow itself is elongate and usually occurs in fine-grained materials or clay-bearing rocks on moderate slopes and under saturated conditions. However, dry flows of granular material are also possible.

d. Mudflow: A mudflow is an earthflow consisting of material that is wet enough to flow rapidly and that contains at least 50 percent sand-, silt-, and clay-sized particles. In some instances, for example in many newspaper reports, mudflows and debris flows are commonly referred to as "mudslides."

e. Creep: Creep is the imperceptibly slow, steady, downward movement of slope-forming soil or rock. Movement is caused by shear stress sufficient to produce permanent deformation, but too small to produce shear failure. There are generally three types of creep: (1) seasonal, where movement is within the depth of soil affected by seasonal changes in soil moisture and soil temperature; (2) continuous, where shear stress continuously exceeds the strength of the material; and (3) progressive, where slopes are reaching the point of failure as other types of mass movements. Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges (fig. 1.2J).

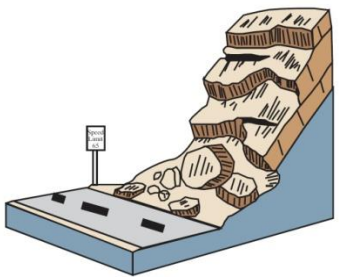

Figure 1.2A: Rockfall

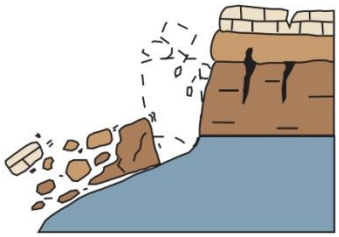

Figure 1.2B:Topple

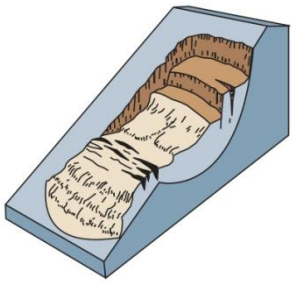

Figure 1.2C: Rotational landslide

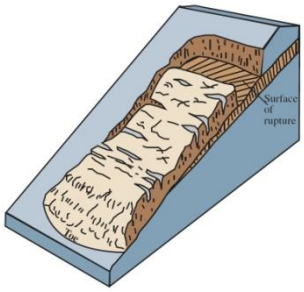

Figure 1.2D: Translational landslide

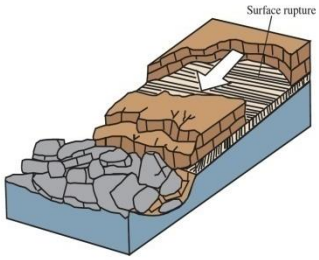

Figure 1.2E: Blok Slide

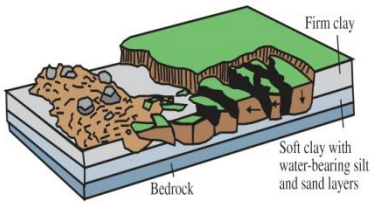

Figure 1.2F: Lateral Spread

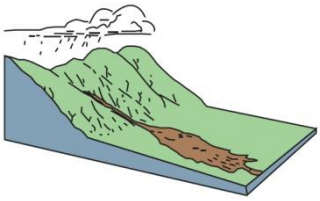

Figure 1.2G: Debris Flow

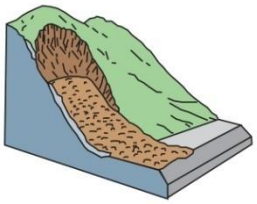

Figure 1.2H: Debris avalanche

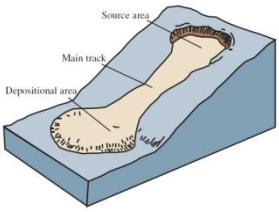

Figure 1.2I: Earthflow

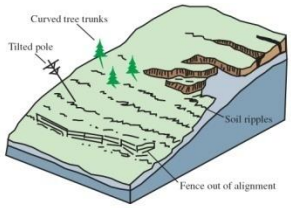

Figure 1.2J: Creep

1.3 Landslide Hazard of India:

According to the United Nations International Strategy for Disaster Reduction (UNISDR), a hazard is a natural process or phenomenon that may pose negative impacts on the economy, society, and ecology, including both natural factors and human factors that are associated with the natural ones. Hazards are the origins of disasters. Hazards are detrimental to the development of human beings and hinder the sustainability of the world.

India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India besides the Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyans, in that order, covering about 15% of the landmass. A different variety of landslides, characterized by a lateritic cap, pose constant

threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone.

A general landslide hazard map of India shown in ***Fig 1.3*** marks the areas of different hazard zones in various States of India; one may note that Himalayas of Northwest and Northeast India and the Western Ghats are two regions of high vulnerability and are landslide prone.

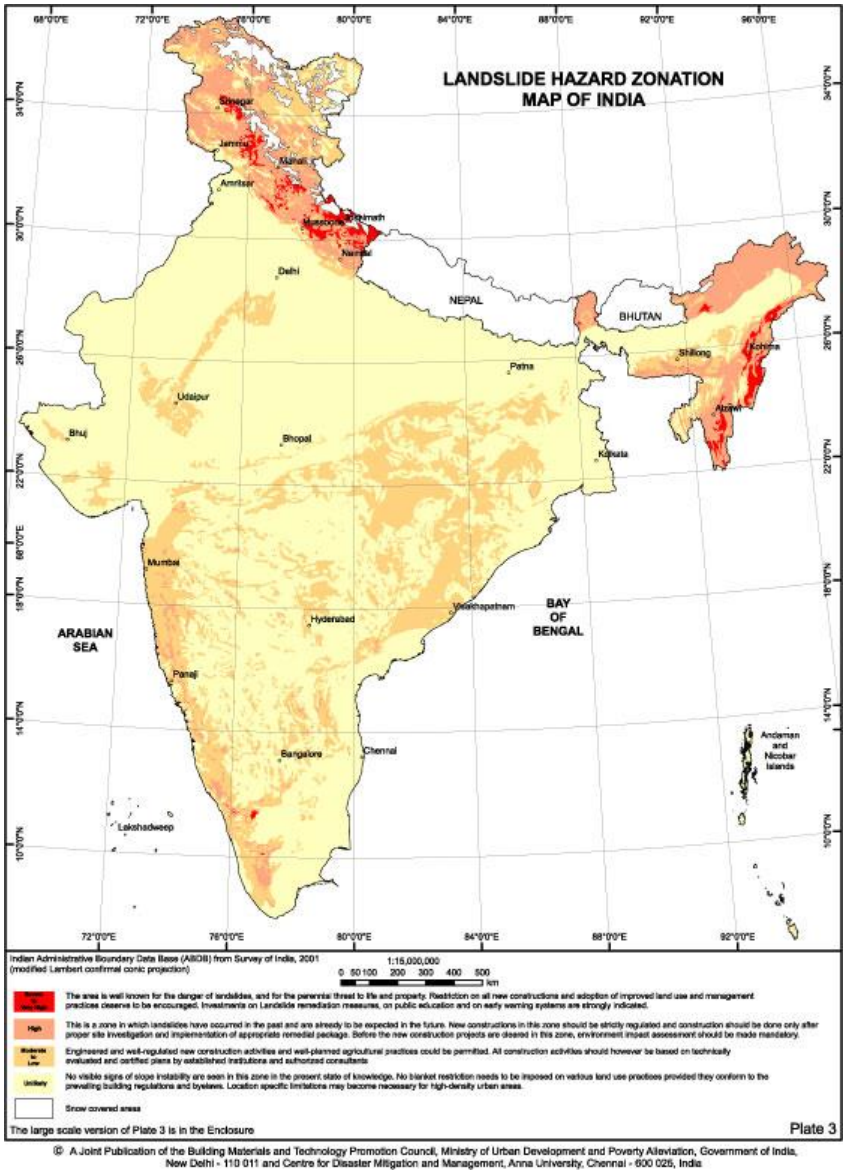

Fig 1.3: Landslide hazard map of India (BMTPC)

CHAPTER 2

LANDSLIDE VULNERABILITY IN KARNATAKA

2.1 Landslides in Karnataka

Landslides affect at least 15.30% of the land area of Karnataka, exceeding 29350.3 km^2 which falls in the 29 taluks. From the past decade in Karnataka, the maximum numbers of landslides were occurred in Uttara Kannada district followed by, Shivamogga, Chikkamagaluru, Udupi, Dakshina Kannada, Kodagu and Hassan and had caused widespread damage and many casualties, together with significant economic losses and social disruption.

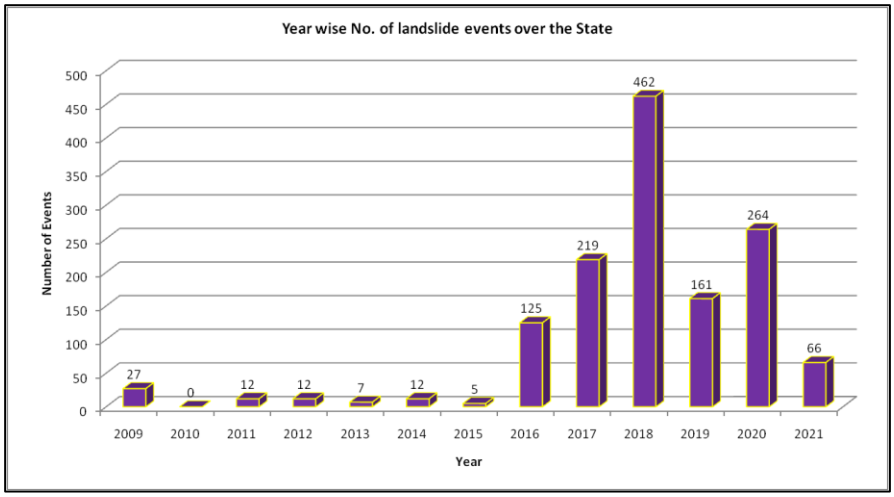

Fig 2.1: Year wise No. of landslide events over the State

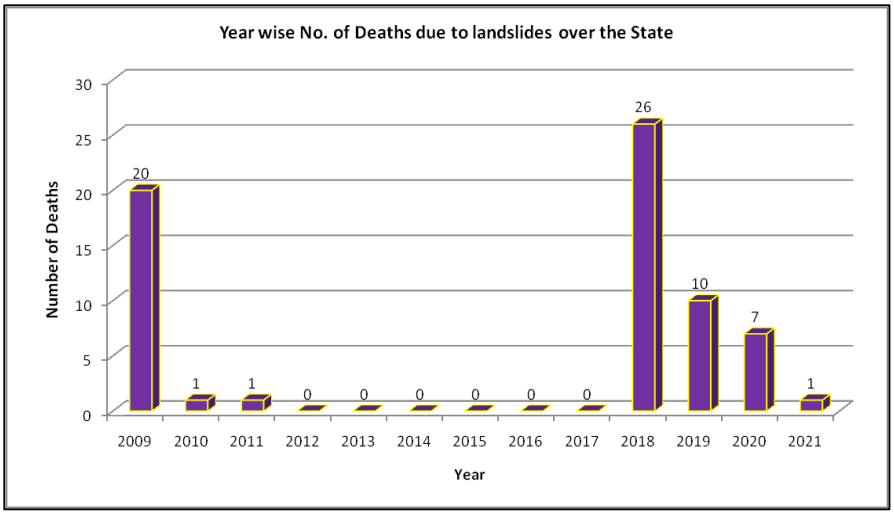

Fig 2.2: Year wise No. of Deaths due to landslides over the State

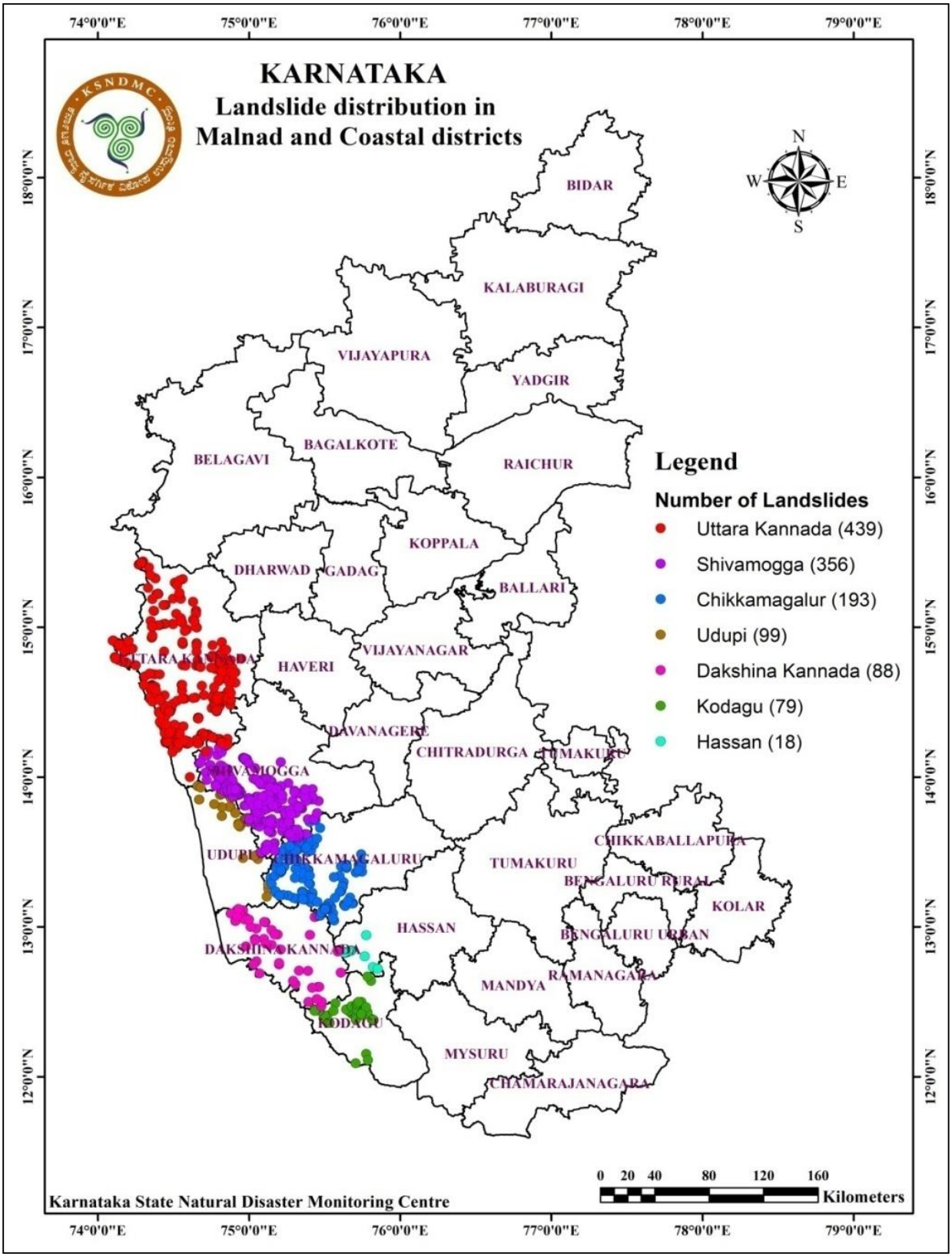

Fig 2.3: Landslide Incidences in Karnataka from Jan 2009 to Dec 2021(GSI & KSNDMC)

Table 2: Landslide occurrence taluks in Karnataka

Sl No	DISTRICT	TALUK	AREA in km^2
1	Chikkamagaluru	Chikkamagaluru	1590.6
2	Chikkamagaluru	Mudigere	1174.1
3	Chikkamagaluru	Narasimharajapura	808.6
4	Chikkamagaluru	Sringeri	447.2
5	Dakshina Kannada	Beltangadi	1367.6
6	Dakshina Kannada	Bantwal	737.5
7	Dakshina Kannada	Mangaluru	566.5
8	Dakshina Kannada	Kadaba	736.4
9	Dakshina Kannada	Sulya	720.2
10	Dakshina Kannada	Puttur	420.9
11	Hassan	Sakaleshpura	1027.8
12	Kodagu	Madikeri	1448.2
13	Kodagu	Somwarpet	999.2
14	Kodagu	Virajpet	1655.2
15	Shivamogga	Hosanagara	1423.9
16	Shivamogga	Sagara	1932.5
17	Shivamogga	Tirthahalli	1247.7
18	Udupi	Hebri	449.6
19	Udupi	Bynduru	575.1
20	Udupi	Karkala	723.6
21	Udupi	Kundapur	889.8
22	Uttara Kannada	Ankola	913.5
23	Uttara Kannada	Honnavar	753.3
24	Uttara Kannada	Karwar	742.6
25	Uttara Kannada	Kumta	590.2
26	Uttara Kannada	Siddapura	862.2
27	Uttara Kannada	Sirsi	1322.4
28	Uttara Kannada	Supa	1905.7
29	Uttara Kannada	Yellapura	1318.3

2.2 Landslide Causes

There are three primary categories of causes of landslides: geological, morphological and human-caused. Sometimes, landslides are caused, or made worse, by a combination of the three factors. As per the detailed geo parametric study in Karnataka by KSNDMC & GSI, it is learnt that geo-scientific causes of most of the landslide, here are some general causes which acts as triggering factors of the landslides in Karnataka.

i. High intensity/prolonged Rainfall
ii. Modification of Natural Slopes
iii. Blockage of Natural Drainage
iv. Clean water flow in force from inside the slope
v. Water Tanks / Ponds in Coffee Estates
vi. Flash flood due to temporary dam formation in nala
vii. Geological Causes (Geological Lineaments / structures)

2.3 Landslide Susceptible Zones

Since the growth of population and infrastructure in such Himalayan, Northeastern States and Western Ghats/ Konkan areas are enormous in post-independence era, risks to landslide hazards also increase manifold and the losses incurred so far due to landslide hazards are huge. Thus sustainable infrastructure development and practicing the relevant land use zoning regulations strictly by following the prevalent landslide hazard scenarios of these areas are essential to reduce the landslide risks and its cascading effects.

Moreover, due to climate change, behaviour, role and frequencies of the main landslide triggering factor i.e. the monsoon and extreme rainfall events are becoming more erratic and unpredictable nowadays, and thus sustainable developmental planning and its execution on ground must honour strict implementation of land use zoning practices for safer construction of buildings, and infrastructure. The same will not only ensure reduction of landslide risk in the mountainous terrains but also will ameliorate the resilience of people living in such fragile landmass to cope up the ever increasing risks of landslide hazards in India (***Source**: BMTPC*). District wise susceptibility maps are represented from figures 2.4A to 2.4H

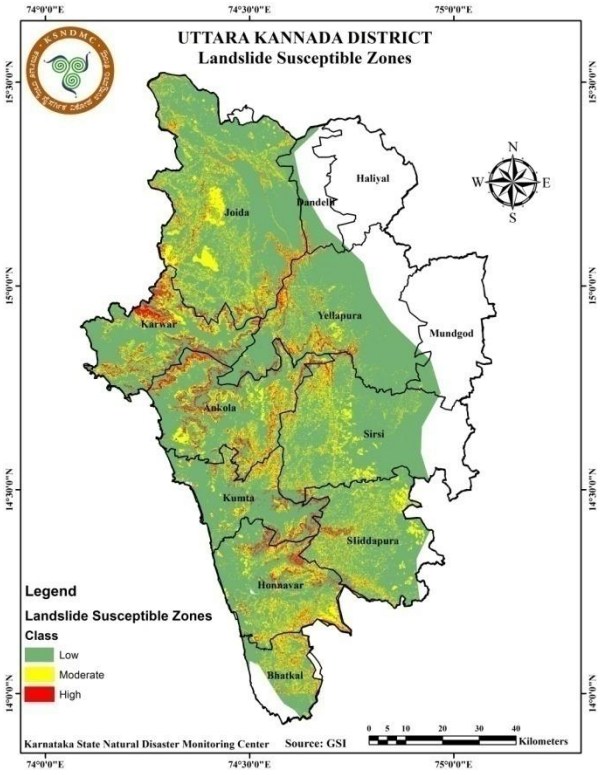

Fig 2.4A: Uttara Kannada

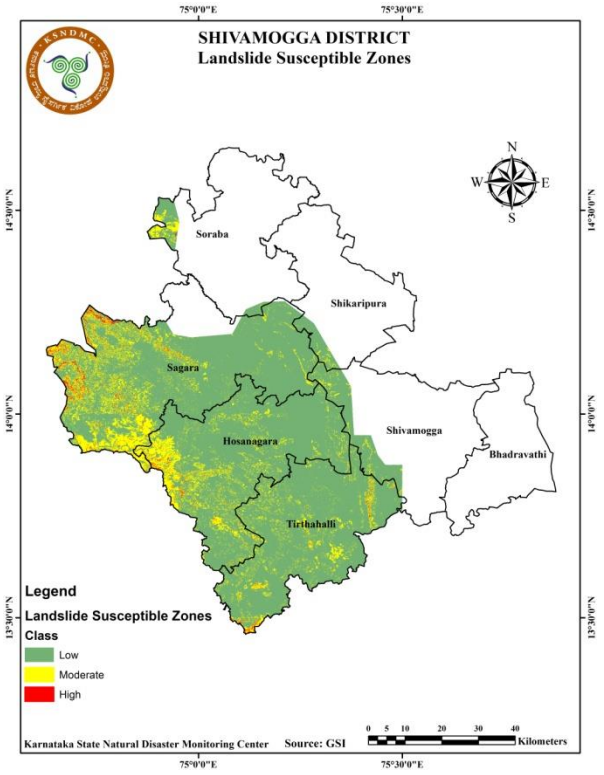

Fig 2.4B: Shivamogga

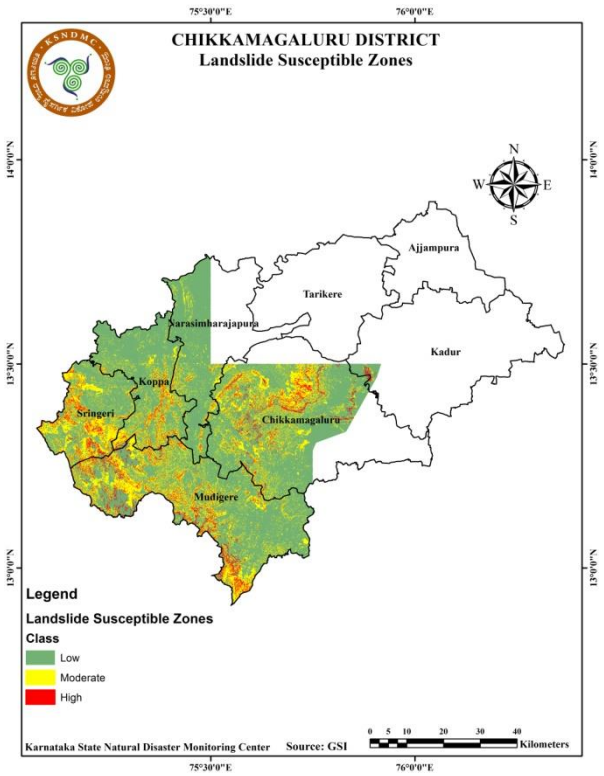

Fig 2.4C: Chikkamagalur

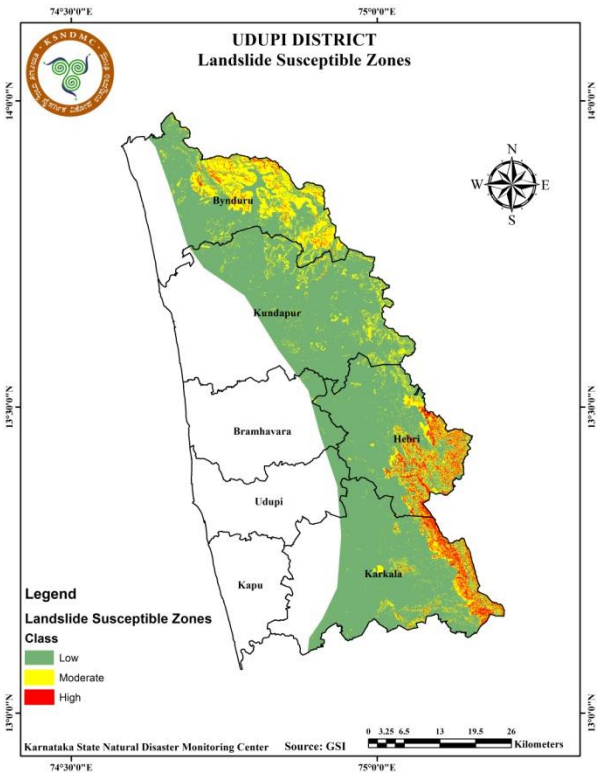

Fig 2.4D: Udupi

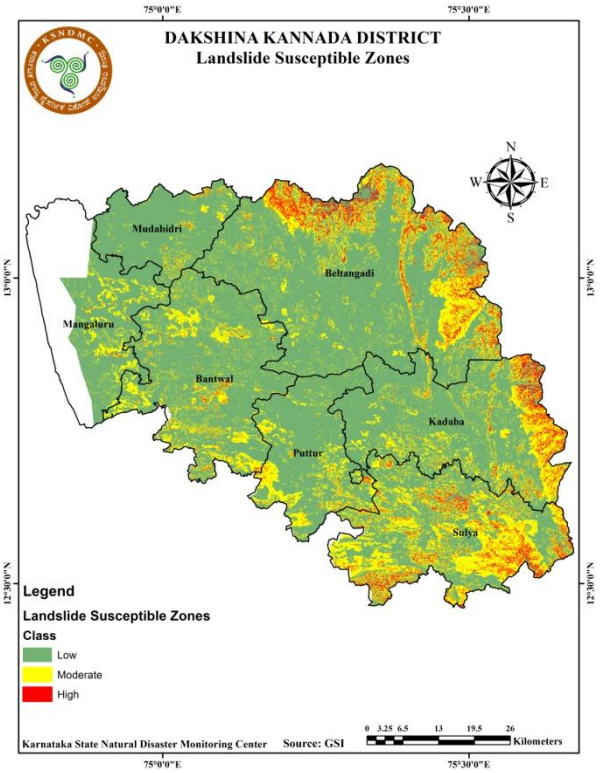

Fig 2.4E: Dakshina Kannada

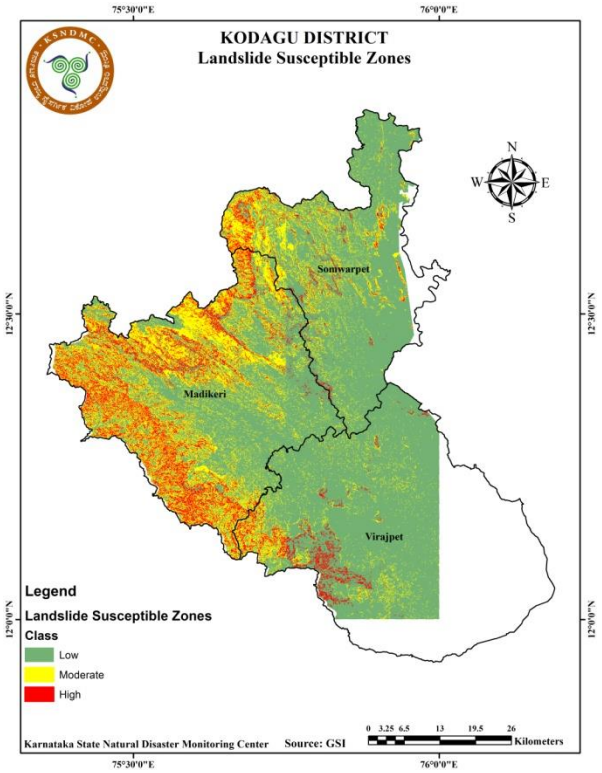

Fig 2.4F: Kodagu

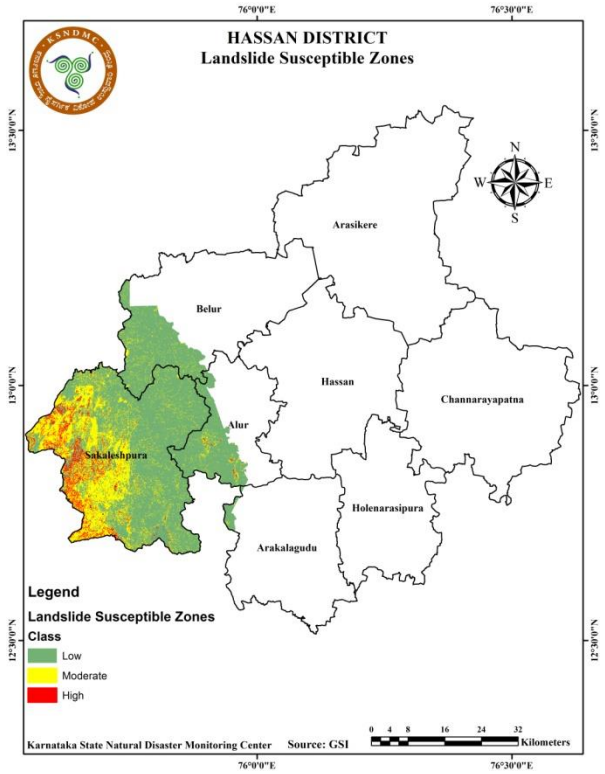

Fig 2.4G: Hassan

2.4 Landslide Vulnerability in Karnataka

Vulnerability is related to the characteristics and circumstances of a community or system, these characteristics and circumstances make community or system susceptible to hazard and cause loss. There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management (UN-ISDR, 2009).

Vulnerability = (Exposure) + (Resistance) + (Resilience)

With: ***Exposure***: at risk property and population;

Resistance: Measures taken to prevent, avoid or reduce loss;

Resilience: Ability to recover prior state or achieve desired post-disaster state.

Karnataka's vulnerability to landslides is seen in the threat of landslides to our housing and infrastructure, farms and fields, and railway lines, and transmission line projects, pilgrim routes, and tourist spots. By considering the landslide incidences locations in the 29 taluks of Karnataka, the following locations are vulnerable to landslides:

i. Previously slided locations are prone to recurrence
ii. Untreated vertical cut slopes in Roads, settlements and nala sections
iii. Land use having slope angle more than 45°
iv. Areas falls under blockage of natural drainage system
v. Temporarily created pond/lake locations on high altitude
vi. Disturbed forest areas
vii. Areas receiving high/prolonged rainfall
viii. Areas falls under uncontrolled Mining activity
ix. Dense network of lineaments

Apart from the above said landslide vulnerable zones following road sections are most vulnerable as the slope cutting having slope 45°:

I. Mudigere (Chikkamagalur) — Beltangadi (D.K) road section, Charmudi Ghat
II. Sakaleshpura — Gundya - Nellyadi road section, Shiradi Ghat
III. Sakaleshpura - Kukke Subramanya road section, Bisile Ghat
IV. Madikeri (Kodagu) - Sulya (D. K) road section
V. Madikeri (Kodagu) - Talacauveri road section
VI. Yellapur - Karwar road Section

Some examples of devastating landslides in the Karnataka include the Kadwad and Kalache landslides in Uttara Kannada district; the Madikeri, Monnanageri, Thora and talacauvery landslides in Kodagu district; Mudigere landslides in Chikkamagalur district; and Gurpur landslide in Dakshina Kannada district.

Table 2.1: Hazard Vulnerability Matrix on Risks of Disasters
(*Disaster Risks and Resilience in India: An Analytical Study 2019***)**

HAZARD MATRIX	VULNERABILITY MATRIX													
	Built Environment			Production System			Vulnerable Socio-economic Conditions					Vulnerable Environment		
	Buildings	Social Infrastructure	Physical Infrastructure	Agriculture	Livestock	Industries	Poverty	Women	Children	Disabled	Elderly	Forest Cover	Mangrove Cover	Water Stress
Landslide	√	√	√	√	√	√	√	√	√	√	√	√		

√ denotes the vulnerabilities in horizontal matrix that are relevant to the hazards in vertical matrix

2.5 Landslide Impacts in Karnataka

Landslide disasters have both short-term and long-term impact on society and the environment. The short-term impact accounts for loss of life and property at the site and the long-term impact includes changes in the landscape that can be permanent, including the loss

of cultivable land and the environmental impact in terms of erosion and soil loss, population shift and relocation of populations and establishments.

Like in any other disaster, the most affected are the socio-economically weaker sections of the society who inhabit the vulnerable areas. They have meager sources of livelihood, which when wiped out by a hazard, leaves them without any food or shelter. Apart from this, the injuries and casualties suffered add to the woes of the affected families. The biggest loss is that of private and government property, as well as damage to/destruction of infrastructure and heritage structures.

Photo 1: Madikeri - Somwarpet road during 2018

Photo 2: Ranipet, Madikeri Taluk, Kodagu District during 2018

Photo 3: Madikeri-Mangalore Highway during 2018

Photo 4: Madikeri-Somawarapet Highway during 2018

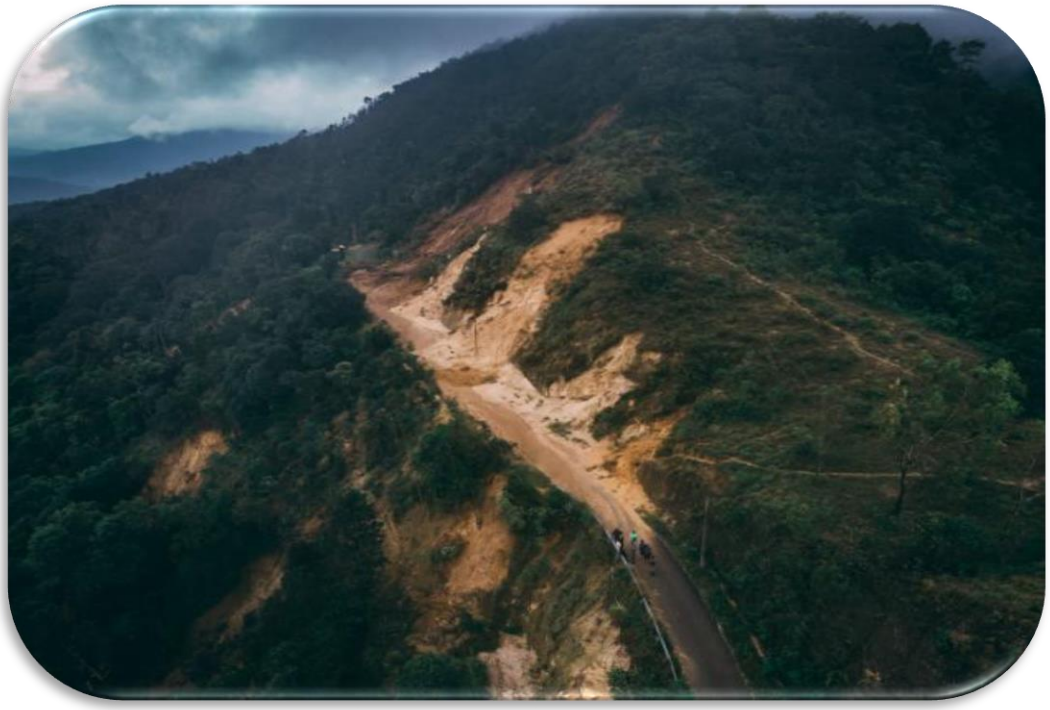

Photo 5: Mudigere Taluk, Chikmagalur during 2019

Photo 6: Channahodlu-Ukkada road, Chikmagalur during 2019

Photo 7: Landslide in Arabail-Ramanagar Road during 2021

Photo 8: Kalache GP, Yellapura, Uttara Kannada district during 2021

CHAPTER 3

MONITORING, FORECAST, WARNING AND DISSEMINATION MECHANISM

3.1 Monitoring Mechanism of landslides

Monitoring is an important component of landslide investigation/studies that includes the measurement and analysis of landslide dynamics as well as changes in the factors that cause landslides. It is also necessary some times to undertake post-stabilisation monitoring of a landslide to evaluate the efficacy of the remedial measures implemented. Most landslide monitoring programmes include real-time, continuous (or at relatively close intervals) measurement of the temporal and spatial variability of mass movements at and beneath the surface, micro-topography, soil moisture, ground water levels, and precipitation. Typically, these measurements are collected at a central data recording and transmission point on the site. This data is often used in landslide warning systems in high-risk areas.

Landslide monitoring is generally not practiced in our country. Considering the incidence of a huge number of landslides in the Himalayas, NER, Western Ghats and Nilgiri hills in South India, it is not possible to undertake monitoring of each individual landslide. Therefore, a few landslides will be identified for monitoring and early warning.

Karnataka State Natural Disaster Monitoring Center (KSNDMC) in association with Geological Survey of India (GSI), Govt of India is working towards establishment of landslide monitoring instruments in selected high-risk areas. Monitoring of landslides can be both surface and subsurface. Surface measurement used to assess stability of slope may include raingauge and crack & joint meters, etc. Subsurface deformation measurements viz., inclinometer, piezometer and fixed borehole extensometers are required if sliding occurs and depth of sliding is not apparent from surface measurements and visual observations.

3.1.1 Landslide monitoring by Telemetric Rain Gauge stations:

In Karnataka most of the landslides are triggered by Rainfall and rainfall monitoring in small scale is a prerequisite to develop rainfall warning in Coastal and malnad regions f Karnataka. At present, Karnataka State Natural Disaster Monitoring Centre (KSNDMC) has set up a dense network of rainfall monitoring stations by installing about 6500 Telemetric Rain

Gauge (TRG) stations and 923 Telemetric Weather Stations (TWS) which are recording surface meteorological parameters and rainfall at every 15 min (96 data points / stations / day). The near-real time data is being processed, analysed, converted into information and advisories, reports are being disseminated to the end users. It shows good pattern of rainfall variability in Karnataka which will help in prioritizing the decision making and field level management.

Besides, the data is used for generating Grampanchayath level weather forecast for Karnataka which is first of its kind in the country. The data, information and advisories are being utilized for Agriculture, Horticulture, Watershed Management, Disaster Management and other services.

Fig 3.1: Telemetric Rain Gauge (TRG)

Fig 3.2: Telemetric Weather Monitoring Station

Figure 3.3: Telemetric Rain Gauges

Figure 3.4: Telemetric Weather Stations

3.2 Weather Forecast System

Early warning thresholds for well-studied seasonal (repetitive) rain-induced landslides on discrete boundary shears with known pore pressure variations on the landslide boundaries are the most reliable. Since the inter-relationship between rainfall intensity, slope surface and sub-slope movements, and pore pressures provide a powerful means for reliable landslide forecasting, studies regarding this will be encouraged. Rainfall and the associated slope behavioral information will be utilized for developing indicators for landslide alerts, especially for high landslide hazard areas known to succumb to cloudbursts and high intensity short duration rainfall. In cases where no such information is available, a warning of a general nature and low reliability may still be possible through the study of rainfall records in the backdrop of the previous landslide history.

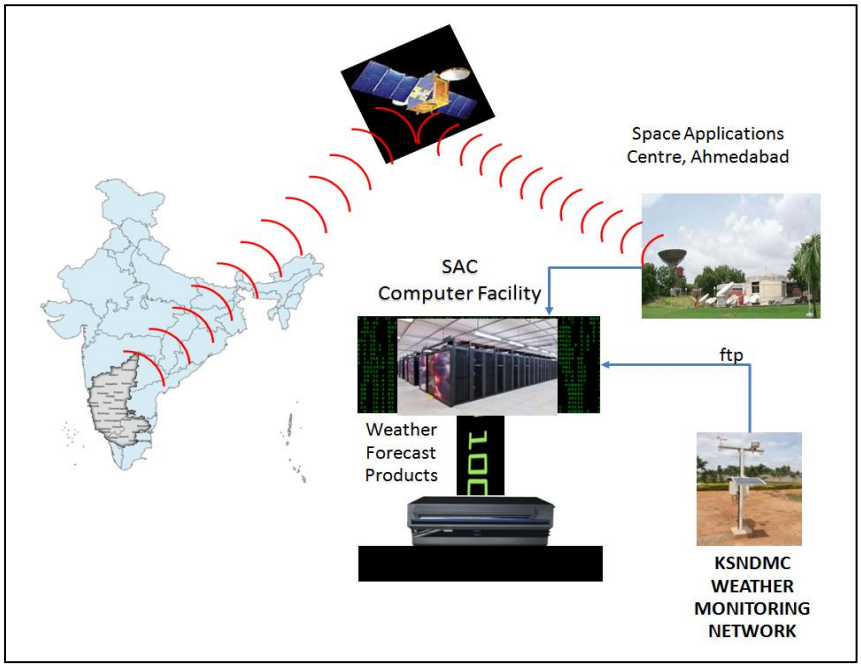

Fig 3.5: Gramapanchayath level Weather Forecast

Weather Forecast at high Spatial & Temporal Resolution is a pre-requisite for planning and executing Risk reduction program with respect to Hydro-Meteorological Disasters. KSNDMC has been collaborating with Space Application Centre, Ahmadabad and providing Gramapanchayath level Rainfall& Weather forecast at 12, 24, 36, 48, 60 and 72 hrs formats for Karnataka. The observational 15 minutes data collected through KSNDMC's Weather Stations Network is ingested into the SAC model. The Initiative, first of its kind in the Country, is appreciated by the farmers. Equal Spatial Resolution of Weather Forecast & Monitoring Network is a unique feature and advantageous for validating the Weather Forecast. The Observational data is used to validate the Weather Forecast and the result is incorporated in the Model to improve the output dynamically. This forecasted information will be effectively used for evacuate community during severe weather instances in terms of intensity, time, and geographical span.

3.3 Rainfall Early Warning System

Early warning information are standardised messages (signs, words, sound or images) that announce an imminent danger, e.g. from natural hazards. Heavy rain early warning information is dealing with the eponymous natural hazard “heavy rain”. Information is provided by KSNDMC

for regional scale. Forecasting for early warnings and subsequent actions requires reliable knowledge of hazard forecast at appropriate spatial and temporal scales and sufficient lead-times. Rainfall warning will be automatically developed using software's if the rainfall is crossed the threshold values.

Fig 3.6: Rainfall Early Warning System

3.4 Dissemination and Communication

Dissemination and communication mechanisms, as far as early warning systems are concerned, must be operational, robust, and available round the clock. These should be designed to the meet the needs of a wide range of different threats and different user communities. Information Dissemination plays an important role in Disaster Risk Reduction. KSNDMC has employed various Systems for Disseminating Disaster related Information, Alerts & Advisories at Real Time to the Government Executives & Communities. Based on the prevailing conditions and the Weather Forecast, Customised Alerts & Early Warnings are being generated and disseminated to the Communities at Risk through SMS, e-mail, print media, electronic media, dynamic web portal, and social media. Interactive facility is enabling the Farmers and public to get first hand Information with clarity within 2 minutes. Information & Advisories are available in simple terms in regional language for their Gramapanchayath whenever THEY NEED.

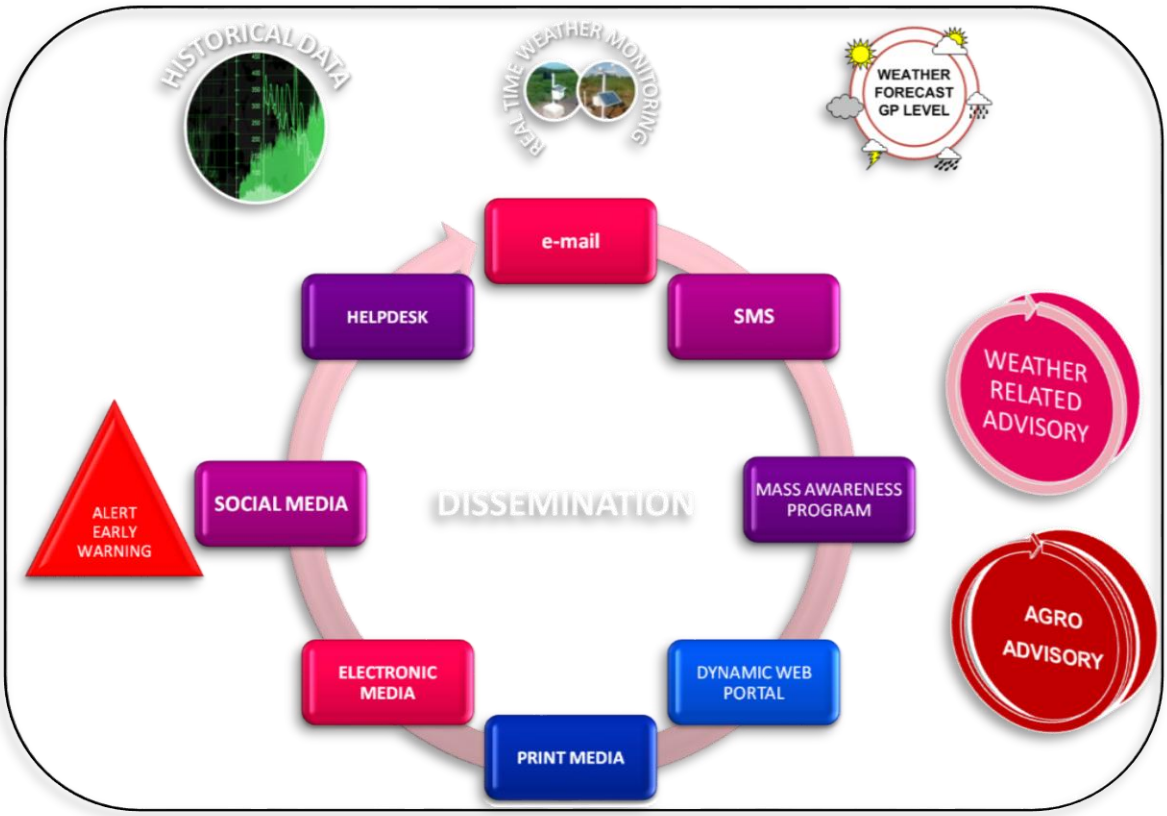

Figure 3.7: Information Dissemination Mechanism of KSNDMC

CHAPTER 4

NEED FOR LANDSLIDE ACTION PLAN

4.1 Principles for preparing Action Plan

A "Disaster" is defined under section 2 (d) of the Disaster Management Act, 2005 as a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, and is of such a nature or magnitude as to be beyond the coping capacity of the affected area. The purpose of this landslide action plan is to identify emergencies that could threaten the society and to plan for an expedited, effective response to mitigate in the landslide event of a potentially hazardous situation. The procedure is to protect lives and prevent property damage from landslides. Improved urban land-use planning (LUP) and the implementation of landslide disaster risk reduction (LRR) measures are demanded for the exposed families. In any case, hazard–vulnerability combinations affect risk.

"Disaster Management" has been defined under section 2 (e) of the "Disaster Management Act, 2005" as a continuous and integrated process of planning, organizing, coordinating and implementing measures which are necessary or expedient for

a) Prevention of danger or threat of any disaster
b) Mitigation or reduction of risk of any disaster or its severity or consequences
c) Capacity building
d) Preparedness to deal with any disaster
e) Prompt response to any threatening disaster situation or disaster
f) Assessing the severity or magnitude of effects of any disaster
g) Evacuation, rescue and relief and
h) Rehabilitation and reconstruction (Recovery)

Karnataka State also one of the State which is frequently affecting by landslides during the last four consecutive years with varying intensity and frequency. There is an urgent need to devise a State level strategy and plan to reduce the adverse effects of these disasters. Therefore, with the support of NDMA guidelines, the present action plan has been brought out to mitigate and

take measures for preparedness with active participation from all line departments and stakeholders.

4.2 Objectives

Major objectives to prepare landslide action plan in coastal and Malnad districts of Karnataka are as follows:

i. Reduced losses from landslides.
ii. Policies to encourage landslide hazard mitigation through government agencies with the involvement of communities.
iii. Establishment of a well-coordinated landslide emergency response mechanism.
iv. Real-time monitoring of critically hazardous rainfall induced landslides.
v. Greater public awareness about landslide hazards and methodologies for mitigating losses.
vi. Preparation of training materials for geologists, geo-technicians, engineers, administrators, and planners.
vii. Curricula and training material for public awareness on landslide hazards.

4.3 Action Plans:

Action plan can be divided into short term, medium term and long term plans as follows:

Recurring/regular activities:

a) Identification of landslide vulnerable locations on priority basis.
b) Implementing evacuation procedures before the cyclone/ severe rainfall period
c) Multiple medium of communication (in Kannada) like Television, Radio, Newspapers and social media.
d) Identify and reduce awareness gap by disseminating information using pamphlet, hoardings, LED displays on advertisement boards.

Short Term:

a) Rainfall monitoring in local scale, forecast, advisories, alert issue and warnings

b) Preparation of alternate evacuation route map, alternate transportation route map and is easily available to general public

c) Monitoring of abrupt topographical changes in landuse (Surface cracks, Forest, Agricultural land, roads, construction of houses & industries etc..) on local scale.

d) Preparation of District level landslide action plan for its effective implementation.

Medium Term:

a) Regular meetings of the different stakeholders/departments should be organized at state/district level for sharing of information, developing strategies for relief operations.

Long Term:

a) Preparation of route map and alternate route map for rescue purpose.

b) Installation of sign boards for rockfall/debris flow/slide locations

c) Construction of buildings and infrastructures based on Engineering and design practices.

d) Preparedness for Emergency relief (shelter, food, clothing, sanitation etc.)

e) Regular meetings of the different stakeholders/departments should be organized at state/district level for sharing of information, developing strategies for relief operations.

f) Evaluation of Geotechnical and geological studies (Soil, rock, building and infrastructures etc) to distinguish the slopes on stability basis.

g) Integrating flood vulnerable locations and adaptation efforts in LAP.

h) Yearly improvisation of landslide action plan through response and feedback data collection.

i) Building retaining walls in areas that are prone to landslides.

4.4 Evaluating and Updating the Plan

The approach towards landslide incidences must be flexible and iterative to determine whether the strategies to deal with them are effective and have no unintended negative consequences. After every monsoon season, the State must assess the efficacy of its Action Plan, Including the processes, outcomes and impacts. Stakeholders should then identify gaps and make

improvements for the next season. The plan should be updated annually with name, designation, contact details, etc., of key officials and concerned department/stakeholders should be made aware of these changes.

4.5 Landslide Emergency Kit

Stocking up on food, water, and other preparedness items is necessary for any disaster but when thinking about landslides, I think it's especially beneficial for those who live in landslide-prone regions with limited options for obtaining supplies.

Some of the supplies recommended are the following:

- **Water and a method of purification:** Make sure to store enough clean water that can sustain you for the first 3 days and longer, if possible. Consider getting purification tablets or another method of purification. Since landslides can cause damage to water and sewage pipes, should expect drinking water source to be contaminated. Do not drink from the tap unless local authorities say it's safe to do so.
- **Long-term food storage:** Food is also essential for survival, but calories alone are not sufficient also eat nutritious calories.
- **A method of cooking:** A stove and fuel kit like this one is ideal because it can be used indoors and outdoors since it does not release toxic fumes.
- **Plastic ware:** Including plates, cups, utensils, and several black trash bags for easy disposal.
- **An evacuation or bug out kit:** Include all the essentials that you need to survive for at least 3 days.
- **A whistle:** You will need it in case you're trapped and/or need to signal for help.
- **A radio:** Preferably a Weather Radio. You can also download the Weather App on your phone
- **A toilet and sanitation kit:** Since the power lines and plumbing system may be disrupted, you should consider an alternative to flushing your toilet.
- **A complete first aid kit:** Since medical assistance may not be able to get to everyone immediately, make sure you have the basic supplies to take care of at least minor

wounds. Remember that disruption to the city's infrastructure is possible, so consider getting extra prescription medication in the event that pharmacies don't get their regular deliveries of meds.

- **Important documents:** Keeping a digital copy of each of your documents on the Cloud is highly recommended because you don't have the guarantee that you'll be able to recover them from your home or take them with you at a moment's notice.

CHAPTER 5

PREVENTION, MITIGATION AND PREPAREDNESS MEASURES

5.1 Landslide hazard Management in Karnataka

Landslide hazard management in Karnataka had till now been confined to ad-hoc solutions of site specific problems and the implementation of immediate remedial measures including debris removal, and dumping of this debris either down slope or into a river. The aim of these Guidelines is to manage landslide hazard through an institutional mechanism, by following a systematic approach that includes both short-term and long-term planning after a study of the hazard, vulnerability and risk assessment.

Landslide hazard management involves measures taken to avoid or mitigate the risk posed by landslide hazards. The most important role in this process is played by the local government machinery. Once information is received about the probability of landslide occurrence within its jurisdiction, it initiates steps to warn the communities living in the area about the risk involved and tries to convince landowners/ dwellers to shift to safer places. Moreover, further development is avoided in such high risk zones. Mitigation strategies might not be possible in every landslide hazard prone area both due their high cost and the indifferent attitude of the public. Efforts to reduce risk are also made by road construction and maintenance agencies by implementing required treatment measures. There is, however, a need to pre-empt disaster by making adequate information available in advance before it strikes, something that is emphasised in these Guidelines which are to be used by all states, especially those affected by multi-hazards.

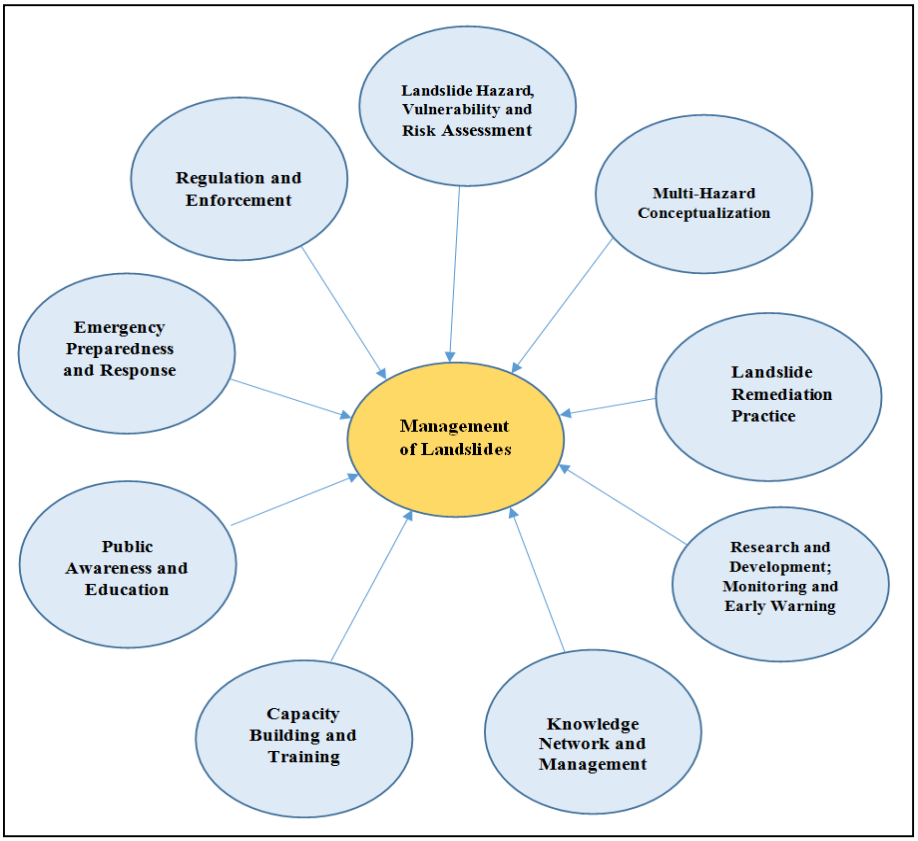

Figure 5.1: The Components of the Landslide Disaster Management Process

5.2 Prevention by Earth Slope Stabilization

Some of the stabilization techniques that are currently available in North America are illustrated in this discussion. We highlight simple methods that can be used safely in the absence of detailed soil or bedrock analysis or in low-risk situations. Some stabilization methods are very expensive and require significant time to implement. This is an overview of stabilization methods; many other methods are in use around the world. Professional advice is essential before, during, and after implementation (where possible), as is further literature consultation.

The stability of any slope will be improved if certain actions are carried out. To be effective, first one must identify the most important controlling process that is affecting the stability of the slope; second, one must determine the appropriate technique to be sufficiently applied to reduce the influence of that process. The mitigative prescription must be designed to fit the condition of the specific slope under study. For example, installation of drainage pipes into a

slope that has very little ground water is pointless. Slope stabilization efforts take place during construction or when stability problems develop unexpectedly following construction. Most slope engineering techniques require a detailed analysis of soil properties and a sound knowledge of the underlying soil and rock mechanics.

In any high-risk situation, where a landslide may endanger lives or adversely affect property, a professional landslide expert such as a geotechnical or civil engineer should always be consulted before any stabilizing work is undertaken.

The following sections provide a general introduction to techniques that can be used to increase slope stability.

5.2.1 Excavation

Figures 5.2, 5.3, and 5.4 provide a cross-sectional view, in schematic form, of general principles for slope excavation, showing the effects and consequences of where on a slope the excavation takes place. These graphics are general in nature, and a geotechnical engineer or other professional should always be a consulted if possible.

Removal of soil from the head of a slide

This method reduces the driving force and thereby improves stability. This method is suitable only for cuts into deep soil where rotational landslides (see "Basic Landslide Types" in Section I) may occur. It is ineffective on translational failures on long, uniform or planar slopes or on flow-type landslides.

Reducing the height of the slope

Reducing the height of a cut bank reduces the driving force on the failure plane by reducing the weight of the soil mass and commonly involves the creation of an access road above the main road and the forming of a lower slope by excavation. Also, it is possible to excavate deeply and lower the main road surface if the right-of-way crosses the upper part of a landslide. This method is only moderately efficient in increasing stability, and a complete solution may involve additional modification of the land. According to Chatwin (Reference 11), it usually increases the Factor of Safety by only 10 or 15 percent. ("Factor of Safety" in its simple definition is the

ratio of the maximum strength of a piece of material or a part to the probable maximum load to be applied to it.)

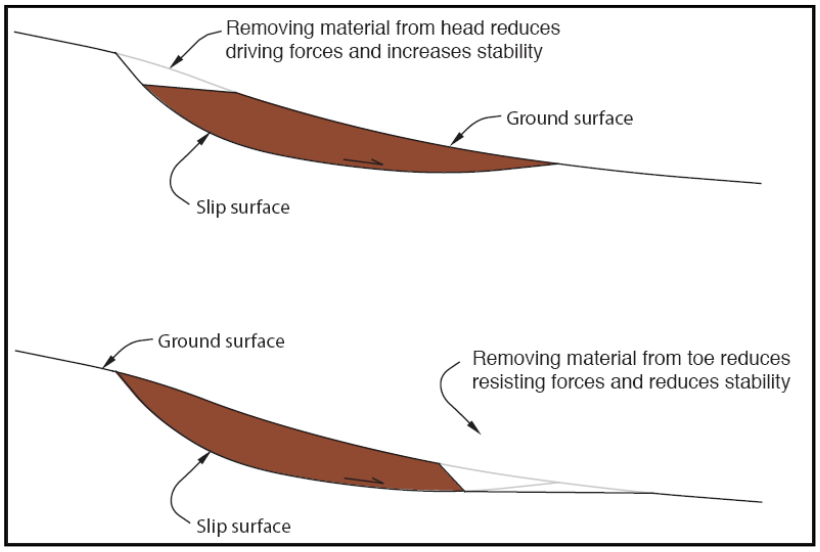

Figure 5.2: Illustration of the differences in stability resulting in excavation at the head and toe surfaces of a slope. (Graphic by Rex Baum, U.S. Geological Survey)

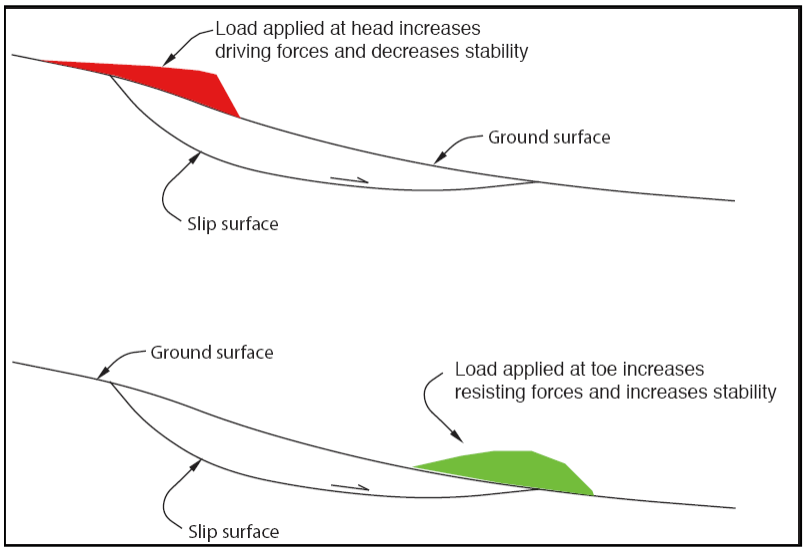

Figure 5.3: Illustration of the difference in stability of loading either the head or the toe of a slope. (Graphic by Rex Baum, U.S. Geological Survey)

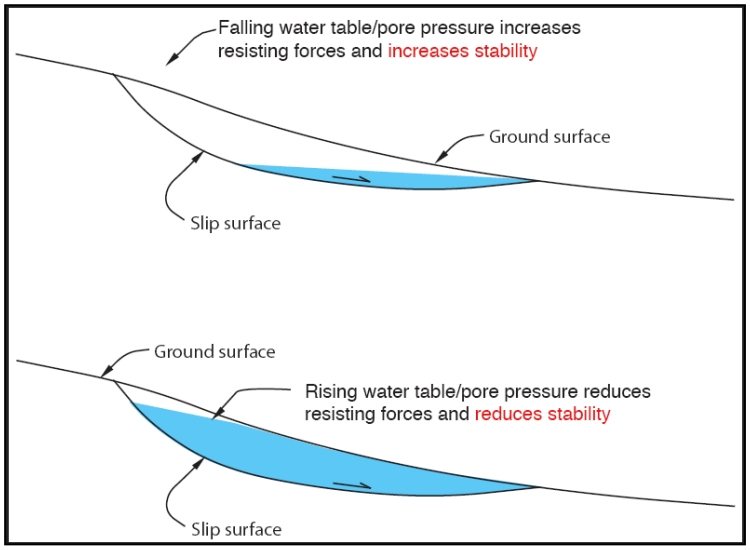

Figure 5.4: Illustration of the importance of water in the stability of a slope. (Graphic by Rex Baum, U.S. Geological Survey)

Backfilling with lightweight material

A technique related to height reduction is to excavate the upper soil and replace it with a lightweight backfill material such as woodchips or logging slash. Then, covered with a thin layer of coarse aggregate, the backfilled material can form a foundation for limited-use traffic (fig. 5.5).

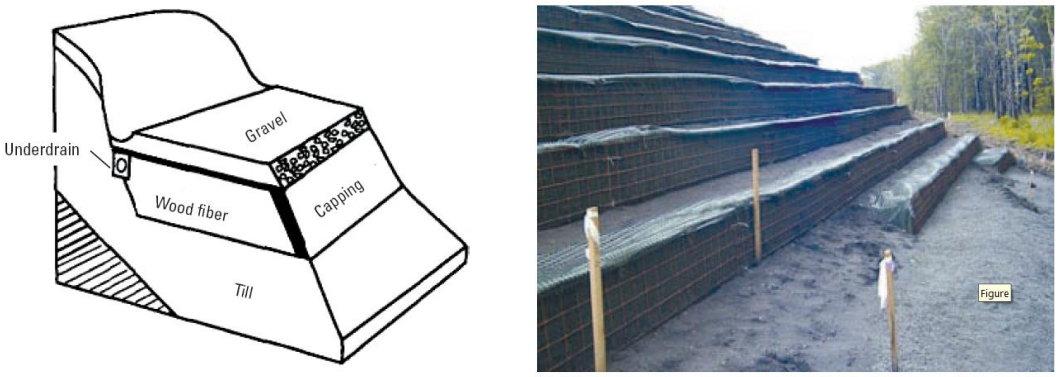

Figure 5.5: Schematic and photograph of a lightweight backfill.

Benches

Benches are a series of “steps” cut into a deep soil or rock face for the purpose of reducing the driving forces. They are mainly effective in reducing the incidence of shallow failures but generally are not very efficient in improving the overall slope stability for which other methods

are recommended. Benches are useful in providing protection structures beneath rockfall-prone cliffs, for controlling surface drainage, or for providing a work area for installing drainpipe or other structures (Fig 5.6).

Figure 5.6: Straw bales have a similar application and are widely available. Individual bale size can be seen in the pile of bales, right center of photograph.

5.2.2 Strengthening of Slopes

Plastic mesh reinforcement

There are numerous synthetic soil reinforcement materials on the market, and one example is a reinforcement material of plastic polymer stretched to form a lightweight, high-tensile-strength grid. The grid acts similarly to reinforcing mesh in concrete, adding strength to the shear strength of the soil.

These types of materials have been used to reduce the amount of ballast needed over soft ground by increasing the bearing capacity of the subsoil. These types of grids also have a number of possible applications in slope stabilization, including soil strength reinforcement, soil drainage improvement, and retaining-wall construction.

Rock-fill buttresses

A simple method to increase slope stability is to increase the weight of the material at the toe, which creates a counterforce that resists failure (fig. 5.7). A berm or buttress of earthfill can be easily dumped onto the toe of a slope. Broken rock or riprap instead of soil is preferable,

however, because it has a greater frictional resistance to shear forces and is also free draining, which reduces the problem of impeding ground-water flow.

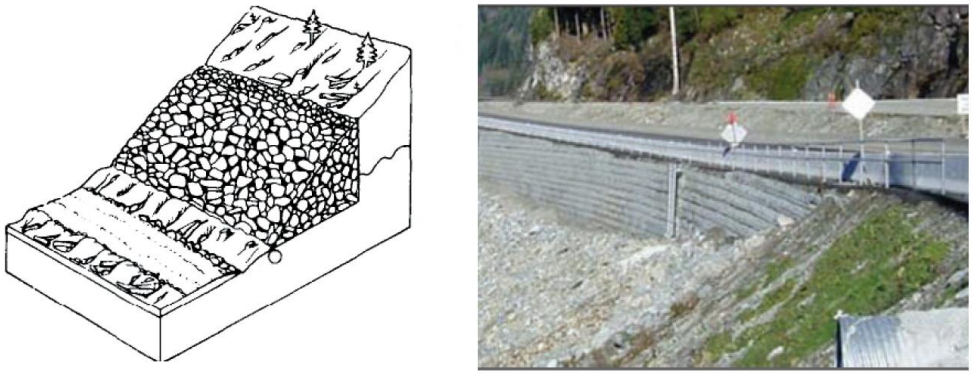

Figure 5.7: Schematic and photograph of a rock fill buttress

Stream channel linings

Channel linings are another way of stabilizing a stream or creek channel and the sides of the stream or creek. The lining is usually slush grouted with high-quality concrete, preferably reinforced by steel fiber mat to resist abrasion. Protruding boulders are set in the concrete to dissipate the energy of water flow.

Channel linings can reduce the incidence and volume of debris flows (fig. 5.8). They are also effective in maintaining channel alignment upstream from a bridge and for protecting the abutments. Channel linings are most effective if applied over the entire reach of an unstable channel. Linings are usually much less costly than, for example, check dams, especially if a long reach is to be stabilized. Check dams are preferable, however, if the banks are very unstable because a dam can be keyed into the bank, providing toe support and thereby enhancing stability.

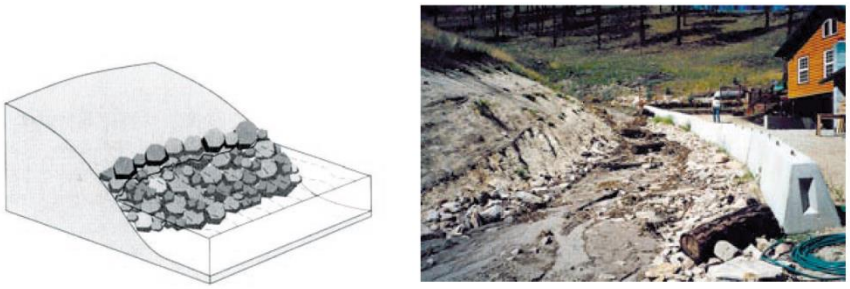

Figure 5.8: Example of creek channel lining using rock

5.2.3 Drainage Techniques

Ground water probably is the most important single contributor to landslide initiation. Not surprisingly, therefore, adequate drainage of water is the most important element of a slope stabilization scheme, for both existing and potential landslides. Drainage is effective because it increases the stability of the soil and reduces the weight of the sliding mass. Drainage can be either surface or subsurface. Surface drainage measures require minimal design and costs and have substantial stability benefits. They are recommended on any potential or existing slide.

The two objectives of surface drainage are to prevent erosion of the face, reducing the potential for surface slumping, and to prevent infiltration of water into the soil, thereby reducing ground-water pressures. Subsurface drainage also is effective but can be relatively expensive. It is therefore essential that ground water be identified as a cause of the slide before subsurface methods are used. The various methods of drainage include the following:

Site leveling

Smoothing the topography of the slide surface can prevent surface water from ponding or connecting with the ground water. Any depressions on the slope that might retain standing water must be removed. Infilling and sealing large cracks in the soil surface by grading the soil mass are beneficial and prevent surface water from reaching the failure plane.

Ditches and drains

Surface drainage can be through either surface ditches or shallow subsurface drains (fig. 5.9). Surface drainage is especially important at the head of the slide, where a system of cutoff ditches that cross the headwall of the slide, and lateral drains to lead runoff around the edge of the slide are effective. Ditch gradient should be at least 2 percent, to ensure rapid flow away from the unstable area.

The simplest type of subsurface drain is the lateral trench constructed above an unstable slope. Drainage trenches are economical only for shallow soils overlying bedrock or hard impermeable till. The trenches should be excavated to the base of the shallow soil to intercept any ground-water flow along the failure plane. They are backfilled with coarse gravel to prevent sloughing of the ditch sidewalls. An improvement is to use drainpipe and then backfill the area with coarse gravel.

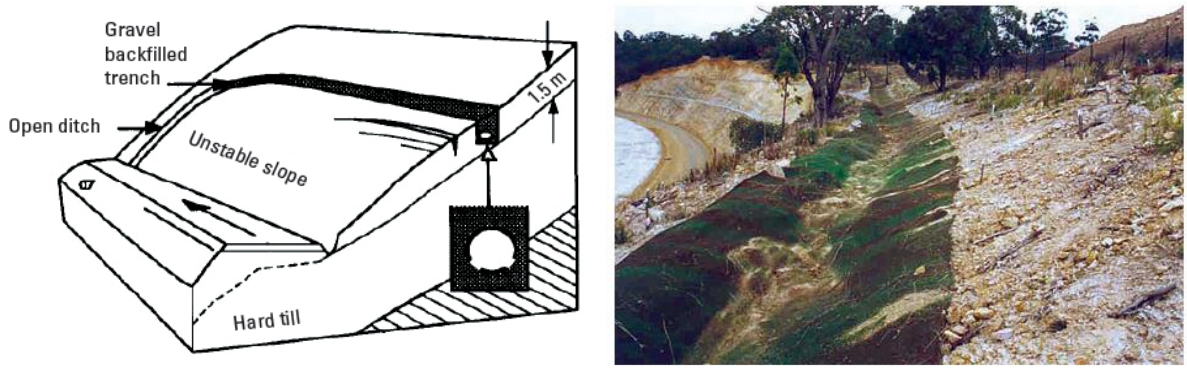

Figure 5.9: Schematic and photograph of a drain trench.

Drainpipes

Horizontal drainpipe is a widely used device for landslide prevention in highway construction (fig. 5.10). It is most effective when installed during initial excavation. Because of the long lag times to lower ground-water tables, the drains are effective only if the pipe is carefully installed, the failure surface is intersected, and the pipe actually drains the soil. As most slopes have varying soil and hydraulic and geometric conditions, drainage systems must be individually designed. After drilling has been carried out to the desired depth and the casing installed, the latter is cleared of soil, and sections of slotted PVC drainpipe are covered with filter cloth, then pushed into the casing and coupled together. The casing is then withdrawn and screen is installed over the end of the drain. Drain holes must be thoroughly cleaned of drill cuttings and mud. Uncleaned holes may be only 25 percent effective.

In clay soils, the full change in ground-water tables can take up to 5 years, with 50 percent of the improvement taking place in the first year. Once water tables are lowered in clay soils, the change is fairly permanent; however, seasonal fluctuations can occur: rainfall will not alter the ground-water level in the slope provided the drains do not clog. In sandy soils, the ground-water table will lower within a few months but will also fluctuate with rainfall.

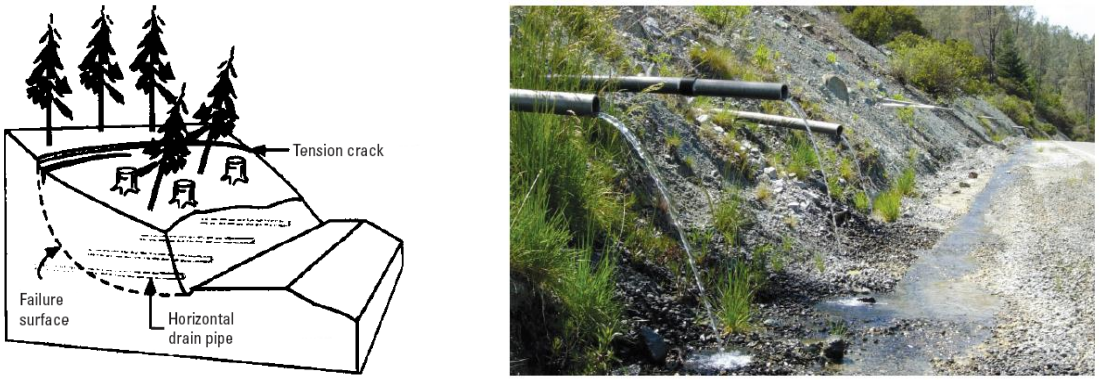

Figure 5.10: Schematic of drainpipes.

Retaining Walls

For all types of retaining walls, adequate drainage through the structure is essential because very high ground-water pressure can build up behind any retaining wall, leading to its failure. Drainage can be provided simply with a coarse backfill and foundation material.

Reinforced earth wall

Reinforced Earth is a patented system for constructing fills at very steep to vertical angles without the use of supporting structures at the face of the fill (fig. 5.11). The system uses horizontal layers of flexible metal strips within the fill to form a composite earth-metal system with high strength.

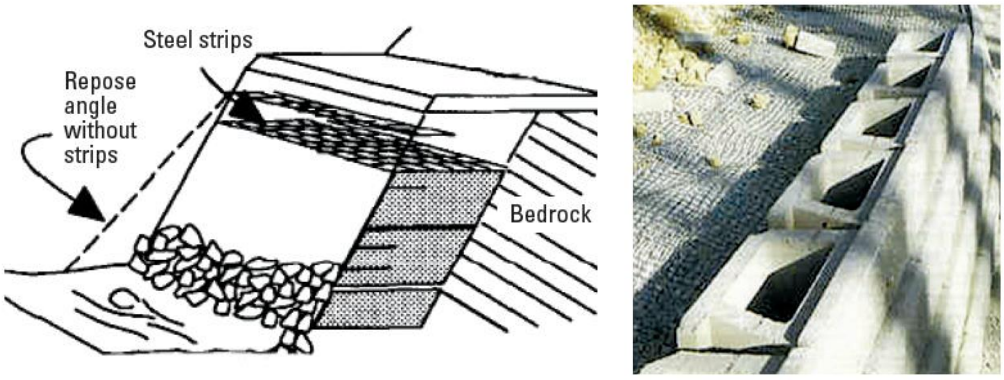

Figure 5.11: Schematic and photograph of a reinforced earth wall.

Gabion walls

Gabions are wire mesh, boxlike containers filled with cobble-sized rock that are 10 to 20 centimeters (4 to 8 inches) size (fig. 5.12). A gabion retaining wall can also be constructed from stacked gabions. Gabion walls usually are inexpensive and are simple and quick to construct. Due to their flexibility, they can withstand foundation movement, and they do not require elaborate foundation preparation. Because of their coarse fill, they are very permeable and thus provide excellent drainage.

Gabion walls work because the friction between the individual gabion rows is very high, as is the friction between the basal row and the soil underneath. When failure occurs, it is almost always in the foundation soil itself. Three-tiered walls up to 2.5 meters (8 feet) high can usually be constructed without consulting any detailed engineering analysis. Higher walls are very heavy by nature of their added bulk and need larger base foundations and possibly counterforts for bracing of the wall. (A counterfort is a buttress bonded to the rear of walls, designed to improve stability.) Gabion walls built on clay soils require counterforts, which can be constructed as gabion headers extending from the front of the wall to beyond the slip circle. The counterforts serve as both structural components and as drains.

Design charts are available for various combinations of hillslope angle and retaining-wall height.

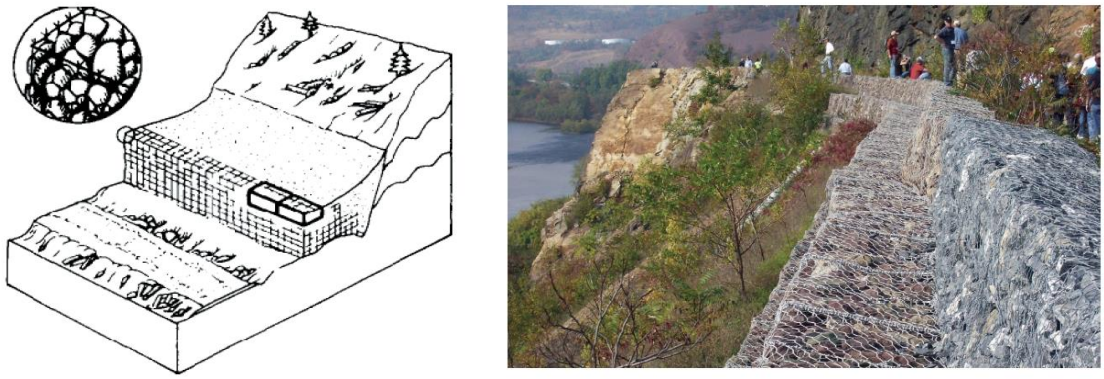

Figure 5.12: Schematic and photograph of a gabion wall along a highway.

Piles

Large-diameter piles can be placed into the toe of a slope to form a closely spaced vertical pile wall (fig. 5.13). Pile walls are normally used as a preexcavation restraint system—the cut slope excavation takes place in front. Whereas large-diameter concrete pile and culvert pile walls

have been used successfully on highways, wood or steel piles that are small in diameter have not. For most earth or rock movement, wood piles are not adequate to provide enough shearing resistance. They are suitable only where the volume of soil to be stabilized is small. On average, one wood pile is necessary for every 50 cubic meters (65.3 cubic yards) of soil, which is not sufficient for large stabilization projects. Too few piles can result in toppling and (or) breakage by the moving mass of soil, as well as by soil movement between the piles.

A major limitation when log piles are used is depth, as many failure surfaces lie below the height of the piles. Wood piles are the best for shallow soil failures over deeper stable soils. The piles should extend well below the potential failure surface and be firmly driven into firm subsoil. If the depth of placement is not sufficient to allow the piles to act as a cantilever system, then the piles must be tied back with an additional anchor system.

Figure 5.13: A concrete-filled pile wall. Reinforcing mesh has been hung over face of piles, ready for shotcrete spraying.

5.2.4 Slope Stabilization Using Vegetation

Seeding with grasses and legumes reduces surface erosion, which can under certain conditions lead to landslides. Planting with shrubs adds vegetative cover and stronger root systems, which in turn will enhance slope stability. If not controlled, surface erosion and small, shallow slope failures can lead to larger problems that cannot be controlled. Large-scale erosion requires applied engineering technology to correct and control. The terms “bioengineering” and “biotechnical slope protection” refer to the use of vegetation as slope protection to arrest and prevent slope failure and surface erosion.

Planning is required for the successful implementation of a revegetation program. Before undertaking seeding, a person with local experience should be consulted for advice. Local knowledge based on successes and failures of projects is invaluable. Seed application should begin immediately following a disturbance, at a minimum of approximately 6 weeks before periods of drought or damaging frost.

A slope made as stable as possible before seeding will be of benefit in making the slope resistant to future erosion and failure. Controlling surface-water drainage, removing cut-bank overhangs, reducing slope angles, and benching all should be done before seeding begins.

There are two basic types of seeding: dry seeding and hydraulic, also known as hydro seeding:

Dry Seeding

Dry seeding is done with rotary disk and air-blown seeders. These methods are less costly than hydraulic seeding but are limited to rough soil surfaces and gentler slopes. Rotary disk seeders spread seed and fertilizer by centrifugal force. The simplest seeder is the cyclone-type, hand-held seeder. Air-blown seeders use air to blow or shoot seed and fertilizer a distance of 5 to 8 meters (15 to 24 feet). Equipment can be adapted for motorized vehicles.

Hydraulic Seeding, or Hydroseeding This type of seeding is the application of seed in a water slurry that contains fertilizer, soil binder, and (or) mulch. The system requires a mixing tank with mechanical hydraulic agitation and volume pumping capacity. Hydraulic seeding is effective for seeding slopes 1:1 and steeper, where tacking of the seed to the slope is necessary.

Types of seeds

A combination of two to five species is the normal grass-legume mix used for erosion control. Suitability of seeds depends on soil type, climatic conditions, species compatibility, and species replacement. Local conditions will vary, and no universal type of grasses or legumes can be recommended. The types of vegetation can vary from locality to locality, and it is best to get advice from locals who are familiar with local growing conditions.

Mulching

Mulch is a nonliving material spread over the soil surface to provide protection from surface erosion by rain and retention of soil moisture. Various types of mulches will work—straw, grass fibers, wood fibers, seaweed, and paper products.

Figure 5.14: A Vetiver grass system is being used

5.3 Rock Slope Stabilization/Mitigation Techniques

Rockfall can range from a few fist-sized rocks to large cliff sections and boulders which, depending on size and shape, can roll, bounce, and careen down slopes, landing in areas at great distances from the fall lines. Recreation areas such as beaches near cliffs, parks, and open spaces are affected by rockfall, and people are frequently exposed to these hazards. People venturing too near the edges of cliffs and rocky slopes can add pressure to already weak overhangs and cause rockfalls to land on people below or sustain injuries themselves on these collapsing edges. Whether hiking, camping, walking, or working around cliffs or rock faces, people encounter the hazard many times without warning. A variety of engineering techniques can be implemented to help mitigate the effects of rockfalls, and some of these are discussed here. In some cases, more than one type of engineered solution is the best, and a combination of these remediation measures applied to one area of rockfall hazard is shown in figure 5.15.

Figure 5.15: This photograph shows rockfall countermeasures that include mass concrete retaining walls, gabion walls (both wall types are at top of photograph), check fences, boulder treatment, and buttressing.

5.3.1 Safe Catching Techniques

Catch Ditches

Wide catch ditches are effective in containing rockfall, but the ditches must be designed with the cliff geometry taken into account, and it is best to consult a professional about specifications. The bottom of the catchment ditch should be covered with loose earth to prevent falling rock from bouncing or shattering into pieces or shards. If there is not enough space to construct as wide a ditch as is specified, then a combination of smaller ditches with a gabion or rock wall along their downhill edges can be used.

Cable, Mesh, Fencing, and Rock Curtains

Cable lashing and wire nets are simple, low-cost methods for protecting a road or path from rockfall. For large, unstable blocks, strands of metal cable are wrapped around the blocks and anchored to the slope (Fig 5.16).

Figure 5.16: Example of wire mesh placed over a rocky slope to contain the rocks that may come down.

5.3.2 Excavation of Rock

Horizontal benches excavated into a rock face are among the most effective kinds of protection from rockfall. In addition to intercepting rockfall, benches reduce tensional forces in the surface rock and reduce surface erosion rates. They also reduce the rate of occurrence of rockfall. However, they have little or no effect on potential deep-seated rock failure.

5.3.3 Reinforcing Potential Rockfall Areas

Shotcrete and Gunite

Shotcrete and gunite are types of concrete that are applied by air jet directly onto the surface of an unstable rock face. Shotcrete is an all-inclusive term to describe the spraying of concrete or mortar either by a dry- or a wet-mix process. Gunite refers only to the dry-mix process in which the dry cementitious mixture is blown through a hose to the nozzle, where the water is injected immediately before application. This is a rapid and relatively uncomplicated method commonly used to provide surface reinforcement between blocks of rock and also to reduce weathering and surface scaling. Shotcrete contains aggregate up to 2 cm in size and is more

commonly used than gunite, which has smaller aggregate. Both materials can be applied rapidly by air jet so that large areas can be covered in a short time.

5.4 Debris-Flow Mitigation

This section describes some simple mitigation methods for debris-flow hazards for homeowners, businesses, and others. A short section on erosion and fire control is included since erosion, fire, and subsequent debris flows and flooding are interrelated hazards.

Strengthening Slopes for Erosion/Debris Flows

Erosion may cause the steepening and lengthening of gullies and cause the loosening of soil, plant debris, rocks, and boulders, which can intensify the effects of debris flows. Keeping an area free of excess fuel for fires can also help in the mitigation of debris flows, as burned slopes become more vulnerable to the effects of debris-flow initiation and erosion. Loss of vegetation that holds soil in place and physical and chemical changes to the soil that result from intense heat and burning by fires make this soil more prone to debris flows.

5.4.1 Strengthening Slopes for Erosion/Debris Flows

Erosion is a process that must be taken into account when reinforcing an area, and some simple steps can be taken to lessen the effects of erosion. Erosion can sometimes lead to slope failures and drainage problems; trying to prevent it is something a homeowner can do, proactively, before bigger slope-failure problems are encountered. Straw or wood chips are effective in holding the soil in place. They have the further value of increasing the organic content of the soil. Place a covering of chips or straw about one-half centimeter (one-quarter inch) thick as slope and soil conditions indicate. Fertilizer may be added. Work the material into the top few centimeters (or inches) of the soil.

5.4.2 Structures for Mitigating Debris Flows

Debris-flow basins

These catchment basins are commonly built at the base of slopes where debris flows are frequent. They are used especially in areas where the debris must be contained so that soil and

debris are stopped from flowing into sensitive ocean or river shorelines areas or where there are structures at the base of the slope that are vulnerable to debris-flow damage. These basins will eventually fill with the debris-flow deposits and must be emptied periodically or they will overflow. Commonly, large pieces of equipment such as dump trucks and power shovels are needed to empty the debris and carry it away. However, small basins can be emptied manually. They should be designed to be able to contain the maximum flow volumes of an area to prevent overtopping during a flow event.

5.5 Landslide Warning Signs

- 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.
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house.
- Tilting or cracking of concrete floors and foundations.
- Broken water lines and other underground utilities.
- Leaning telephone poles, trees, retaining walls or fences.
- Offset fence lines.
- Sunken or down-dropped road beds.
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content).
- Sudden decrease in creek water levels though rain is still falling or just recently stopped.
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb.
- A faint rumbling sound that increases in volume is noticeable as the landslide nears.
- Unusual sounds, such as trees cracking or boulders knocking together, might indicate moving debris.

5.6 What To Do Before a Landslide

- Do not build near steep slopes, close to mountain edges, near drainage ways, or natural erosion valleys.
- Get a ground assessment of your property.
- Contact local officials, state geological surveys or departments of natural resources, and university departments of geology. Landslides occur where they have before, and in identifiable hazard locations. Ask for information on landslides in your area, specific information on areas vulnerable to landslides, and request a professional referral for a very detailed site analysis of your property, and corrective measures you can take, if necessary.
- Watch the patterns of storm-water drainage near your home, and note the places where runoff water converges, increasing flow in channels. These are areas to avoid during a storm.
- Learn about the emergency-response and evacuation plans for your area. Develop your own emergency plan for your family or business.
- Minimize home hazards:
    - Have flexible pipe fittings installed to avoid gas or water leaks, as flexible fittings are more resistant to breakage (only the gas company or professionals should install gas fittings).

- Plant ground cover on slopes and build retaining walls.
- In mudflow areas, build channels or deflection walls to direct the flow around buildings. *Remember*: If you build walls to divert debris flow and the flow lands on a neighbor's property, you may be liable for damages.

5.7 What to Do During a Landslide

- Stay alert and awake. Many debris-flow fatalities occur when people are sleeping. Listen to a NOAA Weather Radio or portable, battery-powered radio or television for warnings of intense rainfall. Be aware that intense, short bursts of rain may be particularly dangerous, especially after longer periods of heavy rainfall and damp weather.
- If you are in areas susceptible to landslides and debris flows, consider leaving if it is safe to do so. Remember that driving during an intense storm can be hazardous. If you remain at home, move to a second story if possible. Staying out of the path of a landslide or debris flow saves lives.
- Listen for any unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together. A trickle of flowing or falling mud or debris may precede larger landslides. Moving debris can flow quickly and sometimes without warning.
- If you are near a stream or channel, be alert for any sudden increase or decrease in water flow and for a change from clear to muddy water. Such changes may indicate landslide activity upstream, so be prepared to move quickly. Don't delay! Save yourself, not your belongings.
- Be especially alert when driving. Bridges may be washed out, and culverts overtopped. Do not cross flooding streams!! Turn Around, Don't Drown®!. Embankments along roadsides are particularly susceptible to landslides. Watch the road for collapsed pavement, mud, fallen rocks, and other indications of possible debris flows.
- Be aware that strong shaking from earthquakes can induce or intensify the effects of landslides.

5.8 What to Do if You Suspect Imminent Landslide Danger

- Contact your local fire, police, or public works department. Local officials are the best persons able to assess potential danger.
- Inform affected neighbors. Your neighbors may not be aware of potential hazards. Advising them of a potential threat may help save lives. Help neighbors who may need assistance to evacuate.
- Evacuate. Getting out of the path of a landslide or debris flow is your best protection.
- Curl into a tight ball and protect your head if escape is not possible.

5.9 What to Do After a Landslide

- Stay away from the slide area. There may be danger of additional slides.
- Listen to local radio or television stations for the latest emergency information.
- 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.
- Check for injured and trapped persons near the slide, without entering the direct slide area. Direct rescuers to their locations.
- Help a neighbor who may require special assistance - infants, elderly people, and people with disabilities. Elderly people and people with disabilities may require additional assistance. People who care for them or who have large families may need additional assistance in emergency situations.
- Look for and report broken utility lines and damaged roadways and railways to appropriate authorities. Reporting potential hazards will get the utilities turned off as quickly as possible, preventing further hazard and injury.
- Check the building foundation, chimney, and surrounding land for damage. Damage to foundations, chimneys, or surrounding land may help you assess the safety of the area.
- Replant damaged ground as soon as possible since erosion caused by loss of ground cover can lead to flash flooding and additional landslides in the near future.

- Seek advice from a geotechnical expert for evaluating landslide hazards or designing corrective techniques to reduce landslide risk. A professional will be able to advise you of the best ways to prevent or reduce landslide risk, without creating further hazard.

5.10 Suggested Local Government Outreach for Landslide Hazard

- Newspaper bulletins/advertisements.
- Public-service brochures distributed door-to-door or displayed in public places.
- Community meeting discussions.
- Posters in public buildings and (or) marketplaces with as much visual information as possible.
- Media announcements through radio, television, loudspeakers, or other means.
- Public lectures by experts or other officials.
- Signs posted in immediate areas of hazards, informing people of the kind of hazard and warning them to be cautious. An example of this would be a sign warning of rockfall hazards along well-used footpaths.
- In areas where literacy rates are low, oral communications with graphics, photographs, and illustrations of hazards can be extremely effective. Pictures may take the place of a thousand words!
- Telephone book—In areas where phone service is widespread or accessible, municipal listings for engineering, emergency planning, and police or fire departments.
- Where possible a municipal Internet Web site is a useful source of safety information and contact phone numbers and emails for emergency personnel and engineering and (or) planning departments.
- Determine local landslide hazard problems through a working committee and (or) secure professional advice. State/Provincial or Federal geological surveys, university geology or engineering departments, and private geotechnical companies are sources of advice. Provide for a mapping program where possible, either within local government or contracted with professionals.

- Conduct public education and information programs through community meetings, city council, or other councils.
- Adopt and enforce appropriate land-use policies—discuss with landowners, developers, buyers, and sellers. One option is to require disclosure of geological hazards during property sales to ensure that the new buyer is aware of any problems.
- Monitor changes in unstable slopes and take appropriate actions (see "Mitigation" section of this handbook).
- Construct street and drainage projects that meet local safety needs and ordinances.
- Pursue public grant programs, government programs for infrastructure, and public works improvement projects.
- Be informed about insurance programs available and liability issues and know where local government responsibility lies for public safety and well-being.
- Have an emergency response plan for the community. Consult with neighboring towns and (or) communities that have plans and have used them in an emergency. Evaluate their effectiveness for your own situation.

CHAPTER 6

ROLES AND RESPONSIBILITY

6.1 State Level

The State Government in line with the National Disaster Management Act, 2005, has constituted State Disaster Management Authority (KSDMA), the State Executive Committee (SEC). It has constituted the District Disaster Management Authority (DDMA) laying down the roles and responsibilities for the State and district authorities along with constituting the State Crisis Management Committee (SCMC).

The Revenue Department (Disaster Management), Govt. of Karnataka is primarily responsible for emergency response and relief in the State, while the Karnataka State Disaster Management Authority (KSDMA) is designated as the nodal agency for formulation of policies, long-term planning, coordination and monitoring body for mitigation, reduction and preparedness for disasters in the State. As per the KSDMA, the responsibility for initiation and execution of emergency preparedness and response measures before, during and after earthquake rests with the Principal Secretary to Govt., Revenue Department (Disaster Management) and Commissioner, KSDMA in conjunction with other relevant line departments.

Table 6.1: The roles and responsibilities of the line departments at State level are given below

Sl. No.	Agencies	Roles & Responsibilities
01.	**Karnataka State Disaster Management Authority (KSDMA), Govt. of Karnataka**	• Promotes a coordinated and integrated system of disaster management including prevention or mitigation of disaster by the State, local authorities, stakeholders and communities at large • Data to be collected on all aspects of disasters and disaster management and analyze it and further cause and conduct research and study relating to the potential effects of events that may result in disasters • Acts as a repository of information concerning disasters and disaster management in the State • Lays down policies and plans for disaster

Sl. No.	Agencies	Roles & Responsibilities
		management in the State for the disasters vulnerable • Promotes or causes to promote awareness and preparedness, advice and train the community and stakeholders for readiness in the event of disasters
02.	**State Crisis Group / State Crisis Management Committee (SCMC)**	• Apex body in the State to deal with major chemical accidents and to provide expert guidance for the same • District Crisis Groups have been constituted with the respective Deputy Commissioner of the district as the Chairman and the representative of the Department of Factories and Boilers as the Member Secretary for chemical and industrial hazards resulting from Earthquakes • The SCMC gets activated in the event of a crisis. The Chief Secretary is the Incident Commander at the State level and will formulate the response teams/Crisis Management Groups as per the type and severity of the crisis • Review the contingency plans of each Department and assess the efficiency of the contingency plans of the departments • Guide and direct the Crisis Management Groups of each administrative departments as and when necessary • Provide Inter departmental Coordination during crisis management and give specific directions to the line Departments to take immediate measures during crisis when it is severe in nature • Review all district off-site emergency and contingency plans in the State with a view to examine its adequacy in accordance with the Manufacture, Storage and Import of Hazardous Chemicals, Rules and forward a report to the Central Crisis Group once in every three months • Assist the State Government in the planning, preparedness and mitigation of major chemical accidents in the State • Continuously monitor the post accident situation arising out of a major chemical accident in the State and forward a report to the Central Crisis Group
03.	**Centre for Disaster Management (CDM), Administrative Training**	• Provides training related to disaster management in close coordination with NIDM

Sl. No.	Agencies	Roles & Responsibilities
	Institute (ATI), Govt. of Karnataka	• Undertakes activities for human resource development, public education and community awareness, safety etc., in disaster education and management • It shall be involved in training, research, documentation and development of a State level information base and also organize training of trainers, DM officials and other stakeholders • It shall network with other knowledge-based institutions and function within thebroad policies and guidelines laid down by the KSDMA
04.	**Karnataka State Fire & Emergency Services (KSF&ES), Govt. of Karnataka/ SDRF**	• Provides crucial and immediate response during any disaster in the State • The first responder department in the events of fire, rescue and other disasters • The technically trained personnel are setting new benchmarks in saving lives and properties, risking their lives • The department has put its right step through capacity building, advance training and provides regular training to the fire staff in using and maintaining the equipment
05.	**Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Revenue Department (DM), Govt. of Karnataka**	• Monitoring GP level rainfall with GPRS enabled telemetric raingauge stations for every 15 minutes and the data is used for landslide triggered mechanism in Karnataka. • Engaged in dedicated landslide research and analysis • Planning to install landslide monitoring instruments in high risk areas. • Provides community awareness programmes to the local community in the event of local tremors through Do's & Don't's • Facilitates the use of spatial and geo-spatial technologies for planning &developmental activities pertaining to agriculture, water resource management, watershed development, disaster management and education • Provides specialized services and solutions in implementing map-based Geo-Spatial Information Systems • Provides GIS solutions for disaster management in the State • Provides consultancy services to few private companies in feasibility studies related to

Sl. No.	Agencies	Roles & Responsibilities
		seismicity of the area prior to establishing a major project

6.2 State Emergency Operation Centre (SEOC)

The State Emergency Operation Centre (SEOC) of Karnataka is functional with critical facilities including display room, media room, VIP Conference Room (with provision for video-conferencing facility, State alert & warning room, chamber for Principal Secretary, staff room and department room and is located adjacent to the Vidhana & Vikasa Soudha to attend emergency meetings as and when necessary.

The existing State Emergency Operation Centre (SEOC)/Control Room shall be the nerve centre for coordination and management of disasters. It shall be the physical location from where coordination of response, relief and restoration will take place. It functions 24x7 and is equipped with contemporary technologies, communication infrastructure facilities and adequate human and material resources. This will work in close coordination with the Karnataka State Natural Disaster Monitoring Center (KSNDMC), Indian Meteorological Department (IMD), Ministry of Home Affairs (MHA), National Disaster Management Authority (NDMA) and other concerned line departments.

a) Activation of SEOC:

As the SEOC is a nodal point for the overall coordination and control of relief work, the DEOC will be activated in case of a Level 1 disaster (disaster that can be managed at the district level), and in case of an Level 2 disaster (disaster situations that require assistance and active mobilization of resources at the State level), SEOC will be activated along with the DEOC.

b) Command & Control of EOCs:

The EOC, its system, and procedures are designed in such a way that information can be promptly assessed and relayed to concerned parties. Immediatedissemination of information contributes to quick responseandeffective decision making during an emergency. Being the main coordination and control point for all disaster specific efforts, the SEOC is the place of decision-making, under a unified command.

The SEOC in normal circumstances will work under the supervision of Principal Secretary to Govt., Revenue Department (DM) at the State level andunder the Deputy Commissioner at the District level. It is the nerve centre to support, co-ordinate and monitor the disaster management activities at the district level. In a disaster situation, the SEOC will come under the direct control of Chief Secretary to Govt. or any other official designated by the Chief Secretary as Chief of Operations.

c) <u>Functions of the SEOC:</u>

i) The SEOC supports local jurisdictions by providing requested resources, information, advice, strategic assistance, and communication, which allows for flexibility to match the manpower requirements commiserate with the mission requirements

ii) As the core component of the SEOC, the staff have been assigned and been made aware a variety of responsibilities in the SEOC

iii) Receive, monitor, and assess the disaster information in the State and accordingly monitor, assess, and track response units and resource requests

iv) Proclaim local emergencies as needed and providedirectionand management for EOC operations through set priorities and establish strategies as per the situation demand

v) Coordinate operations of all responding units, including law enforcement, fire, medical, logistics and augmentcomprehensive emergency communication from SEOC to any field operation when needed or appropriate

vi) Maintain EOC security and access control

vii) Keep senior, subordinate and tenant officials informed

viii) Keep local jurisdictions (Gramapanchayath / Village/ Town / Taluk /City, district and State) informed and operate a message centre to log and post all key disaster information

ix) Develop and disseminate warnings and instructions

x) The State Emergency Operations Centre (SEOC) functions under the administrative and supervisory control of the Special Relief Commissioner

6.3 District Emergency Operation Center (DEOC)

District Emergency Operation Centre (DEOC)/ District Control Room shall be the nerve centres for coordination and management of disasters at district level. They shall be the physical location from where coordination of response, relief and restoration will take place. They shall function 24x7 and shall be equipped with contemporary technologies, communication infrastructure facilities and adequate human and material resources. They shall work in close coordination with the State Emergency Operation Centre, Karnataka State Disaster Management Authority and Karnataka State Natural Disaster Monitoring Centre. The DEOCs shall get activated in the event of:

- Any disaster event is or has the potential to becoming an L2 disaster; or
- Any specialist rescue operation is required; or
- If there are insufficient local emergency rescue resources

6.4 District Disaster Management Authority (DDMA)

The District Disaster Management Authority (DDMA), headed by the Deputy Commissioner, with the elected representative of the local authority as the Co-Chairperson shall act as the planning, coordinating and implementing body for DM at District level and take all necessary measures for the purposes of DM in accordance with the guidelines laid down by the NDMA and KSDMA. It shall, inter alia prepare the District DM plans for the respective districts and monitor the implementation of the State DM Policy, the State DM Plan and the District DM Plan. DDMA shall also ensure that the guidelines for prevention, mitigation, preparedness and response measures laid down by the NDMA and the SDMA are followed by all the line departments of the State at District level and the local authorities in the district as per the National Disaster Management Act 2005.

6.5 District & Local Level:

For the purpose of this policy, local authorities would include Panchayath Raj Institutions (PRI), Municipalities, District and Cantonment Boards and Town Planning Authorities, which control and manage the local civic services. These bodies shall ensure capacity building of their officers and employees for managing disasters, carrying out relief, rehabilitation and reconstruction activities in the affected areas and shall prepare DM Plans in

consonance with guidelines of the NDMA, SDMAs and DDMAs. Specific institutional framework for dealing with disaster management issues in mega cities will be put in place as per the National Disaster Management Act 2005.

There are 31 District Emergency Operation Centres (DEOCs) in the State. DEOC gets fully activated in case of Level 1 emergency, wherein the command & control and functions of DEOC are similar to that of SEOC. A detailed matrix clearly laying down the roles/responsibilities of all stakeholders is given in **ANNEXURE - I**.

6.6 Line Departments of the State Government

a) Agriculture & Cooperation Department

- Formulate a trained team for assessing damage to crops, soil and other agricultural damage incurring from an landslide

b) Animal Husbandry Department

- Prepare a database of veterinary hospitals, clinics and agencies working for animals
- Identify source for procurement of fodder and safe locations for cattle camps
- Ensure proper transportation facilities for sick or critically injured animals, if any during an landslide
- Identify space for burial of dead animals

c) Civil Aviation Department

- Ensure that sites for helipads are identified across the State as per the laid guidelines

d) Education Department

- Organise camps in school and colleges for awareness of do's and dont's for landslides
- Ensure preparation of DM plans and first aid kits in all schools and colleges
- Identify safe schools and colleges which can be used as relief shelters for short duration of time in aftermath of any landslide

e) Fire & Emergency Services / SDRF

- Ensure proper maintenance and functioning of all fire fighting equipments and personnel protection equipments
- Prepare a database of private fire fighting agencies and their resources

- Keep vigil regarding chemical MAH units and other hazardous installations in the State and prepare for possible emergency situation

f) Food & Civil Supplies Department

- Prepare for structural and fire safety of godowns
- Prepare for out movement of stored food grains to a pre-identified safer location
- Enlist godowns and cold storage facilities, refrigerated transportation vehicles present in the State along with their storage capacities and facilities available
- Enlist private retailers and wholesale dealers of food items and packaged drinking water
- Enlist available kerosene depots, petrol pumps, CNG pumps, diesel depots, LPG agencies, etc., for emergency usage as and when the situation demands

g) Health & Family Welfare Department

- Develop plan for hospital preparedness and mass casualty management
- Prepare a database of registered private hospitals, clinics, diagnostic labs, blood banks, etc. along with their capacities and facilities provided
- Establish paramedic cadre through training programmes and accredit/ license them
- Recognize and accredit trauma centres
- Establish Statewide medical emergency access number
- Ensure authentic medical database enlisting public and private facilities available in the State. This includes details of manpower, logistics, medical equipments, medicines, antidotes, personal protective equipments, disinfectant, vaccines, etc.,
- Standardize and license ambulance services
- Ensure availability of adequate supply of life saving equipments and drugs, portable supplies like portable oxygen cylinders, portable x-ray machines, triage tags, etc.,
- Formulate trained medical first responder
- Prepare trained psychological and psychosocial care teams
- Impart training to manpower for emergency services
- Ensure proper and safe management of medical waste

h) Commerce and Industries Department

- Create awareness for health & safety for workers and factory management
- Make a database of Chemical MAH units and hazardous installations in the State and

their safety officers

- Ensure preparation of onsite emergency management plan by all industrial units
- Prepare a database of suppliers/ manufactures of antidotes for hazardous chemicals

i) Information Department

- Display verified Information Education and Communication (IEC) material for mass dissemination and awareness among the public
- Prepare a database of media channels and media persons (both print and electronic media) for providing information during an earthquake
- Ensure proper mechanism with the channels for addressing public so as to avoid and manage rumours with help of various media

j) Water Resources Department

- Ensure proper early warning mechanism for flood in case of damage to dam/s due to landslide
- Ensure proper functioning of all equipments including dewatering pumps
- Prepare for arrangement of safe drinking water supply for community in the affected areas, relief camps and shelters
- Prepare for prompt repair of pipelines supplying potable water
- Ensure availability of adequate number of water tankers, drums, jerry cans or identify their private suppliers to prepare for supply of water, in scarcity period and in emergency
- Ensure availability of water supply/ filling points for fire tenders, water cannons, hospitals and other necessary life saving infrastructure

k) Police Department

- Ensure proper functioning of all equipment and vehicles
- Prepare for quick deployment of Home Guards and volunteers for providing safety to affected population and evacuated structures/ houses
- Prepare plan for rumors and crowd management
- Train police personnel and staff of PCR van in first aid and basic life support
- Prepare communication plan for uninterrupted communication to all police posts and various control room and emergency operation centres across the State

l) Transport Department & Port Department

- Ensure proper functioning of filling station, vehicles and equipment
- Prepare for prompt deployment of vehicles at short notice for various purposes like mass evacuation, transportation of response teams, relief items, victims, etc.,
- Prepare mechanical team for prompt repair of equipment and vehicles
- Train drivers, conductors, crew members, port officials in first aid and basic life saving techniques

m) Revenue Department

- Develop relief norms and packages
- Assess all needs for immediate relief measures and compensation
- Organising and coordinating the immediate response
- Coordinate with Central/ State Agencies
- Arrange with service provider companies for multiple warning messages to community, officials, etc., as the need may be
- Implementation of Risk Transfer Arrangements including multi_-hazard insurance for life and property
- Develop and promote insurance, disaster bonds, tax rebate, etc., against the disaster

n) Public Works Department

- Ensure availability and functioning of all equipments like cranes, earthmovers, etc., and prepare a database of availability of the same with private agencies also
- Prepare for prompt clearance of debris in the aftermath of earthquake
- Prepare the demolishing squad for prompt demolition of unsafe buildings post disaster
- Prepare for prompt clearing and repairing of damaged roads, culverts, bridges and flyovers
- Ensure prompt construction of new temporary roads for diverting traffic from the affected areas
- Prepare for construction of temporary facilities like that of medical post, temporary shelters, etc., at short notice.
- Prepare for prompt establishment of helipad near the affected site for responding teams and officials visits
- Prepare restoration of government buildings damaged during landslides

o) Department of Telecommunication

- Ensure proper mechanism to issue alert/ warnings through SMS from the service providers
- Prepare for providing safety and serviceability of critical communication towers through respective service providers
- Prepare for prompt establishment of alternate communication links like HF, VHF, HAM radios, Satellite Phones, etc., in case of failure of primary communication channels during landslides

p) Social Justice & Empowerment Department

- Prepare and regularly update database of scheduled castes, social and economically backward classes, minority communities, physically and mentally challenged persons (Divyangans), orphans, destitutes, beggars, old aged persons and ensure that they are able to avail benefits under respective welfare schemes so as to reduce their vulnerability to disasters

q) Youth Empowerment &Sports Department

- Organise training and awareness camps for youth or first aid, relief and camp management, psycho social care, search and rescue for small incidents, firefighting and thereby creating a trained volunteer database

r) Tribal Welfare Department

- Prepare a database of tribal groups in the State, their population and habitats
- Ensure they are well covered under all Government schemes meant for them with special focus on the five Particularly Vulnerable Tribal Groups

s) Women & Child Development Department

- Prepare a database of authentic NGOs working for women and children empowerment/ rights
- Prepare for prompt action in aftermath of landslide so as to prevent human trafficking particularly that of women, girls and children
- Ensure women and children in vulnerable circumstances are well covered under various government schemes targeted to them

Table 6.2: Tasks and Responsibility during landslides

Sl No	Time Frame	Task	Responsibility	Activity
1	Time = -48 to 0 hrs	Warning receipt and dissemination	KSNDMC, KSDMA, SEOC, DDMA, Line Departments and Local Authorities	• Report the weather forecast, land subsistence and any other sign of slide activity. • Alert all response teams in the area. • Remain in constant touch with DEOC and SEOC.
2	Time = 0 hrs	Review of situation and reporting	DDMA	Instruct all heads of departments of the key line departments to activate their departmental plan and DDMP
3	Time = 0 + 24 hrs	Review of situation and reporting	DDMA	• Work as per DDMP and departmental plan. • Report to HODs and KSDMA on two hours basis.
4	Time = 24 + 48 hrs	Review of situation and reporting	DDMA	• Work as per DDMP and departmental plan. • Report to HODs and KSDMA on 6 hours basis.

ANNEXURE – I

Landslide Resilience & the Responsibility Framework of the State & Its Agencies

I. Landslide Risk Reduction (Understanding Risk Reduction):

Sl. No.	Sub-Thematic Area for DRR	State Agencies and their Responsibilities	
		State Agencies	**Responsibility**
1.	Hazard Zonation mapping, geological, and geotechnical Investigations in regions prone to landslides	DMG, GSI, KSRSAC, KSNDMC	• Preparation of landslide hazard vulnerable zone large scale mapping. • Studies and monitoring of risk prone areas on site and using Remote sensing products. • Studies to classify Hazard Vulnerable areas. • Develop the Landslide hazard mapping for the Landslide prone areas.
2.	Research and Development	DMG, GSI, KSNDMC	• Scientific assessment of the triggering factors of landslides.
3.	Hazard Risk Vulnerability and Capacity Assessment (HRVCA)	DMG, GSI, KSNDMC, KSDMA	**Recurring / Regular (RR)** • Comprehensive research studies and documentation on vulnerabilities and capacities covering Social, Physical, Economic, Ecological, Gender, Social inclusion and equity aspects. • Provide technical support and guidance for comprehensive HRVCA.
			Recurring / Regular (RR) • Undertake HRVCA as part of preparing and periodic revision of DM plans. • Constitute/ strengthen the mechanisms for consultation with experts and stakeholders.
4.	Dissemination of warnings	KSNDMC, GSI	**Recurring/ Regular (RR)** • Coordinate with central agencies for quick, clear, effective dissemination of information. • Developmentofamodelonlandslideforecasting anddissemination ofwarnings. • Ensure facilities and infrastructure for the implementation of adequate access to communities at risk. • Dissemination of warnings to last mile.
5.	Monitoring, Warning Systems, and Dissemination	KSNDMC, GSI	• Deploy reliable monitoring and warning systems. • Establish a mechanism for monitoring and evaluation.

II. Landslide Risk Reduction (Inter Agency Co-ordination):

Sl. No.	Sub-Thematic Area for DRR	State Agencies and their Responsibilities	
		State Agencies	Responsibility
1.	Overall Disaster Governance	Revenue Department (DM) KSDMA	**Recurring / Regular (RR)** • Providing coordination, technical inputs, and support. • All aspects of Disaster Risk Management and mainstreaming DRR. • Ensuring coherence and mutual reinforcement of DRR, CCA and development. • Preparation and implementation of DM plans and ensure the functioning of agencies with DM tasks.
2.	Response	Revenue Department (DM), KSDMA, DMG	**Recurring / Regular (RR)** • Activate Incident Response Teams at all level • Provide necessary resources in terms of material, manpower and monetary support. • Coordinate with central agencies for the necessary support process, mobilization of necessary resources during and after the landslides.
			• Organizing and coordinating the immediate response towards Rescue, Relief & Rehabilitation.
		KSDMA, KSF&ES, Police, NDRF,SDRF, Civil Defence, Home Guards etc.,	**Recurring / Regular (RR)** • KSDMA in consultation with Revenue Department (DM) to coordinate, guide and command the Rescue, Relief &Rehabilitation.
3.	Warnings, Information, Data	DMG, GSI, SEOC	**Recurring / Regular (RR)** • Effective coordination and seamless communication among Central and State agencies to ensure quick, clear, effective dissemination of Warnings, Information and Data.
4.	Non-structural measures	Revenue Department (DM)	**Recurring / Regular (RR)** • Coordination among central and state agencies for: a) revised/ updated rules, norms b) adoption of new/updated standards c) enact/amend laws, regulations and d) adopt/ review policies

III. Landslide Risk Reduction (Investing in DRR-Structural Measures):

Sl. No.	Sub-Thematic Area for DRR	State Agencies and their Responsibilities	
		State Agencies	Responsibility
1	Protection of Human Settlements	Revenue, Revenue (DM), PWD, UDD, ULBs, PRIs, Housing dept.	**Recurring / Regular (RR)** • Ensuring landslide resistant infrastructure, roads, and land stabilization work.
2	Protection of Heritage Structures	Archeological Department	• Preparelistsofstructures/sitesatriskduetolandslides/slopestabilityproblems and prioritise them for hazard mitigation.
3	Multi-Hazard Shelters	PWD,UDD, ULBs, PRIs, Housing department	• Identification of safe buildings and sites to serve as temporary shelters for people and livestock evacuated from localities at risk. • Constructionofmulti-purposesheltersinhighriskareasatsafesitesaway from hazard-prone locations. • Proper maintenance of roads in risk- prone areas.

IV. Landslide Risk Reduction (Investing in DRR-Non Structural Measures):

Sl. No.	Sub-Thematic Area for DRR	State Agencies and their Responsibilities	
		State Agencies	Responsibility
1.	Site selection for Human Settlements in Landslide Prone Areas	PWD,UDD, ULBs, RDPR, Housing department	• Detailed land-use zonation incorporating landslide risks as applicable. • Adopt suitable byelaws for rural and urban areas. • Enforce model codes into practice. • Ensure proper compliance.
2.	Regulations and building codes	PWD,UDD, ULBs, RDPR, Housing department	**Recurring / Regular (RR)** • Ensure implementation and adherence to codes and guidelines. • Adopt the techno-legal framework for ensuring compliance with landuse zoning and landslide avalanche safety issues. • Adopt land use zoning, building bye-laws and model legislation with suitable modification for reducing risk.
3.	Licensing and certification of Professionals	UDD, ULBs, RDPR	• Evolve an Appropriate Techno-Legal Framework for mandatory licensing of professionals.
4.	Public Private Partnerships	Revenue Department (DM) and corporate Sectors	**Recurring / Regular (RR)** • Promote private participation in DRR.

V. Landslide Risk Reduction (Capacity Building):

Sl. No.	Sub-Thematic Area for DRR	State Agencies and their Responsibilities	
		State Agencies	**Responsibility**
1.	Training	PWD, DMG, KSDMA	**Recurring / Regular (RR)** • Train professionals on how to handle slope failures and their remediation and landslide emergencies by promoting observational method of design and construction with training on the development of contingency plans • Support and collaboration to National Agencies.
		ATI-CDM	**Recurring / Regular (RR)** • Conductingandcoordinatingtrainingtoallgovernmentofficialsinvolved in the planning and implementation of Preparedness, Mitigation Response and Relief Work.
		SIRD	**Recurring / Regular (RR)** • Conduct Training Programmes for the Elected Representatives, officers, staff of Panchayat Raj Institutions and NGOs.
		SIUD	**Recurring/ Regular** • Conduct Training Programmes for the Elected Representatives, Officers, Staff of Urban Development Department.
		Police Training Academies	• Conduct training to police officers in Disaster Management- Crowd Management, Evacuation, Rescue and Relief Operations. • Conduct search and rescue training to local volunteers.
		KSF&ES	• Conduct training to fire officers in Disaster Management-Evacuation and Rescue Operations.
		SDRF, NDRF	• Conduct training to SDRF and NDRF personals in Disaster Management- Evacuation and Rescue Operations. • Community training programs to prepare volunteers for Rescue, Relief, First Aid Response. • To identify and prepare a list of Ex-service men, Swimmers & Divers in the local community to be engaged during the Flood event.
		Department of Animal Husbandry & Veterinary	• Training and orientation programs for professionals of Veterinary care and Volunteers to support the Search, Rescue, Evacuation and Cattle and Animal Management of Landslide affected areas.

		Services	
		Health and family welfare department	• Training and orientation programs for professionals and volunteers on Disaster Management adopting to high altitude Landslide affected areas.
2.	Curriculum Development	Education department	• Ensure scientific knowledge on landslides in thecurriculum.
3.	Awareness Generation	Revenue Department (DM), SDMA, ATI(CDM), DMG, Information and broadcasting, Civil Defence, Police, KSF&ES, SDRF, RD&PR, NGO's	• Carry out Mass Media campaigns • Promote culture of Disaster Risk Prevention, Mitigation, and Better Risk Management. • Promote attitude and behavior change in awareness campaigns. • Promote use of insurance/ risk transfer. • Promote Community Radio. • Inform people about care & protection Affected Animals.
4.	Mock Drills/ Exercises	SDRF, Police, KSF&ES	• Joint planning and execution of emergency drills.
5.	Documentation	Revenue Department (DM), DMG, GSI, KSNDMC	• Constitute Multi-Institutional and Multi-Disciplinary Teams for carrying out post landslide field investigations and document the lessons learnt.
6.	Empowering women, marginalised and persons with disabilities	Child and women welfare department, ATI-CDM	**Recurring / Regular (RR)** • Incorporating gender sensitive and equitable approaches in capacity development covering all aspects of Disaster Management at the State level.
7.	Community-Based Disaster Management	KSDMA, ATI-CDM	**Recurring / Regular (RR)** • Strengthen ability of communities to manage and cope with disasters based on a Multi-Hazard approach. • Strengthen ability of communities to manage and cope with disasters based on a Multi-Hazard approach. • Training panchayat members, SHGs, NCC, NSS, Youth, local community organizations.

VI. Landslide Risk Reduction (Climate Change Risk Management):

Sl. No.	Sub-Thematic Area for DRR	State Agencies and their Responsibilities	
		State Agencies	Responsibility
1.	Research, Forecasting/Early Warning, Data Management, Zoning, Mapping	GSI, KSNDMC, DMG, EMPRI	**Recurring / Regular (RR)** • Sponsor and promote State & Local specific efforts for GACC Mitigation and Adaptation. • Document state-specific GACC impacts and coping mechanisms. • Promotelocalweather-basedinsurancemechanismsandagriculturalpractices. • Promote state-specific studies on enhanced risks (Economic, Social, etc.) under different GACC impact scenarios. • Promote research studies with State specific contexts on GACC and consequent changes in hazards.
2.	Hazard Risk Vulnerability and Capacity Assessment (HRVCA)	SDMA, Dept. of social justice and empowerment	• Undertake HRVCA as part of preparing and periodic revision of DM plans • Develop State specific strategies • Assess GACC risks of Vulnerable and Marginalised sections • Improve the understanding of the enhanced vulnerabilities of LSA- communities.
3.	Climate Change Adaptation (CCA)	Revenue Department (DM), KSDMA, KSNDMC, Forest & Ecology	**Recurring / Continuous** • Sensitization and awareness creation. • Support national CCA efforts. • Coordination with central agencies. • SponsorandpromotestateeffortsforGACCMitigationandAdaptation • Develop local adaptation strategies and pilot projects. • Sponsor and promote state-specific efforts and local efforts. • Implementation of GACC adaptation programs. • Promote appropriate combinations of Green and Blue infrastructure • Integrate adaptive measures in Social protection programs for the vulnerable groups.

CHAPTER 7

FINANCIAL ARRANGEMENTS

The overwhelming expenditure on disaster management in India, more specifically for post-disaster response, relief and rehabilitation, are incurred by the State Governments and district administration and almost the entire budgetary allocations for the same are met from the allocations made to the States annually for the five year fiscal cycle on the basis of the recommendations made by the Finance Commissions constituted under article 280 of the Constitution of India. In fact, the entire system of financing disaster management in India has evolved around the recommendations of the successive Finance Commissions. The recommendations of the Finance Commissions have been based on the over-riding principle that financial assistance to the States shall be limited to providing immediate gratuitous relief to the victims of natural calamities and to restore the public utilities so that the affected persons are able to restart their economic activities again. This relief centric approach did not encourage strategic thinking on the total financial requirement of the States for holistic management of disasters, quantification of resource gaps and how such gaps can be met over time by various innovative financial instruments for risk management.

The Ministry of home Affairs (MHA), Govt. of India will follow the following procedure to release financial assistance to the affected state government:

- The memorandum of the State Government will be examined to assess the likely requirement of funds as per the items and norms of expenditure under SDRF/NDRF. If a preliminary examination reveals that there are adequate funds in the SDRF with the State for providing relief as per norms, the State will be advised accordingly
- If a preliminary examination reveals that the State is in need of assistance, an Inter-Ministerial Central Team will be deputed to the disaster affected area for an on-the spot assessment
- The report of the Central team will be examined by the NEC through its sub-committee, which will assess the extent of relief expenditure which can be made available through the NDRF, as per the norms of NDRF and SDRF, and make recommendations for the

same

- The High Level Committee will consider the recommendations of the Sub-Committee of NEC and approve the quantum of immediate assistance to be released from the National Disaster Response Fund.

7.1 Funding Mechanism at Various Levels

To ensure the long-term sustenance and permanency of the organisation, funds are generated and deployed on an ongoing basis. Financial mechanism for disaster management is already in place at National, State and District level. Additionally there are various projects, programmes and initiatives catering to different phases of disaster management at Nation, State and District level.

7.1.1 National Level

(i) National Disaster Response Fund: This fund has been created under the legal framework of National Disaster Management Act, 2005. Under the existing guidelines, it is available for assistance from avalanches, cyclone, cloud burst, drought, earthquake/ tsunami, fire, flood, hailstorm, landslides, pest attack and frost & cold wave. In case of calamity of severe nature when State Disaster Response Fund is insufficient to meet the relief requirements, additional central assistance is provided from NDRF to the State Government by following the laid down procedures.

(ii) Prime Minister's National Relief Fund (PMNRF): PMNRF provides immediate relief to families of those killed in natural calamities and to the victims of major accidents and riots. The fund is raised entirely by the public contributions.

(iii) **XV Finance Commission:** The Fifteenth Finance Commission has made a departure from response to mitigation aspect and recommended setting up of National and State Disaster Risk Management Fund (SDRMF).The recommendations of the commission related to financing of relief expenditure have been accepted by the Govt. of India. The coverage of funds recommended by the commission for financing of relief expenditure goes beyond the disaster response funds that already exist at the National (NDRF-National Disaster Response Fund) and State (SDRF-State Disaster Response Fund) levels. The National Disaster Risk Management Fund (NDRMF) and State Disaster Risk Management Fund (SDRMF) have been created. The

allocation for SDRMF for the year 2020-21 for Karnataka is Rs.1,054 Crores.

As per the recommendations of the 15thFinancial Commission, Mitigation funds has been created separately at the national and state levels, in the form of a National Disaster Mitigation Fund (NDMF) and State Disaster Mitigation Fund(SDMF) are setup. The Mitigation funds aims to support those local level and community-based interventions, which reduce disaster risks and promote environmental-friendly settlements and livelihood practices, and not large-scale infrastructure interventions.

7.1.2 State Level

(i) State Budget: KSDMA submits to the State Government for approval a budget in the prescribed form for the coming financial year showing the estimated receipts and expenditure, and the sums, which would be required from the State Government during that financial year. The State Government also allocates funds in the State Budget for relief activities. In addition, funds may be available through the State Disaster Response Fund (SDRF).

(ii) State Disaster Response Fund (SDRF): There is a provision for State Disaster Response Force, which is made available to Commissioner of Relief, Revenue Department (DM) which was meant for meeting expenditure for providing immediate relief to the victims of cyclone, drought, earthquake, landslide, fire, flood, tsunami, hailstorm, avalanche, cloud burst and pest attack.

(iii) Chief Minister Relief Fund: This provides immediate support to the distressed people affected by the natural calamities, or road, air or railway accidents.

7.1.3 Other Sources of Funds

(i) Public funded schemes

The primary mechanism for funding DRR related schemes and projects in Karnataka are through Public Funded Schemes at Central and State level. Various nodal Ministries play a key role in disaster management as far as specific disasters are concerned. These nodal Ministries as well as other Ministries and Departments have dedicated schemes, aimed at disaster prevention, mitigation, capacity building, etc. within their particular domain. Existing examples include the scheme of MHA for Strengthening of Fire and Emergency Services, Financial assistance to ATI's and other Training institutions for disaster management, Integrated Coastal Zone Management programme of MOEFCC,

and flood management and flood forecasting programmes of MOJS. The Department of Space (DOS) has a Disaster Management Support Programme and MOES has a project on Tsunami and Storm Surge Warning System. NDMA is implementation an important World Bank funded project for National Cyclone Risk Mitigation Project.

Apart from this, many of the schemes, which are implemented by various ministries/ departments, have embedded DRR components, as for example, those implemented by the MOEFCC. There are many other programmes that improve societal resilience, which is a critical component of DRR, such as the National Rural Health Mission (NRHM), Mahatma Gandhi Employment Guarantee Scheme, and the Urban Development's Urban Renewal Mission.

(ii) Public Private Partnership: There are projects/schemes in which funding can be done by a public sector authority and a private party in partnership, wherein the private party can share their part.

(iii) Flexi Funds as a part of Centrally Sponsored Schemes: As per Department of Expenditure, Ministry of Finance, the NITI Aayog has issued instructions for rationalization of Centrally Sponsored Schemes (CSS). As per the para 6 of the OM, flexi-funds available in each CSS has been revised to 25% for States, and 30% for UTs, of the overall annual allocation on under each scheme. The flexi -fund component within the CSS can be used to achieve the following objectives:

a) To provide flexibility to States to meet local needs and requirements within the overall objective of any given Scheme at the sub-head level.

b) To pilot innovation to improve efficiency within the overall objective of any given Scheme at the sub-head level.

c) To undertake mitigation/restoration activities in case of natural calamities, or to satisfylocal requirements in areas affected by internal security disturbances.

(iv) Grant-In Aid: The State Government may receive a grant in aid from Central Govt., World Bank, other departments, bilateral or multilateral funding agencies, etc., to carry out specific projects/schemes related to disaster management/ mitigation/ capacity building.

(v) Loan: The State Authority may borrow money from the open market with the previous approval of State government to carry out disaster management functions as described in DM Act 2003.

(vi) Disaster Bonds: The State Government can also raise funds for major disasters by exploring the

options of long term disaster bonds.

(vii) Externally Aided Projects: Besides the funds, which are available through public funded schemes, efforts have alsobeen made by the Centre to mobilize the resources from external funding agencies forvulnerabilities assessment, capacity development, institutional strengthening of responsemechanism and mitigation measures etc. The Central Government would continue to supportthe States for reconstruction and rehabilitation on in the aftermath of major disasters through aidfrom Word Bank and other such external funding agencies.

7.2 Funds Disbursement and Audit

The funds raised from funding agencies are usually accompanied by stringent disbursement and usage restrictions. It is therefore important to monitor the disbursement of such funds to ensure that none of the covenants are breached. KSDMA, in conjunction with relevant agencies, shall monitor disbursal of funds by:

- Prioritizing resource allocation across approved projects
- Establishing mechanisms (like a chain of banks, collection centres, nature of accounts, spread etc.,) for collection of funds
- Ongoing monitoring and control of fund usage throughout actual project implementation.

CHAPTER 8

PLAN MAINTENANCE & UPDATION

The preparation, maintenance and updating the Disaster Management Plan is a dynamic process. To ensure the relevance and effectiveness of the DM Plan, it must be revised periodically, by incorporating the updated information, changes in Government policies, initiatives, and priorities as well as technological changes and global experiences. The Evaluation of the effectiveness of DM plans involves a combination of training events, exercises, and real-world incidents to determine whether the goals, objectives, decisions, actions, and timing outlined in the plan led to a successful response. In this way, the emergency preparedness exercises become an integral part of the planning process. The DM planners must be aware of lessons learnt from the recent disaster events and best practices adopted elsewhere. The trainings, mock drills and exercises is crucial to evaluate the operational aspects of the plan, fill up the gaps and improve the efficiency of the plan. The likelihood of emergencies and actual occurrences are also occasions for evaluating the plan, making innovations, and for updating the plan, SOPs and guidelines. At times, operations experience setbacks due to outdated information, ineffective procedures, incorrect role assignments, and outdated norms. Further, the priorities for a jurisdiction may change over time, as the makeup of the included communities change, as resources expand or contract, and as capabilities evolve.

8.1 Training

At different levels, the nodal agency tasked with developing respective DM plan, has to disseminate it to all other agencies associated with the plan execution having with specific responsibilities (State Govt. depts. etc.,).These key stakeholder agencies are required to train their personnel, so that they have the knowledge, skills and abilities needed to perform the tasks identified in the plan. Each agency shall assign nodal officers for DM and prepare adequate training schedule. Each nodal agency for DM must hold workshops, training programs with mock drills, at least twice a year. Such programs are crucial to ensure full preparedness and to maintain operational readiness of the disaster response teams,

institutional mechanisms, and the equipment. It also helps to test their readiness to deploy within the shortest possible time following the DMP activation. They shall be conducted in a manner similar to that of the drills carried out firefighting department or the army units. These workshops and drills must be held at the pre-designated locations under the guidance of the designated incident commanders and associated departmental heads. These trainings go beyond concepts and guidelines into inculcating in the individuals the critical importance of working as a coherent team for emergency response with a clear chain of command. The workshops and drills will also provide an opportunity to practice and update SOPs.

8.2 Plan Testing

The Commissioner of Relief, Revenue Dept. (DM) shall prepare, review and update Landslide Management Plan periodically. He shall also ensure that Landslide management drills and rehearsals are carried out periodically. While updating the plan, the following aspects need to be considered annually:

- Critical analysis of the outcome of exercises & mock drills as part of plan testing
- Incorporation of lessons learnt in the updated plan as an outcome of mock exercises through identification of gaps and measures to fill them

The plan must be thoroughly tested and evaluated on a regular basis, at least once a year. The main objectives of plan testing are to:

- Determine the feasibility and compatibility of back up facilities and procedures
- Identify areas in the plan that needs modification
- Identify training needs of key stakeholders
- Assess the ability of the organization/department to respond to Landslides

After plan testing and incorporation of lessons learnt, the Revenue Department (DM) should send a copy of the revised and updated plan to the following officials:

- Chief Secretary, Government of Karnataka
- Commissioner, Karnataka State Disaster Management Authority
- Principal Secretary, Revenue Dept. (Disaster Management)
- Heads of all line Depts.
- State EOC
- District EOCs
- ERCs

- GSI
- KSNDMC

All the departments, which have specific roles and responsibilities in Landslide Management Plan, must have a system to ensure that all officers of their departments who have a specific role to play are fully updated with their responsibilities/tasks.

8.3 Mock Exercises

- Mock exercise debriefing and evaluation is of critical importance as the insights are collected from participants and is used to modify the plan
- Hot debriefing is very effective as it is carried out immediately after the exercise. It also includes documentation in terms of recommendations and improvements of the plan

8.4 Review & Updation of Plan

The Landslide Management Plan should be reviewed and updated annually. The plan updation process should normally begin in January each year and should be completed by month of April, based on inputs from the following:

- Drills and rehearsals
- Lessons learnt from any disaster event in other States and Countries
- After significant change in operational resources (e.g., policy, personnel, organizational structures, management processes, facilities, equipment)
- After every case of plan activation in anticipation of an emergency
- A change in the district's demographics or hazard or threat profile
- Enactment of new or amended laws or ordinances
- Directions from Ministry of Home Affairs, National Disaster Management Authority, Government of India, etc.,

KSDMA and all other concerned Line Departments should encourage formal and informal interaction with various stakeholders at different levels to learn and document their experiences, so that such experiences can contribute constructively towards updation of Landslide Management Plan for further improving the capability to deal with future Landslides.

In exceptional circumstances, where the magnitude of the incidence or the situation demands, appropriate authority will make necessary amendments. The State government departments to cooperate and actively participate in the process of DM plan revision.

AS PER SECTION 23(5) OF THE DM ACT, DM PLANS ARE TO BE REVIEWED AND UPDATED ANNUALLY