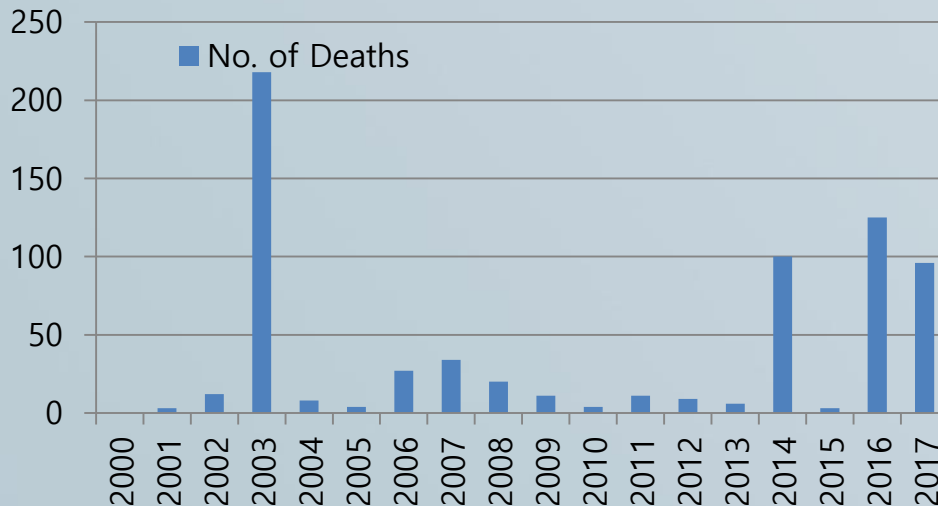


Landslide Risk Reduction in Sri Lanka

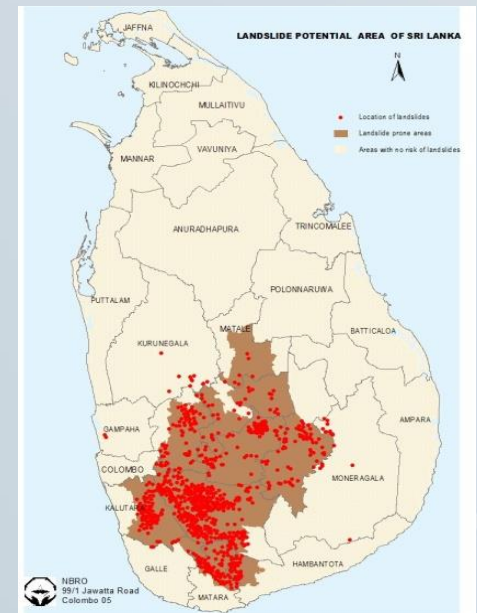
*Eng (Dr.) Asiri Karunawardena,
Director General,
National Building Research Organisation
Sri Lanka*

Landslides in Sri Lanka

- Landslides have become a frequent natural hazard in central highlands of Sri Lanka, which disturbs its life, causes damage to property, constructed facilities and infrastructure.
- Nearly 20% of the land area from 65,000 sq. km of total area in Sri Lanka is identified as landslide prone. Nearly 30% of total population live in these areas.



Number of lives lost due to landslides/slope failures:2000-2017



Landslide Potential Area

Landslides in Sri Lanka



Landslides in Sri Lanka



Kalawana 2003



NBRO

Peradeniya Landslide

Peradeniya 2006



Padiyapelella 2007



Reactivation of Beragala Landslide (Badulla District) 2009

Landslide along major roads



Kahagolla Landslide



Damages due to Unplanned Construction



Pilimathalawa 2007



Nildandahinna - 2007

Non Engineered Construction Leading to Cutting Failures Along Main Roads

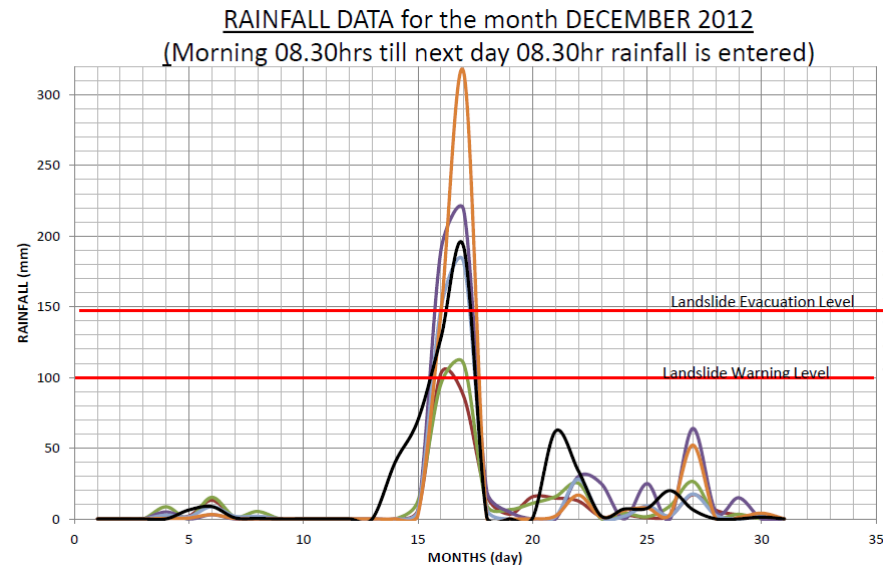
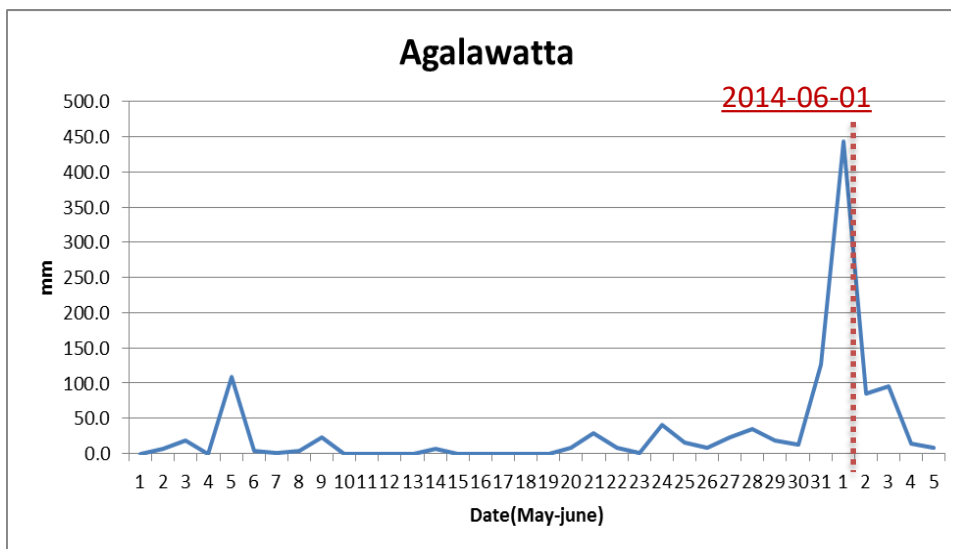
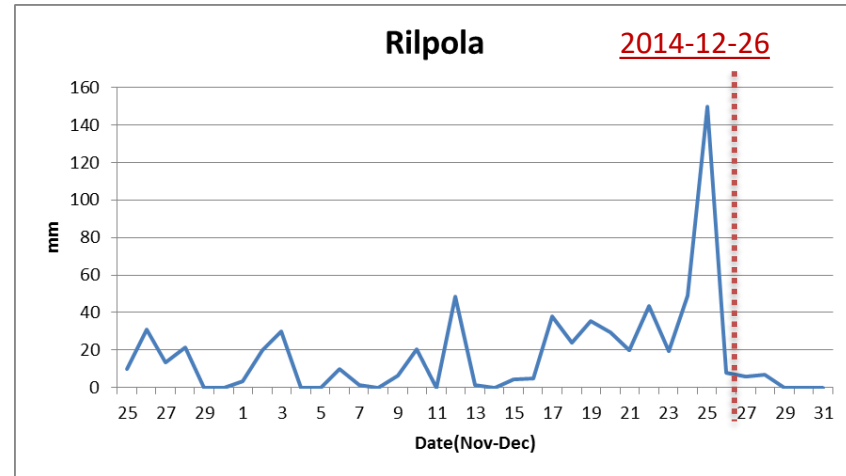
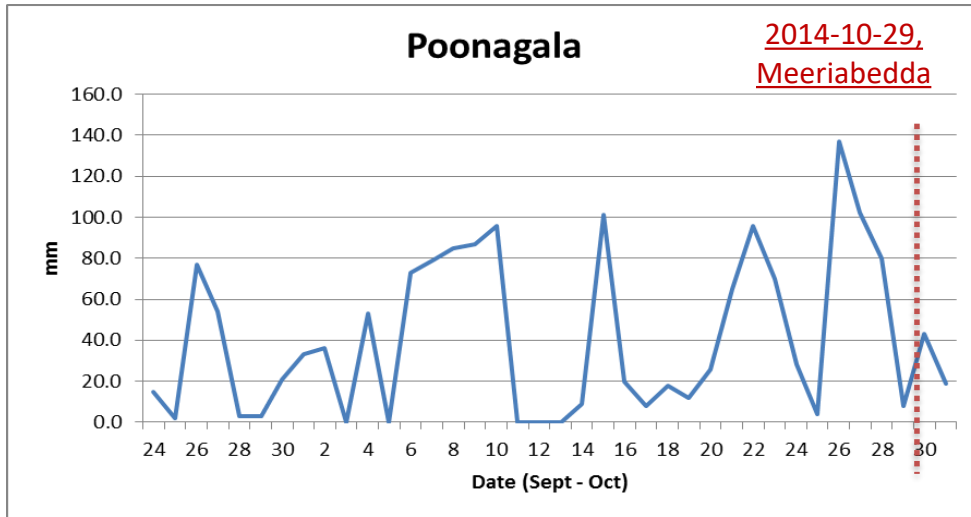


Recent Cutting Failures



Landslides in Sri Lanka

Main triggering factor- Rainfall



Our Strategies In Landslide Risk Management

- Landslide identification and hazard zonation mapping
- Integrate from Hazard to Risk management
- Landslide monitoring and early warning and awareness
- Landslide risk assessment for development and construction projects
- Landslide Special Investigations
- Structural mitigation works
- Related policy development and planning

Landslide Identification & Hazard Zonation Mapping

Mapping Process

Key Map



Former Landslide

Slope range and slope category

Bedrock geology and Structure

Colluvium and Residual soil

Landform and Erosion

Hydrology and Drainage

Rainfall

Human Settlements & Infrastructure

Landuse & Management

*
Ground Surveys
*
Field Investigations
*
Available Maps
*
Unpublished materials

Attribute Maps

Terrain factors & Weightings

- BEDROCK GEOLOGY - 20
- SOIL COVER - 10
- SLOPE RANGE & CATEGORY - 25
- HYDROLOGY & DRAINAGE - 20
- LAND USE & MANAGEMENT - 15
- LAND FORM - 10

Allocated weights for attributes and factor maps according to the statistical analysis and experts knowledge

Final Product

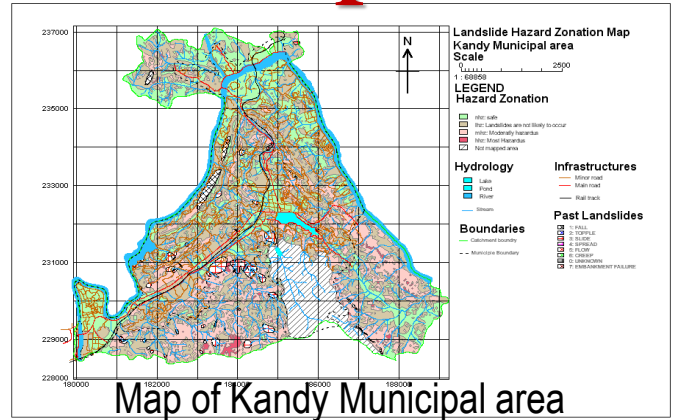
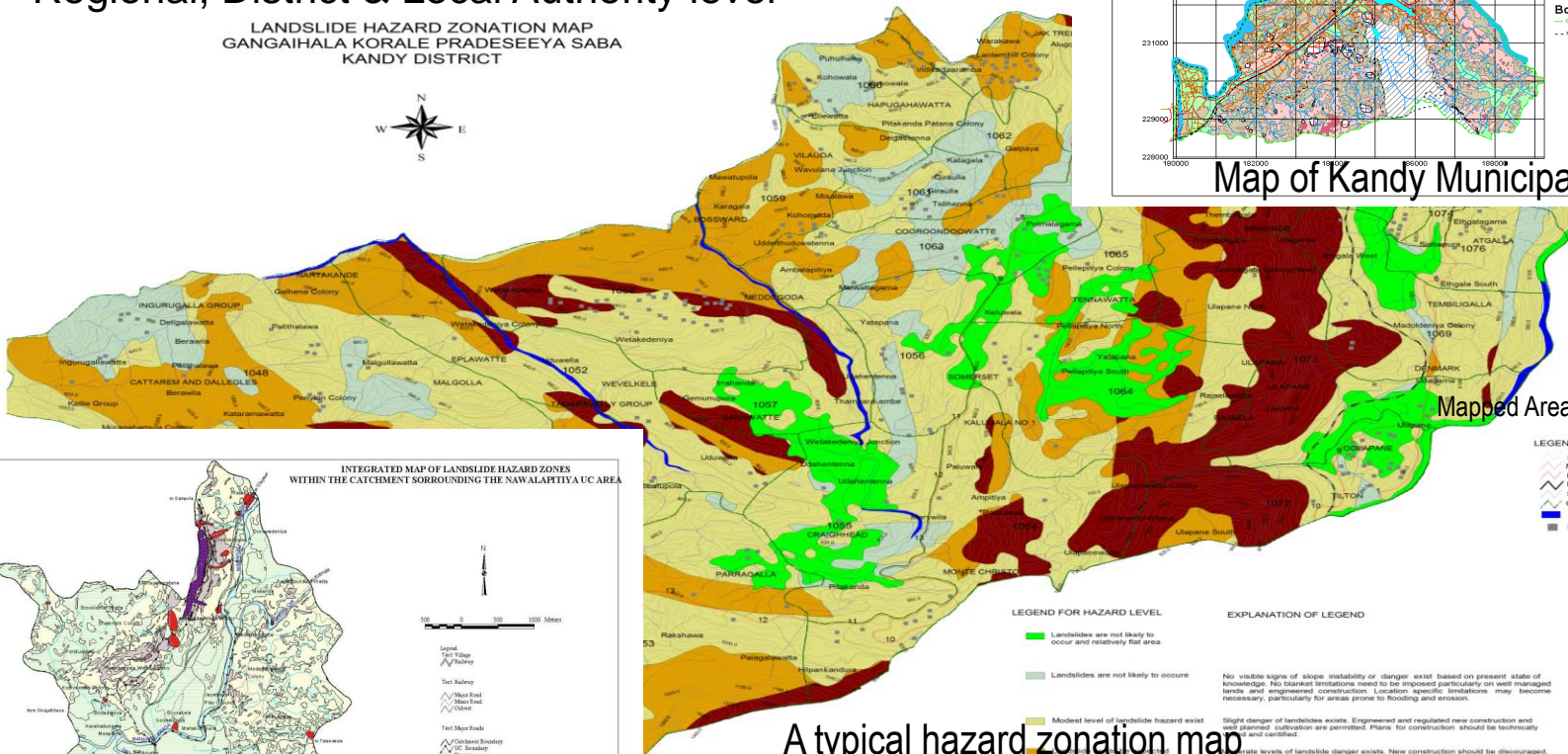


LANDSLIDE HAZARD MAP

Landslide Hazard Zonation Maps

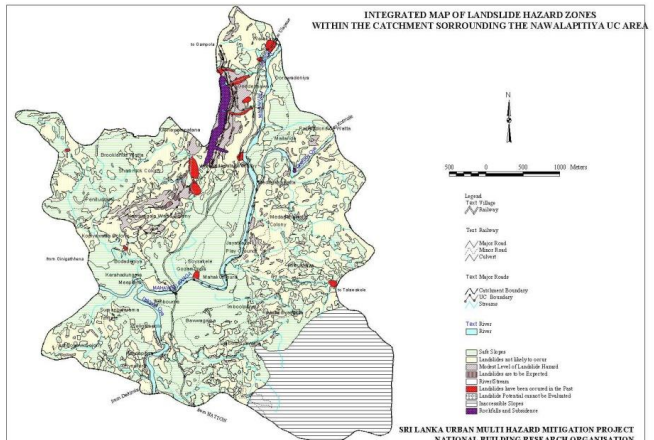
Landslide Hazard Zonation Maps at different levels,
Regional, District & Local Authority level

LANDSLIDE HAZARD ZONATION MAP
GANGAIHALA KORALE PRADESEEYA SABA
KANDY DISTRICT



Map of Kandy Municipal area

Mapped Area



A typical hazard zonation map

1st edition, July -2012

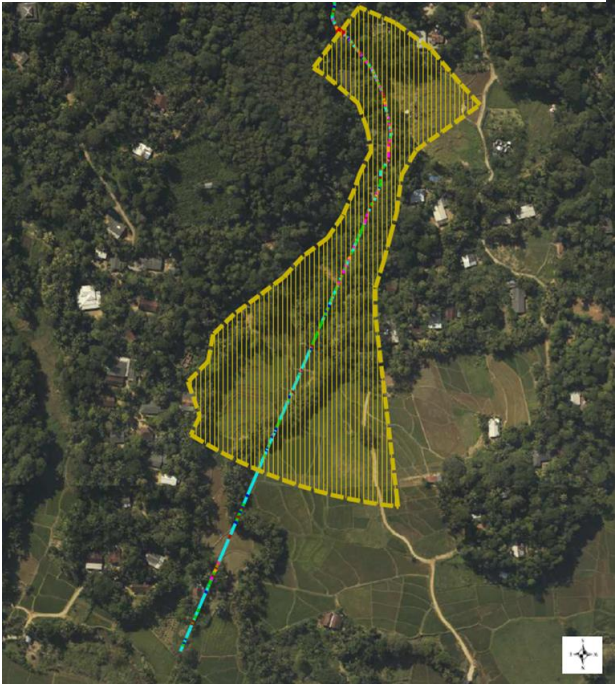
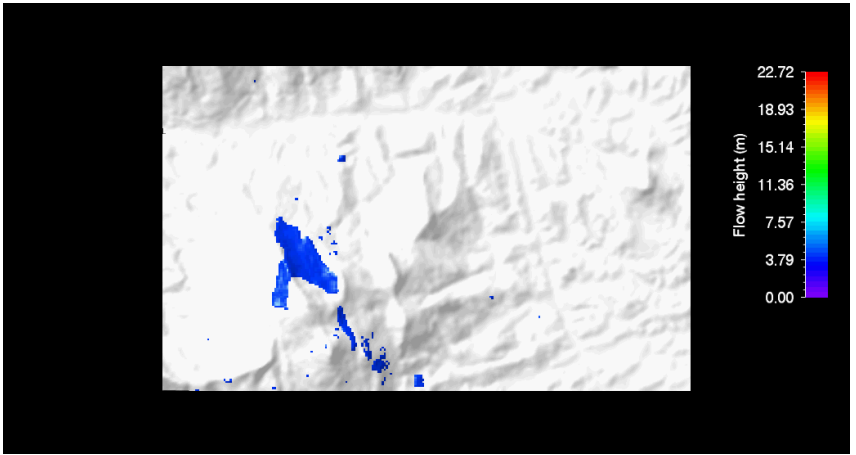
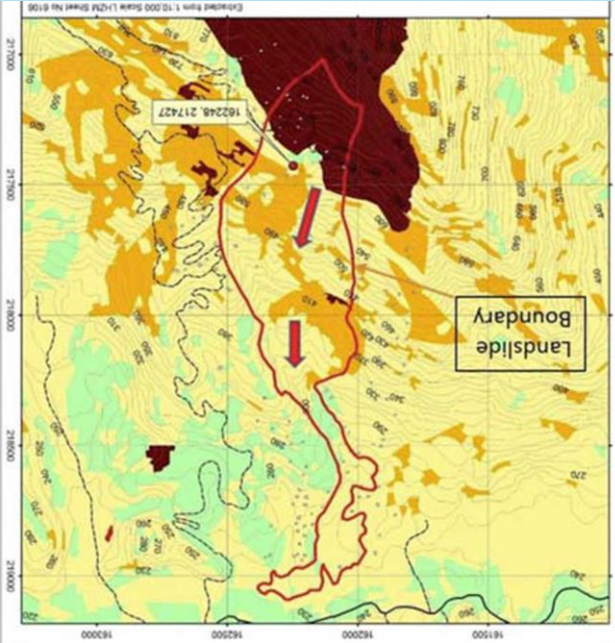
Map of Nawalapitiya Urban Council area

Development of Flow paths

Day 2016.5.17__17:00

2016.5.18__0:00

Damage 28dead,99missing



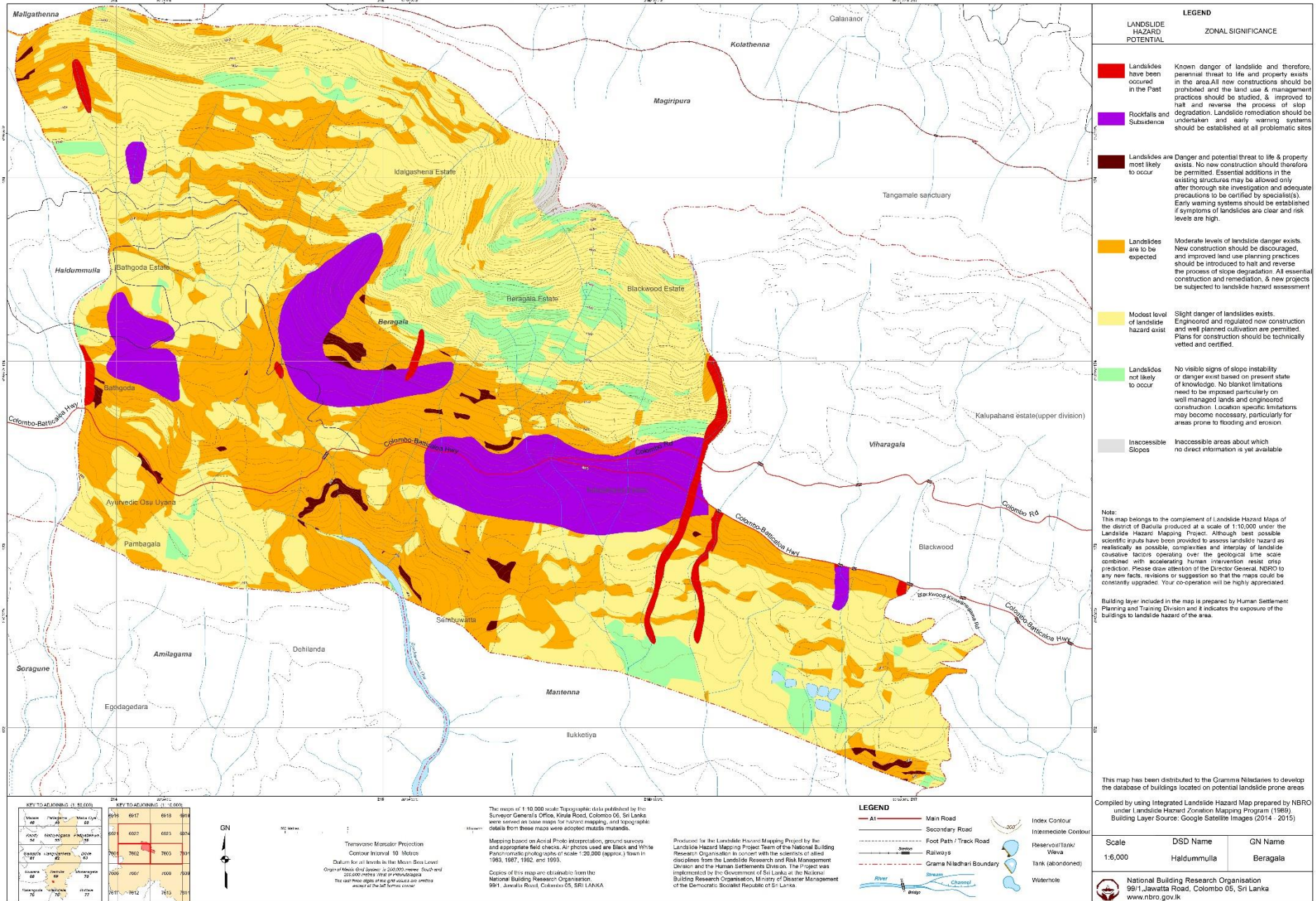
DEVELOPMENT INTEGRATED LANDSLIDE HARZED MAPS

BUILDING FOOTPRINTS



INTEGRATED LANDSLIDE HAZARD ZONATION MAP

INTEGRATED LANDSLIDE HAZARD ZONATION MAP OF BERAGALA GRAMA NILADHARI DIVISION IN BADULLA DISTRICT



LANDSLIDE HAZARD POTENTIAL	ZONAL SIGNIFICANCE	
█	Landslides have been occurred in the Past	Known danger of landslide and therefore, perennial threat to life and property exists in the area. All new constructions should be prohibited and the land use & management practices should be studied, & improved to halt and reverse the process of slope degradation. Landslide remediation should be undertaken and early warning systems should be established at all problematic sites
█	Rockfalls and Subsidence	
█	Landslides are most likely to occur	Danger and potential threat to life & property exists. No new construction should therefore be permitted. Essential additions in the existing structures may be allowed only after thorough site investigation and adequate precautions to be certified by specialist(s). Early warning systems should be established if symptoms of landslides are clear and risk levels are high.
█	Landslides are to be expected	Moderate levels of landslide danger exists. New construction should be discouraged, and improved land use planning practices should be introduced to halt and reverse the process of slope degradation. All essential construction and remediation, & new projects be subjected to landslide hazard assessment
█	Moderate level of landslide hazard exist	Slight danger of landslides exists. Engineered and regulated new construction and well planned cultivation are permitted. Plans for construction should be technically vetted and certified.
█	Landslides not likely to occur	No visible signs of slope instability or danger exist based on present state of knowledge. No blanket limitations need to be imposed particularly on well managed lands and engineered construction. Location specific limitations may become necessary, particularly for areas prone to flooding and erosion.
█	Inaccessible Slopes	Inaccessible areas about which no direct information is yet available

Note:
This map belongs to the complement of Landslide Hazard Maps of the district of Badulla produced at a scale of 1:10,000 under the Landslide Hazard Mapping Project. Although best possible scientific inputs have been provided to assess landslide hazard as realistically as possible, complexities and interplay of landslide causative factors operating over the geological time scale combined with accelerating human intervention resist crisp prediction. Please draw attention of the Director General, NBRD to any new facts, revisions or suggestion so that the maps could be consistently upgraded. Your co-operation will be highly appreciated.

Building layer included in the map is prepared by Human Settlement Planning and Training Division and it indicates the exposure of the buildings to landslide hazard of the area.

This map has been distributed to the Gramma Niladharis to develop the database of buildings located on potential landslide prone areas

Compiled by Integrated Landslide Hazard Map prepared by NBRD under Landslide Hazard Zonation Mapping Program (1989)
Building Layer Source: Google Satellite Images (2014 - 2015)

NPT TO ADU (1:50,000)		NPT TO ADU (1:25,000)	
6515	6517	6513	6514
6503	6502	6503	6504
7003	7002	7003	7004
7503	7502	7503	7504
8003	8002	8003	8004
8503	8502	8503	8504

GN

Transverse Mercator Projection
Contour Interval: 10 Meters
Datum for all levels in the Mean Sea Level
Origin of Mean Sea Level: 20000 meters (at Peradeniya)
The all these maps are for visual use only and should not be used for any other purpose.

The maps of 1:10,000 scale Topographic maps published by the Surveyor General's Office, Kotte Road, Colombo 05, Sri Lanka were used as base maps for hazard mapping, and topographic details from these maps were adopted mostly as standards.

Mapping based on Aerial Photo Interpretation, ground surveys and appropriate field checks. Air photos used are Black and White Panoramic photographs of scale 1:20,000 (approx.) taken in 1985, 1987, 1992, and 1993.

Copies of this map are obtainable from the National Building Research Organisation
99/1, Jawatta Road, Colombo 05, SRI LANKA

Prepared for the Landslide Hazard Mapping Project by the Landslide Hazard Mapping Project Team of the National Building Research Organisation in concert with the scientists of allied disciplines from the Landslide Research and Risk Management Division and the Human Settlements Division. The Project was implemented by the Government of Sri Lanka, the National Building Research Organisation, Ministry of Disaster Management of the Democratic Socialist Republic of Sri Lanka.

LEGEND

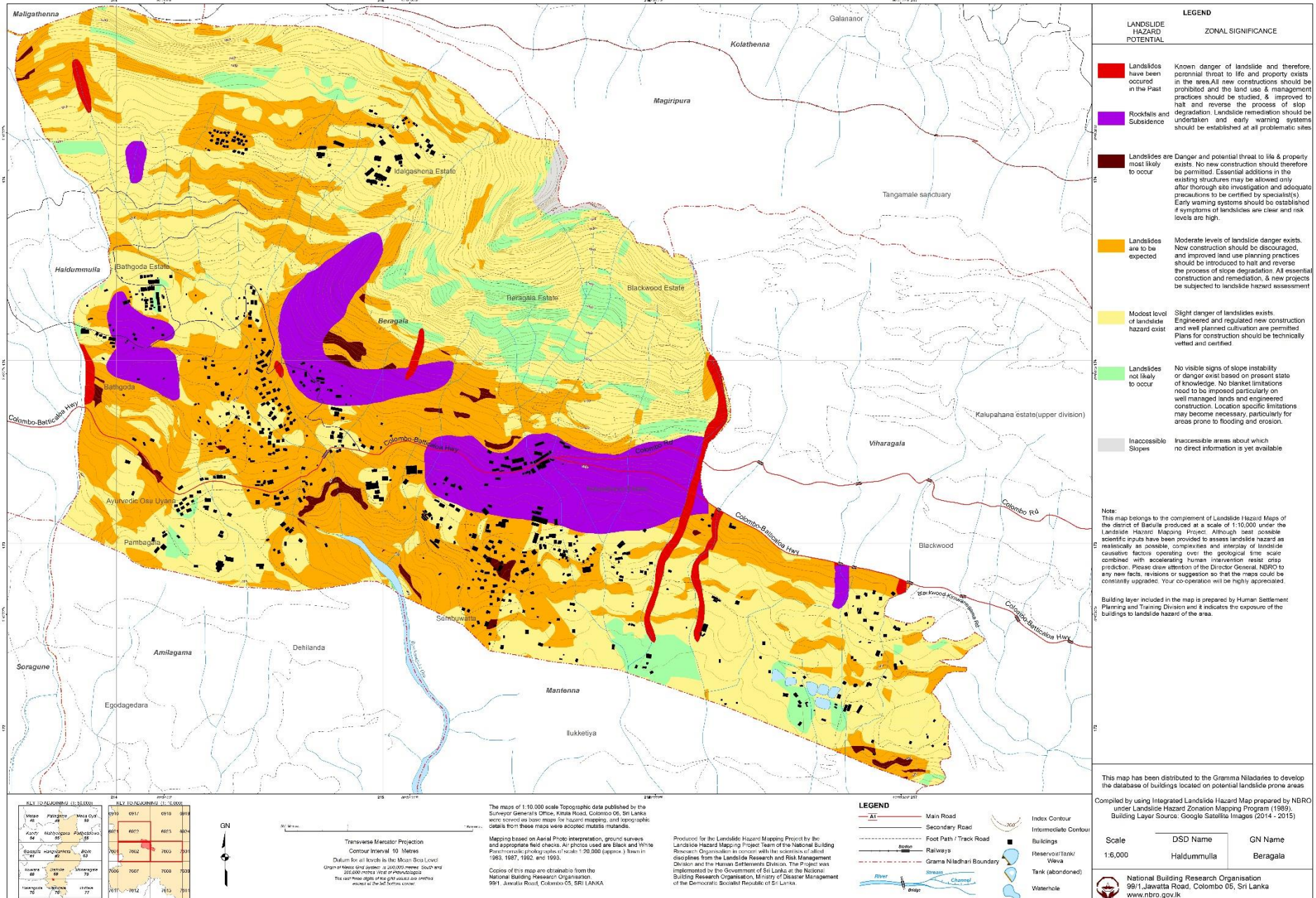
- Main Road
- Secondary Road
- Foot Path / Track Road
- Railways
- Grama Niladhari Boundary
- River
- Stream
- Channel
- Slope
- Index Contour
- Intermediate Contour
- Reservoir/Tank/Wewa
- Tank (abandoned)
- Waterhole

Scale	DSD Name	GN Name
1:6,000	Haldummulla	Beragala

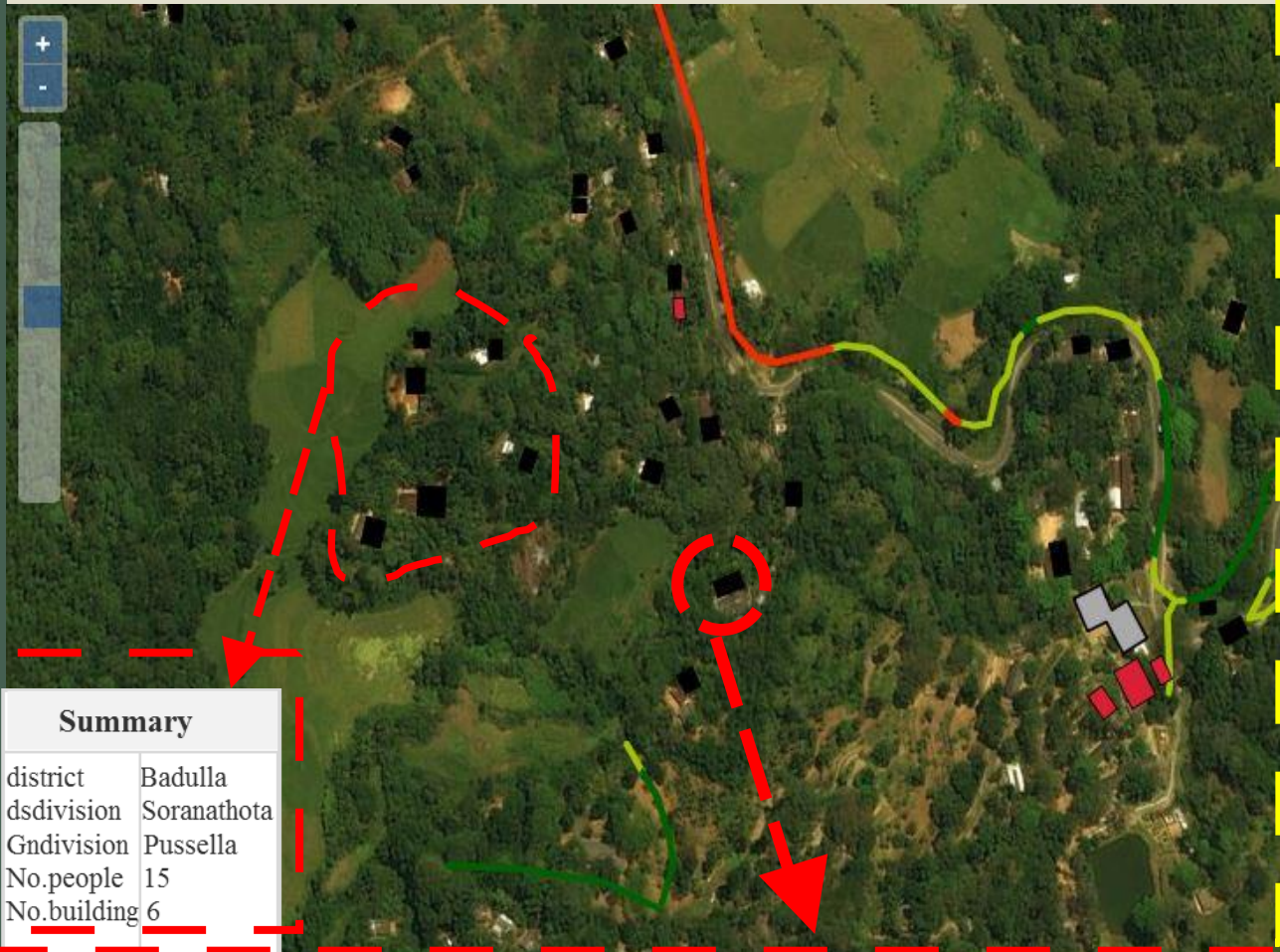
National Building Research Organisation
99/1, Jawatta Road, Colombo 05, Sri Lanka
www.nbro.gov.lk

BUILDINGS EXPOSURE TO LANDSLIDE HAZARD

BUILDINGS EXPOSURE TO LANDSLIDE HAZARD IN BERAGALA GRAMA NILADHARI DIVISION IN BADULLA DISTRICT



DATABASE ON ELEMENTS AT RISK – Data Base



Landslide Hazard Information System

Landslide Prone Areas

Measure Distance/Area

Select **Search**

option in different levels

Feature Filter

Select a layer

Clear filters

Layers

- SPATIAL BOUNDARIES
- TYPES OF BUILDINGS
- SPATIAL LAYERS
- BASE LAYERS

Summary

district	Badulla
dsdivision	Soranathota
Gndivision	Pussella
No.people	15
No.building	6

The attributes of the selected feature.
Please select a layer in the "Popup Layer" dropdown menu. Click on a feature of the selected layer to display the data.

Popup Layer

household Info

household									
fid	sub_number	district	dsdivision	gndivision	sub_num_b	head_house	home_addr	contact_n	contact_no
household.198	42	Badulla	Soranathota	Pussella	42	R.V Edawad Perera	8th Mile post,Thaldena,Badulla	555331846	No_Info

Retrieve data
from selected area or building



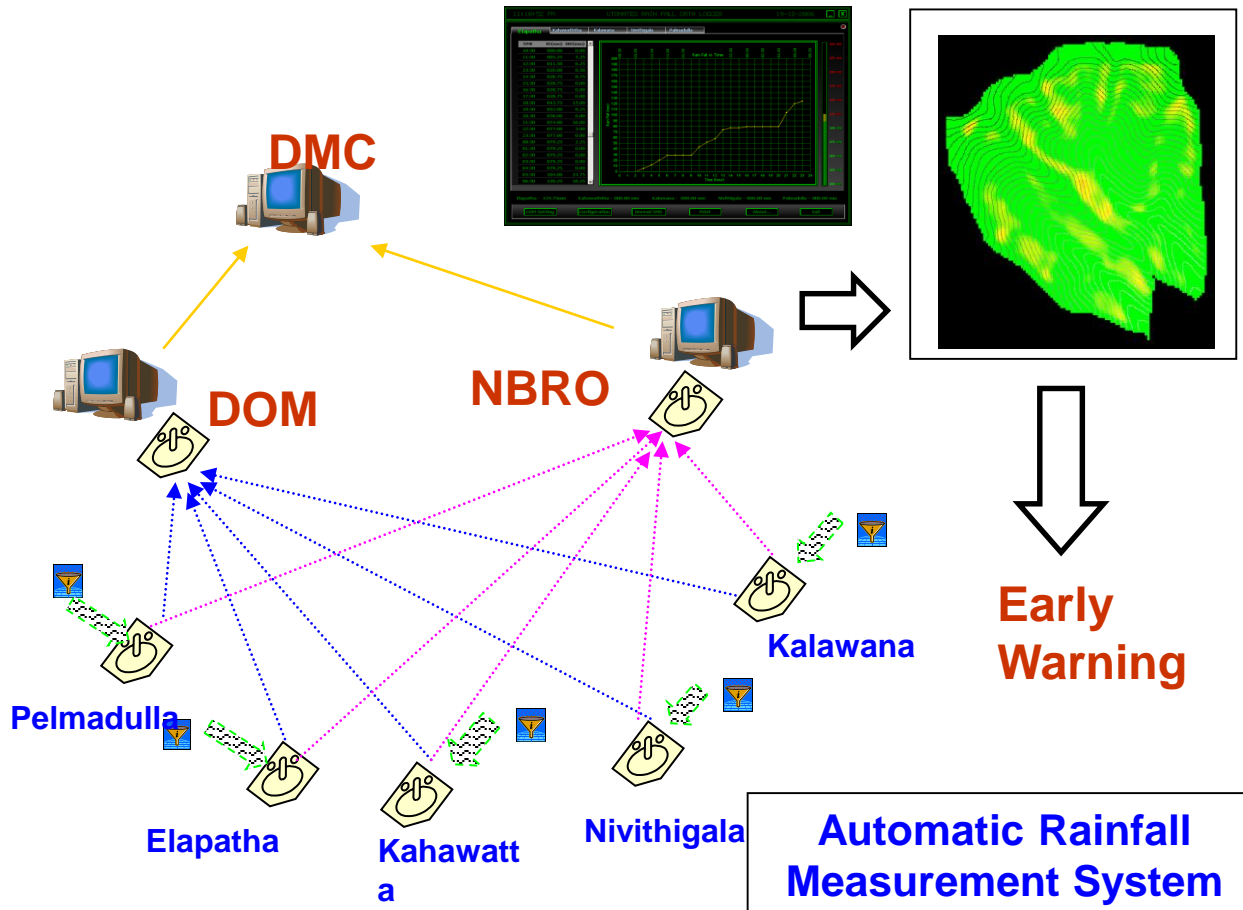
Details of the Risk Levels of the landslide prone locations at all districts

Investigation and Identification of Vulnerable Communities and High Risk Settlements

#	Province	District	Number of Houses in High Risk
1	Uva	Badulla	6,418
		Kandy	1,292
2	Central	Nuwara Eliya	3,496
		Matale	210
		Rathnapura	757
3	Sabaragamuwa	Kegalle	824
		Matara	591
4	Southern	Hambantota	343
		Kalutara	929

Real Time Landslide Monitoring & Early Warning

- 100 automated rain gauge stations in pre-selected catchments in landslide prone districts



Warning and Evacuation

Standard threshold limits of the Rainfall for landslides

Alert 75 mm/day

Warning 100mm/day

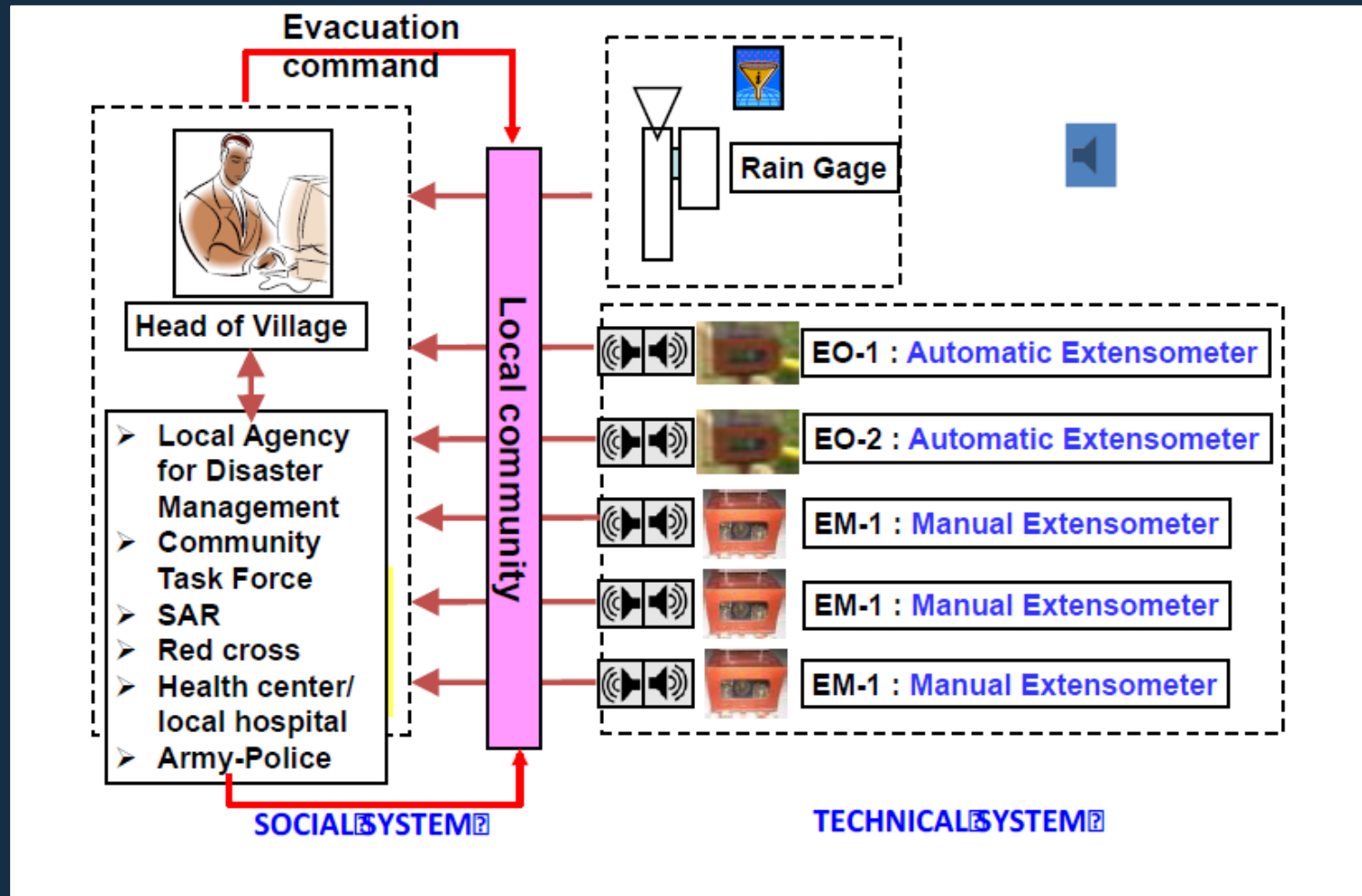
Evacuation, Off limit 75 mm/hour or 150mm/day

Early Warning

Automatic Rainfall Measurement System

Rainfall data is used in computer simulation and early warning is issued depending on threshold limits

Site specific/CB Monitoring, Forecasting and Early Warning



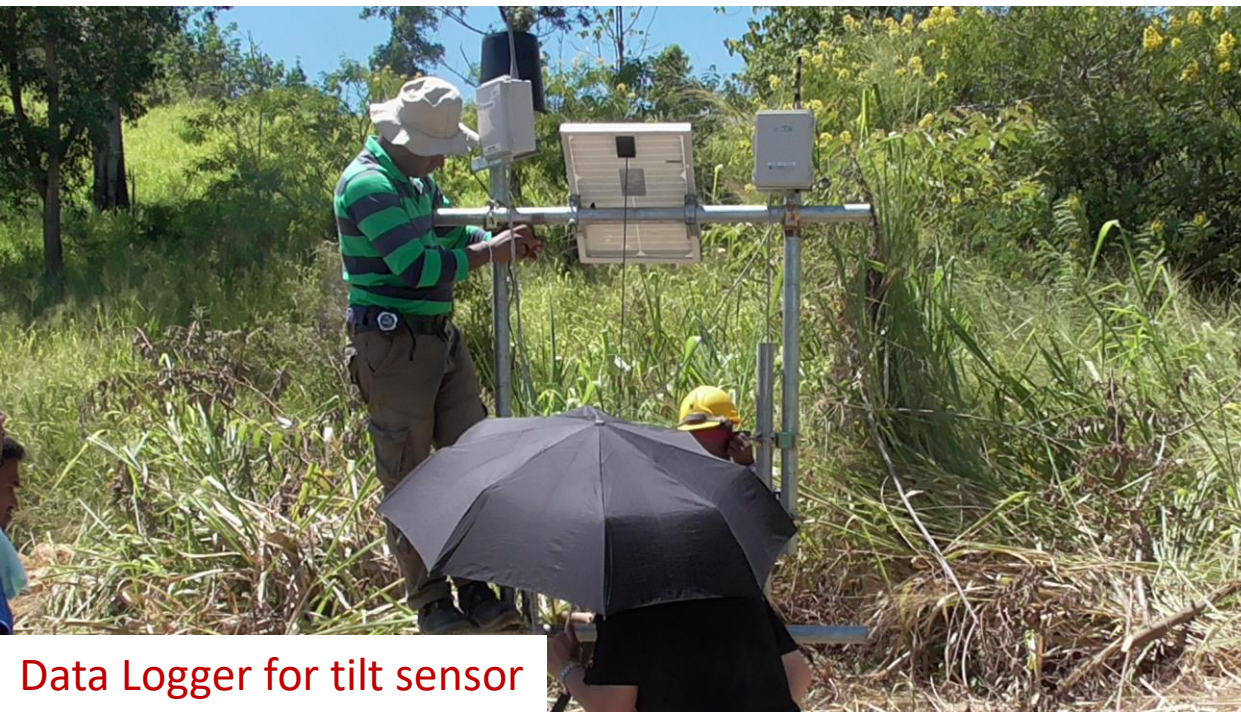
Schematic diagram of the socio-technical management system on landslide early warning



Extensometer

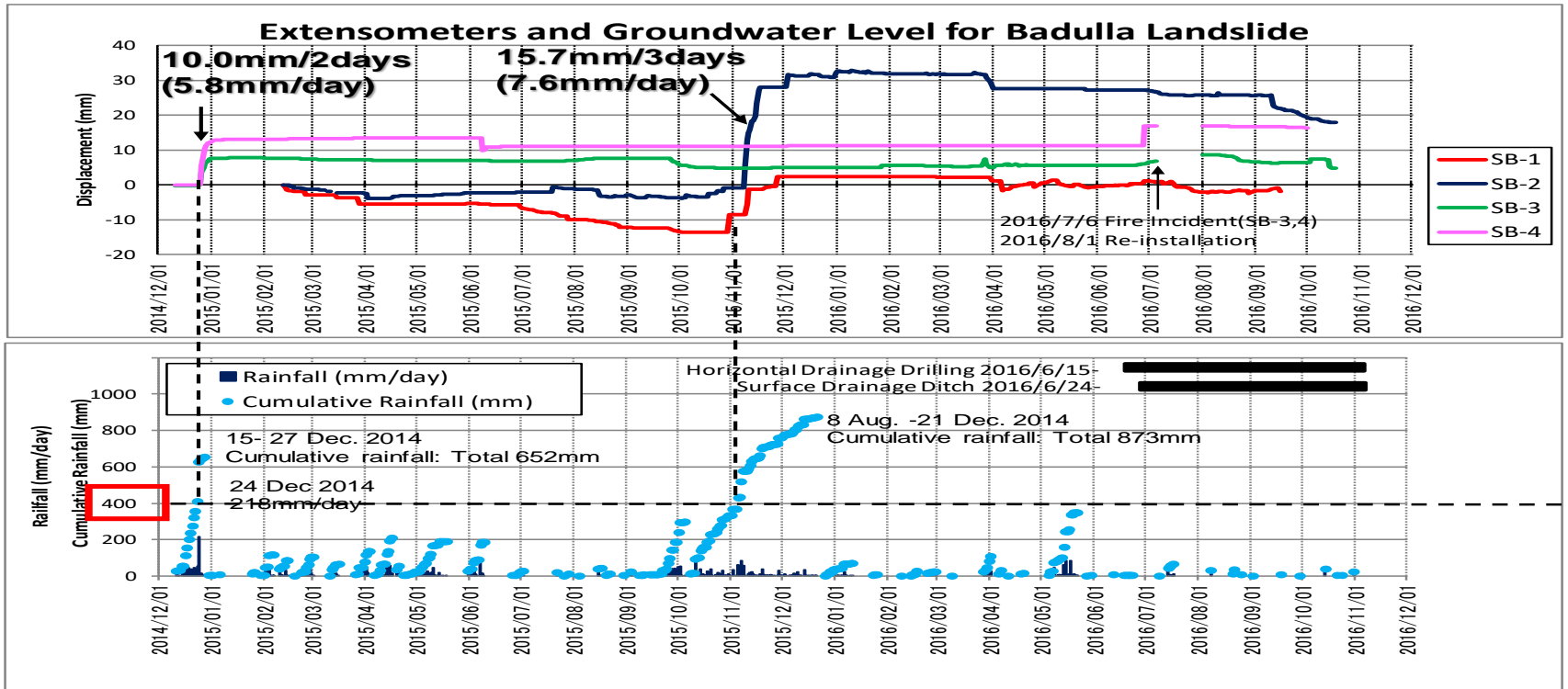
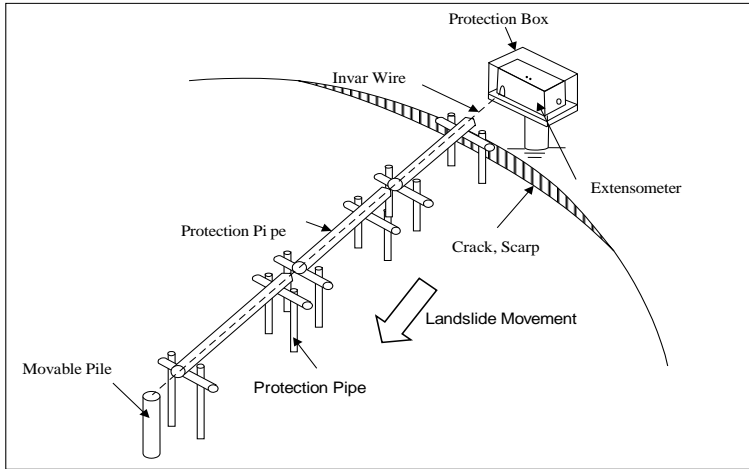


Tilt Sensor



Data Logger for tilt sensor

Instrumentation and Monitoring



*Thank
you*