

Guideline for Disaster Resilient Land Use Regulation / Development Standards

Project for Capacity Strengthening on Development of Non-Structural Measures for Landslide Risk Reduction in Sri Lanka

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**National Building Research Organisation
(NBRO)**



**Japan International Cooperation Agency
(JICA)**



**GUIDELINE
FOR
DISASTER RESILIENT LAND USE
REGULATION / DEVELOPMENT
STANDARDS**

PROJECT SABO

National Building Research Organization

Japan International Cooperation Agency

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INDEX

| | | |
|------------------|---|-----------|
| CHAPTER 1 | INTRODUCTION..... | 1 |
| 1.1 | BACKGROUND | 1 |
| 1.2 | OBJECTIVE..... | 1 |
| 1.3 | SCOPE OF THE GUIDELINE..... | 1 |
| CHAPTER 2 | SEDIMENT DISASTERS AND COUNTERMEASURES IN SRI LANKA..... | 3 |
| 2.1 | TREND OF SEDIMENT DISASTERS..... | 3 |
| 2.2 | OVERVIEW OF COUNTERMEASURES AGAINST SEDIMENT DISASTERS | 8 |
| CHAPTER 3 | LAND USE CLASSIFICATION AND REGULATION | 10 |
| 3.1 | OVERVIEW..... | 10 |
| 3.2 | LEGAL ARRANGEMENT AND REGULATIONS LAND USE AND DEVELOPMENT | 10 |
| 3.3 | OUTLINE OF YELLOW/RED ZONE..... | 12 |
| 3.4 | LAND USE ZONING GUIDE..... | 14 |
| CHAPTER 4 | DEVELOPMENT STANDARD | 19 |
| 4.1 | OVERVIEW..... | 19 |
| 4.2 | DEVELOPMENT AND COUNTERMEASURES IN “RESTRICTED ZONE” | 19 |
| 4.3 | DEVELOPMENT AND COUNTERMEASURES IN “CONTROLLED ZONE” | 20 |
| 4.4 | DEVELOPMENT AND COUNTERMEASURES IN “WARNING ZONE” | 21 |
| 4.5 | DEVELOPMENT AND COUNTERMEASURES IN “DEVELOPMENT ZONE” | 22 |
| CHAPTER 5 | IMPLEMENTATION OF LAND USE ZONING AND DEVELOPMENT STANDARDS..... | 23 |
| 5.1 | INTRODUCTION..... | 23 |
| 5.2 | SDRRP | 23 |
| 5.3 | DEVELOPMENT PLAN AND BY-LAW | 26 |
| 5.4 | IMPLEMENTATION OF LAND USE ZONING FOR SDRRP | 26 |

ABBREVIATION

| | |
|--------|--|
| DMC | Disaster Management Centre |
| DS | Divisional Secretariat |
| GN | Grama Niladhari |
| HR | Hazard Risk |
| H & TI | Housing and Town Improvement |
| LUPPD | Land Use Policy Planning Department |
| LAB | Landslide Approval for Building |
| LAD | Landslide Approval for Development |
| LHM | Landslide Hazard Map |
| LA | Local Authority |
| MOD | Ministry of Defense |
| MLIT | Ministry of Land, Infrastructure, Transport and Tourism, Japan |
| MC | Municipal Council |
| NBRO | National Building Research Organisation |
| NCDM | National Council for Disaster Management |
| NNDIS | National Natural Disaster Insurance Scheme |
| NPPD | National Physical Planning Department |
| PS | Pradeshiya Sabha |
| SDRRP | Sediment Disaster Risk Reduction Plan |
| UC | Urban Council |
| UDA | Urban Development Authority |
| Y/R | Yellow/Red |

CHAPTER 1 INTRODUCTION

1.1 Background

Sediment Disaster is one of the most serious natural disasters in Sri Lanka. In the central and southern mountainous areas, sediment disasters such as slope failures, landslides, and debris flow frequently occur in the monsoon period because of the fragile geology and steep topography. In recent years, sediment disasters caused by heavy rainfall in the spring monsoon season become severer. It is still fresh memory that the large-scale landslide in Aranayake, Kegalle district killed 130 lives in May 2016. In addition, increasing exposure to the hazards due to rapid reclamation and development has been raising sediment disaster risks in urban and rural areas. The Establishment and improvement of the early warning system and legal arrangement for land use planning and development standards are urgent issues in Sri Lanka.

National Building Research Organization (NBRO) under the Ministry of Defense (MOD) with the assistance of the Government of Japan has made efforts to improve the early warning system and legal arrangement for land use planning and development standards. However, to further mitigate sediment disaster risks in Sri Lanka, accurate risk assessment, early warning mechanism, and land use planning based on the assessment are required.

1.2 Objective

The main objective of this guideline is for advocating the practitioners to reduce the sediment disasters risks in Sri Lanka through reducing the exposure and vulnerability to sediment disasters by land use regulation and development standards.

1.3 Scope of the Guideline

1.3.1 Main Target Users of Guideline

The main target users of the guideline are the practitioners of land use planning and development control of both the national government and local government. The officials of Local Authorities (LA), Urban Development Authority (UDA), National Physical Planning Department (NPPD), Land Use Policy Planning Department (LUPPD), and NBRO are assumed as the target users of national and local government.

1.3.2 Composition of Guideline

The guideline consists of five chapters: “Chapter 1: Introduction”, “Chapter 2: Sediment Disaster and Countermeasures in Sri Lanka”, “Chapter 3: Land Use Classification and Regulation”, “Chapter 4: Development Standards” and “Chapter 5: Implementation of Land Use Zoning and Development Standards”.

“Chapter 1: Introduction” addresses the background, objectives, and scope of the guideline as an introductory part of the guideline.

“Chapter 2: Sediment Disaster and Countermeasures in Sri Lanka” shows the tendency of the sediment disasters in Sri Lanka and the outline of countermeasures to the disasters. The tendency of the sediment disaster covers increasing exposure to the hazards due to development in hilly and

mountain areas, and the source and the extent of the impact in the recent sediment disasters. For the countermeasures to the sediment disasters, hazard risk mapping and measures including both structural measures and non-structural measures are also introduced.

“Chapter 3: Land Use Classification and Regulation” shows basic ideas of land use regulation where sediment disaster risk is high, based on the recent tendency of increasing exposure to the hazards due to development in hilly and mountain areas as shown in Chapter 2. Chapter 3 also explains land use classification and regulations for the classified zones; the key points of the concerned laws and regulations; the idea of Yellow and Red zones as the extent of the disaster risks for each type of sediment disaster; four land use classifications based on Yellow and Red zones: Restricted Zone, Controlled Zone, Warning Zone, and Development Zone; possible land use activities at each zone.

“Chapter 4: Development Standards” states necessary development standards for the four land use classifications as explained in Chapter 3. Chapter 4 also addresses what measures including structural and non-structural are necessary for development activities in each zone.

“Chapter 5: Implementation of Land Use Zoning and Development Standards” explains a basic plan as Sediment Disaster Risk Reduction Plan (SDRRP) consisting of a land- use plan and other disaster reduction measures such as structural measures, early warning, evacuation, etc., which will be the basis to implement land use zoning and development standards. The SDRRP can be input to develop or update Development Plan to be prepared by UDA. This chapter also indicates the roles of the concerned stakeholders to implement the land use zoning of the Sediment Disaster Risk Reduction Plan.

CHAPTER 2 SEDIMENT DISASTERS AND COUNTERMEASURES IN SRI LANKA

2.1 Trend of Sediment Disasters

As of 2018, the NBRO inventory database has more than 3,000 documented sediment disasters. The sediment disasters have occurred in 12 districts and are especially concentrated in Kandy, Badulla, Ratnapura, and Kegalle districts, in the mountainous and hilly areas of Sri Lanka. The distribution of sediment disasters reflects regional geology, topography, and land use.

Sediment disasters are the most hazardous natural disasters in Sri Lanka, and the number of sediment disasters has been recently increasing nationwide (Figure 2-1). Many sediment disasters are associated with the cutting failure for house building and road construction. The recent increase in the number of sediment disasters is largely due to inappropriate land use planning and unplanned development onto sloping lands and previous landslide areas. Excavation at the base of slopes, particularly at the toes of potential and active landslides as well as colluvium slopes is the most common human trigger of sediment disasters.

In addition, almost all sediment disasters are associated with intense and/or prolonged periods of rainfalls, indicating that rainfalls are the main triggering factor of such disaster events. Improper planning and inappropriate maintenance of surface drainage systems also increase the potential for slope instabilities.

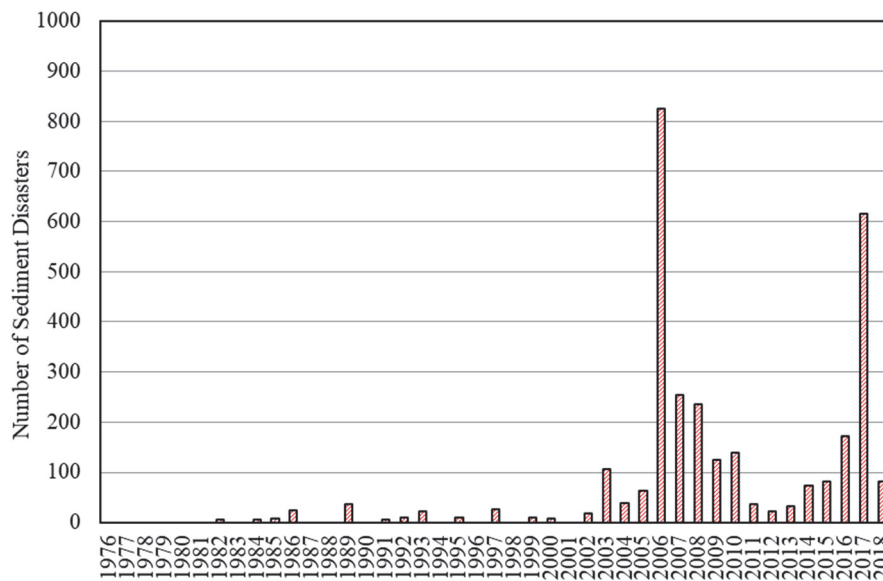


Figure 2-1: Yearly Occurrence of Sediment Disasters in Sri Lanka (1976 to 2018)

(※Systematic data collection was started after 2006)

2.1.1 Slides

Slides are used to describe a downward movement of slope materials along preexisting or potential rupture surfaces or zones according to MLIT, Japan (Figure 2-2). They are the major types of sediment disasters in Sri Lanka and are deep, rotational, or translational sliding caused by groundwater pressures within a gentle hillside. They normally move slowly and involve a relatively large volume of displaced mass, thereby causing significant damage to properties such as houses, roads, and other lifelines.

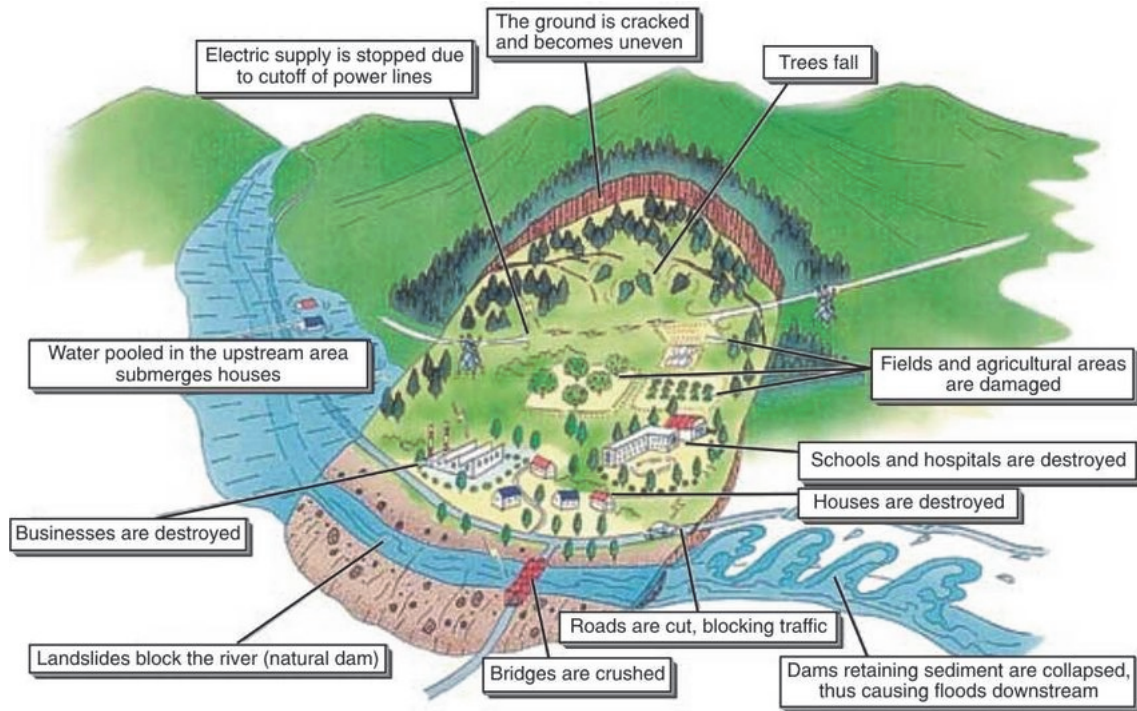


Figure 2-2: Damages by Slides

Source: MLIT, Japan

2.1.2 Slope Failures

Similar to slides, slope failures are also the major type of sediment disaster in Sri Lanka, but shallow, fast-moving on steep slopes, natural and artificial, with a relatively small volume of displaced mass. Slope failures, because of their fast-moving feature and without indication before movement, frequently result in serious injuries and fatalities even in the case of the small volume of displaced mass. Figure 2-3 illustrate the slope failure that occurred in Peradeniya (near Kandy) in 2011 which disrupted the transportation network and social life.



Figure 2-3: Slope failure occurred in Peradeniya

2.1.3 Debris Flows

Debris flows are also a common type of fast-moving sediment disaster in Sri Lanka. They usually start on upper steep hillsides mostly as shallow slope failures or occasionally as slides during intense rainfalls, then fast flow down hills and/or into channels, and finally spread widely on gently sloping grounds. Such sediment disasters, normally together with driftwoods, because of their fast-moving velocity and long-traveling distance, generally claim many lives in addition to the damage to roads, bridges, water supply lines, electricity, and so on along their traveling paths. Even small debris flows have a high potential to cause damage and loss of life.

In Sri Lanka, debris flows can be subdivided, from the viewpoint of hazard identification, into two subtypes, namely, channelized type and hillslope type. The hillslope type debris flows are generally unpredictable or difficult to identify prior to occurring because of no evidence or indication such as an alluvial fan or debris fan and therefore are also excluded from this guideline. Figure 2-4 shows the channelized type debris flow event that occurred in the 2017 Morawakkanda area, which was 3.1 km distance long between scarp to deposition area.



Figure 2-4: Debris Flow in Morawakkanda

2.1.4 Rock falls

Rockfalls are very rapid to extremely rapid fall-down of loosed and fractured rock blocks along steep rock slopes, natural, artificial or both. The fall-down movement takes place mainly through the air by free-fall, leaping, bounding or rolling. An inventory survey shows that rockfalls are



Figure 2-5: Image of Rockfall

common along many cut slopes for road constructions and house buildings, and therefore rockfalls threaten or damage transportation and residential areas. Figure 2-5 shows an image of a rockfall.

2.2 Overview of Countermeasures against Sediment Disasters

To reduce the risk of sediment disasters, there is no doubt that people should not live in sediment disaster-prone areas. However, since the land is limited, it is practically difficult to settle only in sediment disaster-free land such as flat plain apart from mountain hills. Therefore, it is important to 1) identify the existing risk, 2) reduce the risk to the level that people can tolerate, 3) strengthen the coping capacity of the people to the remaining risk, and 4) then, regulate land developments and settlements if the risk level is too high to live despite of the above efforts. Here introduces an outline of general countermeasures to reduce sediment disaster risk. The applicable measures are given in Chapter 4.

In the context of world trends on disaster risk reduction, all the stakeholders in Sri Lanka should follow Sendai Framework for Disaster Risk Reduction (2015-2030), which is the first major agreement of the post-2015 development agenda and provides the Member States including Sri Lanka with concrete actions to protect development gains from the risk of disaster. Its expected outcome is “The substantial reduction of disaster risk and losses in lives, livelihoods, and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries”. To achieve the outcome, it is pursued to “prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience”.

NBRO gives a concept of risk reduction measure for sediment disasters, which is consistent with the above outcome and goal of the Sendai Framework for Disaster Reduction, as shown in Figure 2-6. The risk reduction measures are divided into 1) risk identification, 2) risk communication and 3) risk mitigation. Risk communication includes early warning and education in which people obtain the right knowledge on sediment disasters and promptly receive real-time risk information. Risk mitigation includes development control and appropriate land use to establish disaster resilient society and measures to prevent the occurrence of sediment disasters.



Figure 2-6: Concept of Risk Reduction Measures against Landslides by NBRO (source: Jayathissa, 2015)

Moreover, the measures for sediment disaster risk reductions can be categories into 1) structural measures and 2) non-structural measures as shown in Figure 2-7.

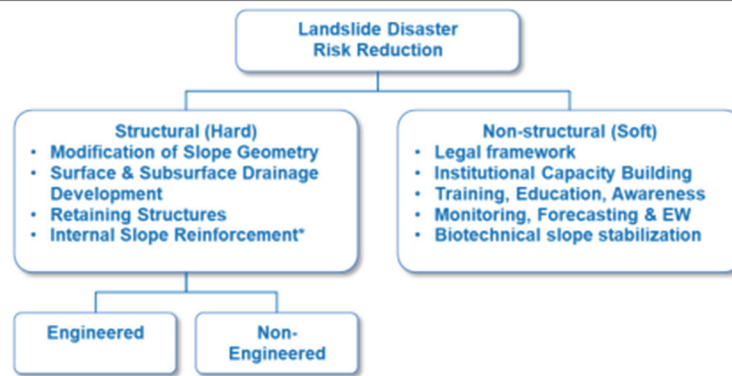


Figure 2-7: Structural and Non-structural Measures against Landslides (Source: Jayathissa, 2015)

Non-structural contains soft component measures such as legal framework; institutional capacity building; training, education, awareness; monitoring, forecasting, and early warning (EW); biotechnical slope stabilization, etc.

In addition to non-structural measures, there are two basic strategies by structural measures such as modification of slope geometry, surface, and subsurface drainage development, retaining structures, internal slope reinforcement, etc. to reduce landslide damages and losses due to landslide disasters:

- (1) Stabilization or Prevention Measures. Prevention measures, for potential landslides, such as slide and slope failure, are performed to directly improve their stabilities to the required levels. Typical prevention measures include grading the unstable portion of the slope to a lower or stable gradient, construction of rock buttresses and retaining walls, drainage improvements, and increase of force resisting sliding or failure. In general, prevention measures are typically moderate to high cost, but provide a long-term solution with low, long-term maintenance costs.
- (2) Protection Measures. Protection measures for potential landslides primarily focus on control, containment and/or diversion of the moving debris of landslide disaster, thereby protecting the involved residential houses and buildings as well as other infrastructures from landslide disasters. Such measures include retaining (containment) walls, embankments, and nets, sabo dams. Protection measures are generally low to moderate in cost compared to the above-mentioned prevention measures. However, considerable long-term maintenance costs are often associated with these measures to clean out and dispose of accumulated debris behind and inside these facilities (measures).

It should be also noted that stabilization measures seek to counter one or more key failure mechanisms and improve stability of the slope, thereby reducing the likelihood of landslide hazards; while protection measures allow landslide occurrence and seek to avoid, protect against, or limit the associated impacts, thereby reducing or controlling the consequence of landslide disasters.

CHAPTER 3 LAND USE CLASSIFICATION AND REGULATION

3.1 Overview

As seen in the tendency of the sediment disasters in Sri Lanka mentioned in Chapter 2, the development of mountainous areas in Sri Lanka has led to an increase in disasters. The causes of the increase in disasters are that residents and developers do not understand disaster risk, that land use plans taking into account disaster risk are not formulated, and that development has progressed at high disaster risk areas without obtaining development permission, and so on.

This chapter introduces how disaster risks are taken into consideration in the planning process of land use plans. Specifically, the relevant legal system related to land use planning in Sri Lanka will be reviewed, and the basic ideas on the method of setting Yellow and Red Zone to be applied in high disaster risk areas be addressed. The target disaster types for setting Yellow and Red Zone are steep slope (slope failure), landslide, and debris flow. Furthermore, this chapter explains the land use classification consists of four zones: Restricted Zone, Controlled Zone, Warning Zone, and Development Zone, which are set based on the Yellow and Red Zones. The basic ideas on possible land use activities for each zone and how to designate each zone are also covered in this chapter.

3.2 Legal Arrangement and Regulations Land Use and Development

Land use planning is the process of regulating the use of land to promote more required social and environmental outcomes and more efficient use of resources. In the Sri Lankan context, a large number of legislations has been enacted for the provision of powers necessary for planning the urban area as well as a rural area. Some of these legislations are intended to encourage people to the development of urban lands and others are designed for the control of development activities to avoid environmental and health problems, city beautifications, and any other social requirement initiated by the planning agencies.

The three (3) local government legislations and three (3) national level legislations have been identified as the key instruments for creating institutions, structures, and procedures for urban development in Sri Lanka. The concerned government officials need to follow these legislations at both the national government level and local government level for the planning and implementation of land use plans. The legislations are,

1. Local Government Legislations - highly oriented to govern some define boundary with political authority.
 - Municipal Council Ordinance – No 29 of 1947
 - Urban Council Ordinance – No 61 of 1939
 - Pradesiaya Sabha Act - No. 15 of 1987
2. National Level Legislations
 - Housing and Town Improvement Ordinance- No 19 of 1915 - enacted with the purpose of providing legal background for whole country
 - Town and Country Planning Ordinance- No 13 of 1946 - enacted with the purpose of providing legal background for whole country

- Urban Development Authority Act – No 41 of 1978 - valid to whole country after the declaration under the act.

3.2.1 Relevant Ordinance / Circular / Guidelines

(1) Issuing Landslide Clearance for construction in Landslide Prone areas

Since the majority of recent landslides are induced by human intervention, His Excellency the President, as the chairperson of the National Council for Disaster Management (NCDM), and the Ministry of Disaster Management have decided to make obtaining the concurrence of NBRO mandatory when construction activities are implemented in the identified landslide prone areas as specified in Circular 2011/01. The executors of the construction activities should obtain concurrence of NBRO when construction activities are implemented in the identified landslide prone areas.

The objectives of issuing NBRO's clearance for construction in landslide prone areas are to minimize the landslide disaster risk and to increase the safety of life and property from future slope instabilities. This objective is achieved by,

- evaluating the existing landslide susceptibility of the land selected for the intended construction based on the existing geological, geotechnical, and hydrological characteristics of the terrain enclosing the selected site.
- evaluating the possible changes in slope stability due to the required ground preparations and slope modifications for planned construction.
- evaluating the possible changes in slope stability due to the impact of planned construction on the hydrological characteristics of the terrain.
- recommending planned construction, with necessary conditions, when the potential for landslides/slope failures are minimal.
- studying the terrain in detail when there is a potential for landslides/slope failures, and if mitigation is viable, then recommending the introduction of remedial measures for the intended construction to minimize the susceptibility for any anticipated landslides/slope failures, and
- discouraging construction where there is a susceptibility to landslides/slope failures for which remedial measures are not feasible.

(2) Hazard Resilient Housing Construction Manual

The executors of the construction activities should refer to Hazard Resilient Housing Construction Manual when engineering design and construction activities are implemented in the identified landslide prone areas.

This Manual has been developed to promote the use of hazard resilient engineering design and construction practices when building houses in Sri Lanka. The Manual focuses on ensuring that housing environment is better prepared for potential disaster events through proper planning, siting, design and construction practices.

The primary aim of this Manual is to minimize the risk associated with individual houses built in natural hazard prone areas. Also, it aims to minimize the damage to at least some structural elements, if not all elements of the house during an extreme event, so that people can resume their day-to-day

activities without much interruption. It attempts to address specific issues associated with the construction of housing in areas prone to specific natural hazards, namely, landslides, high winds, floods, tsunamis, and earthquakes, or in areas exposed to inherent problematic ground conditions that could be hazardous to build therein. This Manual also aims at providing as much technical information as possible in a single reference material that brings together the relevant previously published disaster specific construction guidelines and additional engineering measures that have been adopted recently through research and practice.

3.3 Outline of Yellow/Red Zone

3.3.1 Concept of Yellow/Red Zone

Sediment Disaster Hazard Area (Yellow Zone) is defined as the area that is susceptible to landslide disaster, in which the resistance capacity of normal residential buildings is expected to be larger than the force acting on residential buildings due to the moving debris and earth of landslides. If an area is designated as a Yellow Zone: 1) early warning systems should be established, and 2) steps to raise the awareness of local people about sediment disasters shall be taken. On the other hand, Special Sediment Disaster Hazard Area (Red Zone) is designated as the area that is susceptible to landslide disaster, in which the force acting on residential buildings due to the moving debris and earth of landslides is expected to be larger than the resistance capacity of normal residential buildings. The detailed methodology of the Yellow/Red zone setting is given in the “Manual for Site-Specific Landslide Hazard Zoning”.

The risk level can be improved from Red Zone to Yellow Zone by the implementation of structural measures with technical judgment by NBRO. NBRO judges if or not the applied structural measures have positive effects from the viewpoints of mechanics between resistance capacity of normal residential buildings and force acting on the residential buildings. The concept and detail of the structural measures are illustrated in “Conceptual Planning of Structural Measures around the Designated Red Zone” which is the annex of the “Hazard and risk assessment manual” by NBRO.

3.3.2 Concept of Yellow/Red Zone for Slide

The extracted slide block by topographical and field survey is classified into three ranks, A, B and C, in terms of the clarity of slide topography and its activity based on the above-mentioned survey results. These ranks are defined and shown in Table 3-1.

Table 3-1: Classification of Ranks of a Slide Block

| Classification of Ranks | Definition |
|-------------------------|---|
| Rank A | <ul style="list-style-type: none"> ▪ The slide is confirmed to be completely active at the field survey; and ▪ Its shape including its foot is clearly identifiable. |
| Rank B | <ul style="list-style-type: none"> ▪ The shape of the slide including its foot is clearly identifiable, but the slide is not confirmed to be active at the field survey; or ▪ The slide is confirmed to be locally active, and its shape is not clearly identifiable. |
| Rank C | <ul style="list-style-type: none"> ▪ The slide is not confirmed to be active at the field survey, and also its shape including its foot is not clearly identifiable. |

Concept of setting the Yellow/Red Zone for slide is shown in Figure 3-1.

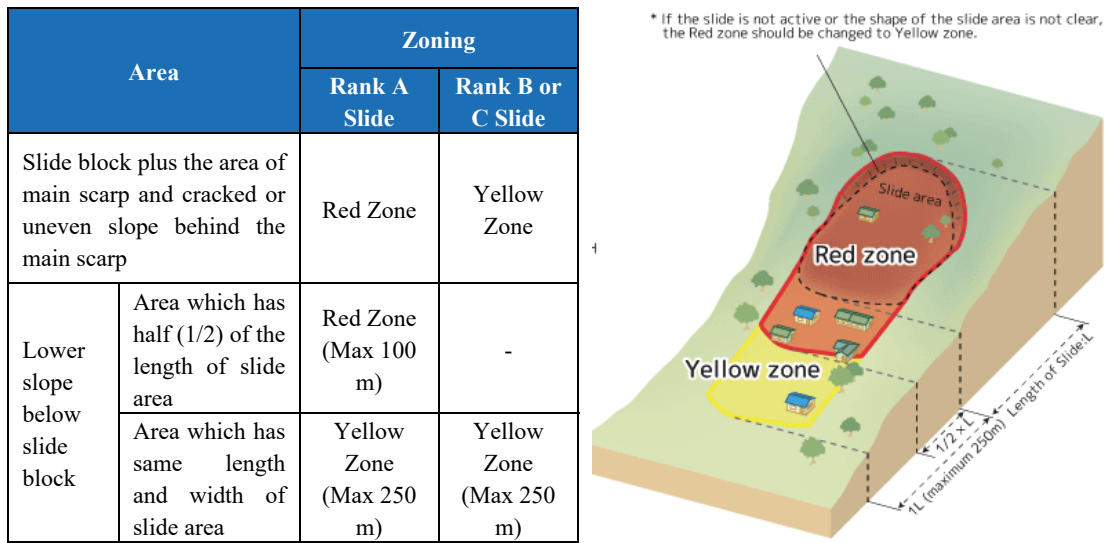


Figure 3-1: Conceptual Diagram of Yellow Zone and Red Zone for Slide

3.3.3 Concept of Yellow Zone and Red Zone for Slope Failures

Slope failures are related largely to slope steepness and slope height. Concept of setting the Yellow Zone or Red Zone for slope failure is Figure 3-2.

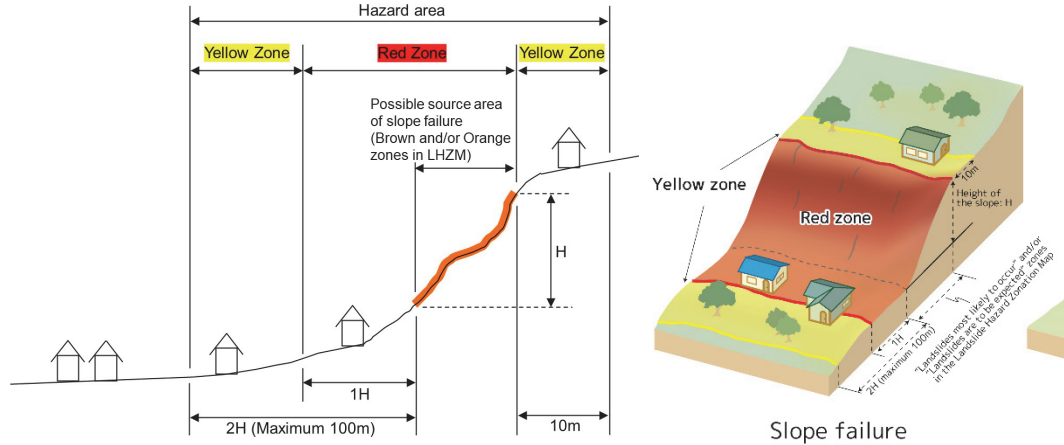


Figure 3-2: Conceptual Diagram of Yellow Zone and Red Zone for Slope Failure

3.3.4 Concept of Yellow Zone and Red Zone for Debris Flow

The lower ends of the Yellow Zone and Red Zone for debris flow shall be determined based on the ground gradient or inclination from the profile of the target area. In addition, the width of the zone shall be determined based on spreading angle such as 30 degrees for Yellow Zone or 15 degrees for Red Zone

Concept of setting the Yellow Zone or Red Zone for debris flow is Figure 3-3.

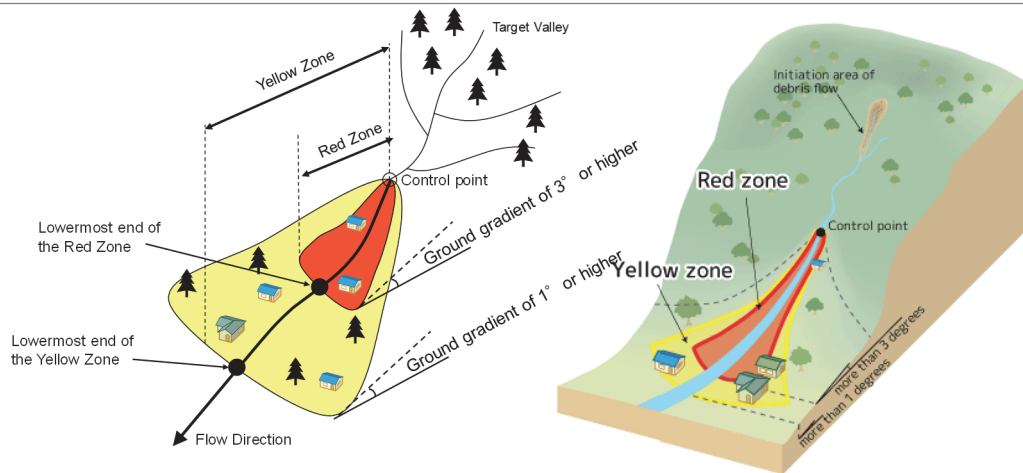


Figure 3-3: Conceptual Diagram of Yellow Zone and Red Zone for Debris Flow

3.4 Land Use Zoning Guide

3.4.1 Concept of Zoning base on Hazard/Risk Assessment

Land use planning is conducted by the planning agencies like UDA, NPPD, LUPPD, and Local authorities. The descriptive land use plan is developed to enhance the future benefits of the local authority area and maximize the land utilization in the local authority. However, disasters will affect the area, either from natural causes or man-made causes. Therefore, it is required to do planning activities by mitigating existing and future risk situations.

Landslide Hazard Map developed by NBRO has main four categories; “Landslide not likely to be occurred”, “Modest level landslide risk exists”, “Landslide risk might be existing” and “Landslide can be occurred”. Out of these four zones, development should be taken place only in the safe areas that were demarcated as “Landslide not likely to be occurred”. However, due to haphazard planning activities of the country, most of the landslide prone categories have settlements. Therefore, a proper zoning mechanism should be introduced to all categories to control the existing settlements and future developments.

For the above purpose, NBRO employed a new concept of Yellow/Red zoning in which more detailed and site-specific hazard risk levels can be indicated to promote appropriate land use on a community scale in the hilly area. The Yellow/Red zoning is also utilized for understanding the flow paths of each landslide types and identifying the possible land development type. Accordingly, the area was categorized into main four (4) zones; “Restricted Zone”, “Controlled Zone”, “Warning Zone” and “Development Zone”.

Where the new concept of Yellow/Red zoning is not applied, land use is to be tentatively examined based on the four categories of the Landslide Hazard Map by assuming that “Landslides most likely occur” is “Restricted Zone”, “Landslide are to be expected” is “Controlled Zone”, Modest level of landslide hazard exists” is “Warning Zone”, and “Landslide not likely occur” is “Development Zone” (see Table 3-2).

Table 3-2: Categorized Zoning based on Yellow/Red zoning and LHM

| | Yellow/Red Zoning (Applied for the Y/R zoning prepared area) | Landslide Hazard Map (Applied for the remaining area) |
|------------------|---|--|
| Restricted Zone | Red Zone* (Sediment Disaster Hazard Area) | Landslides most likely to occur |
| Controlled Zone | | Landslides are to be expected |
| Warning Zone | Yellow Zone (Special Sediment Disaster Hazard Area) | Modest level of landslide hazard exists |
| Development Zone | Else | Landslide not likely occur |

Note: For debris flow, Restricted Zone is designated not only within Red Zone but also beyond Red Zone, that is section from initiation area to control point.

(1) Restricted Zone

The “Restricted Zone” is assigned for the lands identified as “Red Zone” and ranked in “Landslides most likely to occur (HR)” in LHM. The section from the initiation area to the control point beyond Red Zone is also assigned for debris flow. Any construction or any development shall be prohibited in the zone and this zone is a high probability of future landslide events. If any constructions are available in this zone should be relocated, with proper investigations. This land area should be kept as a natural area and required to monitor the environmental condition, water flow, and hazard situation in a detailed manner. In the future, this area shall be demarcated as a sensitive area and control all kinds of human impacts on the area. Landslide flow path area is also considered in this zone and considering the feasibility studies, the land should be converted into a green area for the entire community. It is required to have detailed investigations and proper early warning systems for upper catchments before converting the area a green area.

(2) Controlled Zone

The “Controlled Zone” is assigned for the lands identified as “Red Zone” or ranked in “Landslides are to be expected (HR)” in LHM. This zone is considered as a high-risk zone due to landslide events. Therefore, new developments such as residential, retail, office, and industry, should not be allowed in this zone. Existing developments are encouraged to resettle to Development Zone as the one in Restricted Zone. Where resettlement is difficult, the disaster risk reduction measures such as a proper early warning system should be applied.

Since both most of the Restricted Zone and Controlled Zone is set in Red Zone, how to divide between Restricted Zone and Controlled Zone should be considered. The boundaries of these two zones can be decided based on the situation of the exposure at the sites, mainly the distribution of the existing houses and the topography. Where the existing houses are distributed and the slope is mild, the Controlled Zone is to be designated. It is also possible to set a Buffer Zone between Restricted Zone and Controlled Zone to make a clear distinction between them depending on the site conditions as shown in (5) below. The Human Settlements Division of NBRO has a role to propose the division of the two zones as well as the Buffer Zone by conducting investigation.

(3) Warning Zone

The “Warning Zone” is assigned for the lands identified as the “Yellow Zone”. Development activities are allowed in this zone but need to follow the resilient construction guideline which was published by the NBRO. This zone can have different building densities depending on the risk levels. However, the entire zone should have a proper early warning system and continuous awareness programmes for the commuters and residents. Controlled land uses are allowed in the zone and the management plan of each land uses should be monitored by the respective institutes.

(4) Development Zone

The “Development Zone” is assigned for the lands which are not identified as either the Yellow zone or Red zone. This zone is demarcated by considering the importance of development and hazard levels. This zone can be used to develop any kind of constructions but it should have adhered to the guidelines which are provided by the planning agencies like UDA, NPPD, etc. No resilient construction techniques are mandated for the zone, unless if disaster management professionals were identified as disaster impacted areas. If so, the resilient construction guideline should have adhered to the constructions.

Based on this, the land area could be divided into main four sections and each section should be monitored by the institute. Furthermore, these main zones could be divided into subcategories by considering the hazard zones and development zone, which could be shown in Figure 3-.

(5) Buffer Zone

As mentioned in (3), it is also possible to set a Buffer Zone between Restricted Zone and the Controlled Zone. One of the land uses for a buffer zone is to introduce tree lines as a debris barrier as shown in Figure 3.. It may help to control debris to flow into the Controlled Zone to a certain extent and to make the boundaries of the Restricted Zone and Controlled Zone visible physically at sites.



Figure 3.4 Illustration of Tree Line Layout

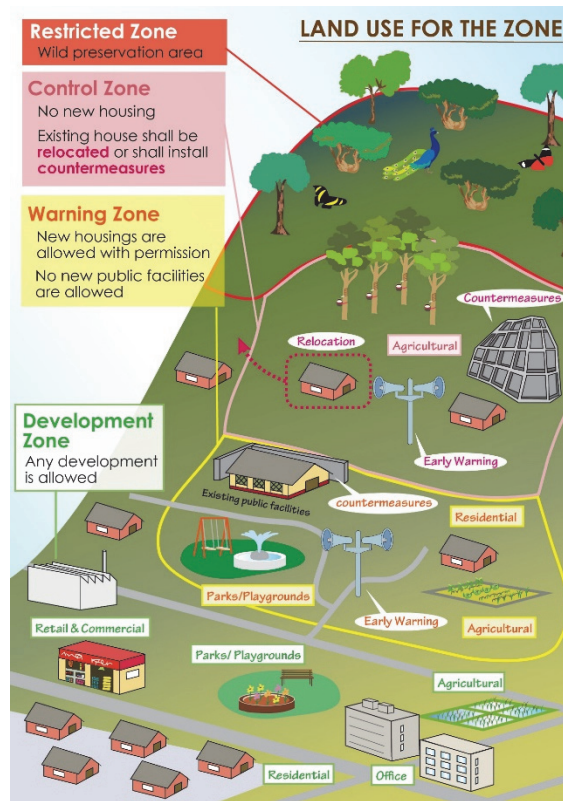


Figure 3-5: Conceptual Diagram of Land Use Zone based on Yellow/Red zoning

3.4.2 Possible Land Uses for the Zones

The possible land types for each zone are considered, and Table 3- shows the allowable and disallowable land use activities in each zone. Where judging if land use types are allowable or disallowable is necessary, a detailed investigation will be executed by NBRO. For example, agriculture use in the Restricted Zone requires detailed investigation for the judgment.

Table 3-3: Possible land uses for the zones

| | Proposed Land use category | | | |
|---------------------|----------------------------|------------------------|------------------------|-------------------------|
| | Development Zone | Warning Zone | Controlled Zone | Restricted Zone |
| Residential | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Retail & Commercial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Office | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Industrial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Parks/ Playgrounds | Suitable for Use | Suitable for Use | Detailed Investigation | Not Suitable |
| Agricultural | Suitable for Use | Suitable for Use | Suitable for Use | Detailed Investigation* |

Note: Home gardening can be allowed depending on the situation.

NBRO will conduct detailed investigation through assessing the impact of hazard to target land use type. The following items are assessed in detailed investigation.

- impact of sediment disaster to be assumed (slope failure, slide, debris flow)
- current land use
- topography (slope, location of river/stream/channel,)
- geology
- vegetation
- location of nearest road, facilities for evacuation

CHAPTER 4 DEVELOPMENT STANDARD

4.1 Overview

Chapter 4 explains the development standard. Chapter 3 explained the four land use classifications: Restricted Zone, Controlled Zone, Warning Zone, and Development Zone. This chapter specifically explains what land use activities are allowed, and what measures are necessary for each zone.

All new development and housing construction are prohibited in Restricted Zone and the Controlled Zone. Existing housings in Restricted Zone should be resettled in a safe area such as Development Zone. Existing housings in Controlled Zone can remain with community-based disaster risk reduction measures and early warning system in Controlled Zone until the enactment of the relocation programme.

For Warning Zone, development with large-scale topographical changes is restricted. Development of a warning evacuation system and consideration for vulnerable people are required in the Warning Zone. The Development zone is designated for low disaster risk areas, so in principle, development is not restricted in the development zone.

4.2 Development and Countermeasures in “Restricted Zone”

“Restricted Zone” is designated where sediment disaster risk is extremely high in the “Red Zone”, such as the area where active landslide movements, cracks of houses, and land deformation are observed. In the Restricted Zone, any development and housing construction are restrictedly prohibited regardless of efforts of countermeasures. Agricultural use can be allowed depending on a detailed investigation by NBRO.

For existing houses in the “Restricted Zone”, the Local Authority and relevant authorities should consider promoting a resettlement programme to save lives from sediment disasters (detailed procedures and compensation application shall be given in section 4.2.1).

4.2.1 Resettlement and Compensation

Resettlement programmes for the existing high-risk houses should be encouraged. NBRO has prepared several plans for the ‘Implementation Framework’ that describes resettlement procedures and roles of relevant stakeholders.

NBRO will further provide technical assistance for the overall programme, providing recommendations for beneficiary selection, land selection, land development, designing the house plan and preparing the BOQ, providing technical advice for a land subdivision, layout planning and house plan selection, monitoring and providing necessary technical inputs for land development and house construction.

Apart from the resettlement programme, it has been introduced National Natural Disaster Insurance Scheme (NNDIS) as a pioneering initiative to use an insurance-based disaster risk financing solution at the country level. It is the first ever model in the world where the Government has obtained an insurance blanket cover against natural disasters to protect uninsured houses and small businesses in the entire country.

Figure 4-1 elaborates the government responses for disaster victims on resettlement and compensations.

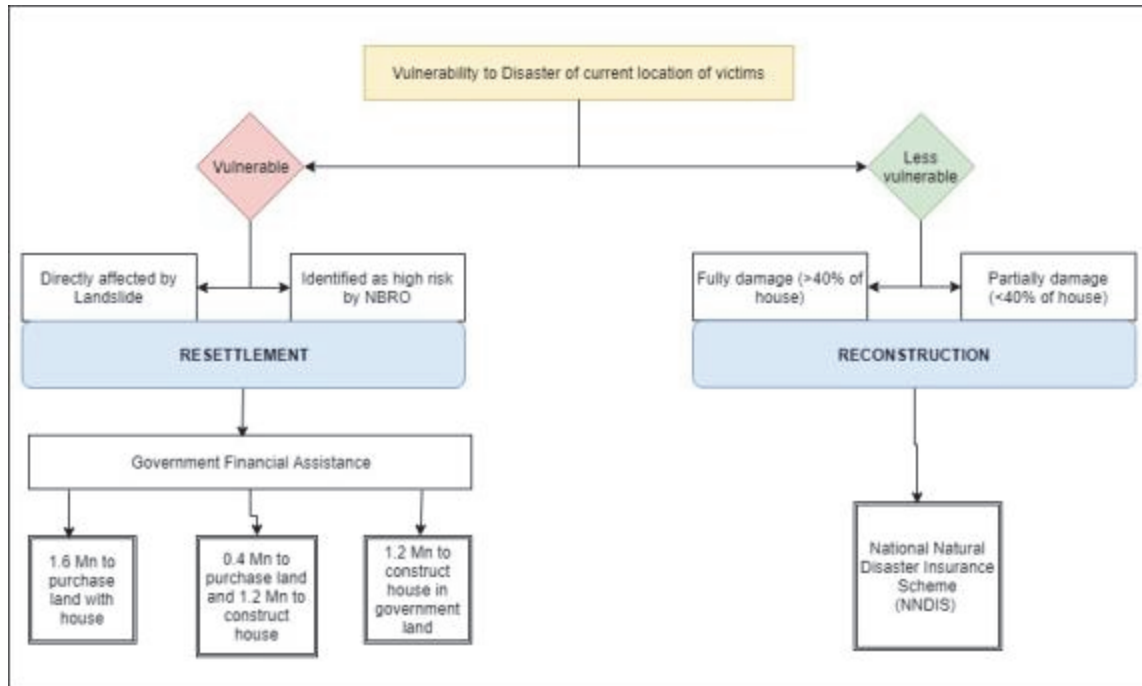


Figure 4-1: Options on Resettlement and Compensation

4.2.2 Effective Use of Restricted Zone

The land use in this zone should be a natural area including the preserving forest, with early warning systems. Agricultural use including home gardening can be allowed through a detailed investigation by NBRO. (Please see section 3.4.2)

In addition to the viewpoints of sediment disaster risk reduction, the land use in this zone as a natural area can be supported by the environmental aspects. Deforestation and loss of vegetation cover have been increasing after the industrial revolution and it is causing severe environmental problems now. The major issue of this is climate change and the greenhouse effect. Hence all the countries are now moving and seeking more environmentally friendly green solutions this concept can be applied to landslide areas too.

4.3 Development and Countermeasures in “Controlled Zone”

4.3.1 Development Regulation

“Controlled Zone” is a high-risk area for sediment disasters. Most area of Red Zone shall be designated as the Controlled Zone. In Controlled Zone, new developments for residential (including resettlement), retail and commercial, office, and industrial are not allowed even if appropriated countermeasures are implemented to prevent sediment disasters. Only agriculture is allowed, and using land as parks and playgrounds requires detail investigation by NBRO.

4.3.2 Structural Measures

In the case that the structural measures for sediment disaster are implemented at the target slope, the Red Zone shall be released, however, that these countermeasures are determined to exert an enough prevention effect of the sediment disaster. In addition, if the implemented countermeasures are considered not to completely mitigate the hazard, the designated Red Zone shall be changed into and remain as the Yellow Zone. Structural measure to be applied depends on the sediment disaster types at the target slope. The followings show the example of structural measures by sediment disaster type.

- slope failure: soil retaining work (Retaining wall), slope protection work, catching debris work
- slides: coupling with soil removal work, horizontal drainage boring, drainage well, channel works, drainage tunnel works, steel pipe pile works, and anchor works
- debris flow: Sabo dam, training channel

4.4 Development and Countermeasures in “Warning Zone”

4.4.1 Development Regulation

“Warning Zone” is regarded as a possible risk area for sediment disasters. Basically, Yellow zone shall be designated as the Warning Zone. In Warning Zone, Local Authorities shall ensure an early warning and evacuation system with the cooperation of central agencies such as DMC and NBRO. There is no restriction on private-use development and housing. However, development with large-scale topographical changes such as commercial housing land development, construction of large factories and motor roads with cutting and filling of the land is restricted. In addition, new construction of public facilities such as schools and hospitals are also prohibited.

For any land developments for housing and construction of building in the Warning Zone, the owners or developers are required to obtain Landslide Approval for Development (LAD) and/or Landslide Approval for Building (LAB) from NBRO before applying the development and construction to Local Authorities / UDA. It is because even if the land is located in the Warning Zone (Yellow Zone) on the zonation map, it might be highly hazardous for individual development on a micro-scale. Expert investigation and evaluation are needed.

4.4.2 Building Regulation

The buildings in this zone should be able to resist the followings

- minor ground movements without damage to the structure,
- moderate ground movements without structural damage but with some non-structural damage.
- larger movements without collapse, but with some structural damage and some nonstructural damage.

Although a certain degree of damage is acceptable in the house due to an unexpected event, loss of life is unacceptable. Accordingly, the structure of the house must be designed to ensure that it has

adequate strength, appropriate rigidity, and will remain as one integral unit, even while subjected to ground movements.

Flexible structures are most appropriate for hilly areas as these can accommodate movements without apparent significant distress. Steel or timber structures are generally used as the main material in them.

For more details in the design and construction of the buildings, the “Hazard Resilient Housing Construction Manual” should be referred.

4.4.3 Ensuring Early Warning and Evacuation System

In Waring Zone, heads of LAs and Divisional Secretariat (DS) Divisions should ensure early warning and evacuation system in cooperation with central agencies such as NBRO and DMC. This includes 1) dissemination of hazard maps and risk awareness, 2) identification of evacuation place and evacuation routes, 3) collecting early warning information, 4) delivering early warning and evacuation orders and 5) preparation and assistance for safe evacuation.

4.5 Development and Countermeasures in “Development Zone”

4.5.1 Development Regulation

This zone is free from landslide hazards and users can develop the land according to the existing building regulations such as Urban Development Authority Law and Housing & Town Improvement Ordinance.

The “Development zone” is set for the area out of the Yellow/Red zone, and is the free area from sediment disasters. Therefore, it is not necessary to regulate land development and building construction from the viewpoint of sediment disasters. The land owner and developer should follow appropriate procedures according to existing legal frameworks (such as UDA Law and Housing and Town Improvement (H & TI) Ordinance).

However, there are often sediment disaster risks due to insufficient accuracy of the topographic map that are essential information for Yellow/Red zone setting and due to local phenomenon, such as cutting failures. Therefore, even if the area is in a “Development zone”, it is required for the land owners and developers to comply with the followings;

- To obtain landslide certificate issued by NBRO (need to comply with 2011/1 circular)
- To comply with the “Disaster Resilient Housing Guideline”.

4.5.2 Securing Resettlement Site

There is no development restriction in the “Development zone”, where sediment disaster risk is low and regarded as a fairly safe area. Local Authorities are required to secure appropriate resettlement sites in this zone when resettlement is needed. For necessary processes and budget request related to the resettlement, please refer to Section 4.2.1. For resettlement site selection, the “Implementation Framework for the Resettlement of Landslide and Flood Victims” published by NBRO should be referred to.

CHAPTER 5 IMPLEMENTATION OF LAND USE ZONING AND DEVELOPMENT STANDARDS

5.1 Introduction

5.1.1 Objective of the Plan

To implement the land use zoning and development standards described in Chapters 3 and 4, local authorities are encouraged to develop the Sediment Disaster Risk Reduction Plans (SDRRP) with the cooperation of central and local agencies.

Therefore, it is required for local governments to refer to this guideline and to develop basic plans that promote the countermeasures such as land use planning, development regulation, structural measures, and strengthening of early warning and evacuation systems with the support of technical institutes, and approval those SDRRP plans in LA's planning committees. In addition, the roles and responsibilities of Local Authorities, DS Divisions, Districts, and the central governments for each countermeasure should be given in the basic plans. It aims to clarify budgets and financial resources for those measures and to facilitate budget allocation. Furthermore, having such plans by Local Authorities are also useful for accepting international investments. Based on the basic plans, investments for sediment disaster risk reduction will be evaluated and optimized at the national level.

The basic plans are expected to be developed as SDRRP by Local Authorities. However, it is difficult for them to develop SDRRP, especially in technical aspects. SDRRP should be developed through participatory workshops organized by the concerned central agencies such as NBRO, DMC and, UDA. SDRRP shall be integrated into the development plan to be prepared by LA or UDA for UDA declared area where the development plan has been prepared or will be newly prepared or updated.

5.2 SDRRP

SDRRP should be as simple as possible, and planning concepts should be visualized by using maps and schematic diagrams so that local residents can easily understand it. For technical aspects such as structural measures in Controlled Zone and early warning evacuation planning in Warning Zone, NBRO's field investigation, technical advises and visual materials should be provided. SDRRP is composed of the following six items.

- Introduction
- Sediment disasters in the area
- Basic policy for the hazard zones
- Land use plan
- Early warning and evacuation system
- Action plan

(1) Introduction

Firstly, general information about the target area such as population composition, living style, vulnerable public facilities (school, hospital, facilities for disabilities), current land use, industrial structure, etc. should be discussed. If there are specially designated areas that should be considered for land use planning, such as forest conservation areas, wildlife sanctuaries, and national parks, should also be mentioned in this section. In addition, existing issues to implementing the land use plan such as illegal development and settlement in the target area are also explained.

(2) Sediment Disasters in the Area

This section gives an overview of past disasters and damage situations in the target area. The Yellow/Red zoning map prepared by NBRO should be obtained and attached. The valuable public facilities and damaged areas of the past disasters will be added to the map as necessary. Since it may be difficult for the residents to identify the locations by looking at the map, it is recommended to put some landmarks that are easy to understand.

(3) Basic Policy for the Hazard Zones

Based on the Yellow/Red zoning map, “Restricted zone”, “Controlled zone”, “Warning zone” and “Development zone” will be designated according to the definition in Chapter 4. The Red zone will be divided into “Restricted zone” and “Controlled zone”. Local Authorities designated a “Restricted Zone” for the area with an especially high risk of sediment disasters and the development prohibits areas such as forest conservation areas.

In this section, basic policies for each zone should be explained. The recommended development standards are as given in Chapter 4. Especially for “Restricted zone” and “Controlled zone”, which may affect the market land prices in future, Local Authorities should explain and make consensus with residents. In case resettlement is needed, Local Authorities should consult with NBRO and other central agencies in advance regarding the appropriateness of the resettlement and suitable lands for resettlement in the target area.

The basic policy can be divided into two depending on the status of the current land use: one for existing residential areas and the other for the vacant area. If the residences exist in hazard zone such as “Restricted zone”, “Controlled zone”, and “Warning Zone”, it is ideal to relocate those existing residences to the “Development zone”. It is, however, difficult to apply land use regulations by relocating them and following possible and allowable land use activities as shown in Table 3.3 in reality. Options of disaster risk reduction measures other than land-use control should be taken into account for the existing residential area in the hazard zone. Land use regulations to prevent new development are to be promoted for the vacant area in the hazard zone.

Table 5-1 DRR measures for Existing Residential Area and Vacant Area in Hazard Zones

| | Red Zone | | Yellow Zone | |
|-------------------|---|--|--|--|
| Possible Land Use | Restricted Zone Only for Natural Vegetation (Forest, bushes, etc.) (detailed investigation for agricultural) | | Warning Zone Agriculture Parks and Playground/ non-residential activities Detailed investigation for Residential, Retail & Commercial, Office, Industrial | |
| | Controlled Zone Agricultural (detailed investigation for Human induces activities: Parks and Playground/non-residential activities) | | | |
| Current Land Use | Existing Residential Area -No special zoning regulations are in practice. | Vacant Area -No special zoning regulations are in practice. | Existing Residential Area -No special zoning regulations are in practice. | Vacant Area -No special zoning regulations are in practice. |
| DRR Measures | -Early Warning -Conduct a detailed investigation and select DRR measures - Land-use regulations (not to allow further development) | - Promote land-use regulations | -Early Warning -Structural Measures (Sabo, Retaining wall, etc.) - Other resilience constructions | - Promote land-use regulations |

(4) Land Use Plan

Based on the above basic policies, a land-use plan for the target area will be developed. Since the objective of SDRRP is to show how to tackle the sediment disaster risks, it is not necessary to develop micro-scale land-use zoning maps. If larger-scale structural countermeasures for landslides and debris flows are needed, Local Authorities should consult with NBRO and other central agencies in advance, and attach the schematic layout plan of the facilities and estimated costs.

In case a development plan was already developed by UDA, Local Authorities should consider it carefully and make sure there are no discordances between each plan. When there is discordance between the land-use plan and the existing development plan, Local Authorities should make a standard By-law in consultation with relevant planning and technical agencies.

(5) Early Warning and Evacuation System

For the “Warning Zone”, a map that indicates necessary facilities for early warning, warning officers in the area, evacuation shelters/places, evacuation routes, capacities of the evacuation shelters and other necessary information for evacuation actions, will be developed. This map can be substituted with the above land use planning map.

In addition, the information communication protocol for early warning in the areas should be clarified in this section. If the construction of evacuation shelters and emergency equipment are required, those items should be shown.

(6) Action Plan

The action plan specifies the projects and the project budgets for implementation of the land use plan, countermeasure facilities and strengthening early warning and evacuation system in the target area. The target years of the implementation plan shall be about 1 year, 4 years and 10 years with consideration of the term of local councils. The projects that will be implemented by Local Authorities, supported by DS Divisions and/or Districts Secretaries and supported by the central agencies (NBRO, DMC, UDA etc.) should be classified in the action plan.

5.3 Development Plan and By-Law

UDA develops Development Plan for UDA declared area. The development Plan defines the policy framework and land-use proposals that will be used to guide development decisions within a specific area. Preparation of Development plans for declared areas is being vested with Urban Development Authority (UDA), after the declaration under section 03 of the UDA Law No. 41 of 1978 as an urban development area.

SDRRP as well as national, regional and local level plans, prepared by different agencies could be incorporated into the development plans, if there is DRR or land-use zoning plans and guidelines have been prepared during the time. Once gazetting the development plans, the implementation of the plans has to be implemented through provincial and local governments.

If there is any plans or guidelines that need to incorporate after gazetting the Development Plans, the provincial and local government have the authority to issue By-laws for implementation. Under Sec. 267 of the Municipal Council Ordinance, Urban Council Ordinance and Pradeshiya Sabha Act every local government may make By-laws following the stipulated procedure which is laid down in the Local Authorities (standard by-laws) Act NO.6 of 1952 and under Sec. 2 of the said Act, the Minister of Local Government made standard by-laws and published in the Government Gazette.

5.4 Implementation of Land Use Zoning for SDRRP

5.4.1 Role and Responsibilities of Concerned Agencies

(1) Roles of concerned organizations

Roles of the concerned organizations on land use zoning and development mentioned in SDRRP depend on the setting of the target area such as urban/rural, the declaration by UDA, with/without Development Plan etc. as shown in the following table. The concerned organizations are NBRO, UDA, Estate Company, Local Authority, and Grama Niladhari (GN). The Urban area is administered by either Municipal Council (MC) or Urban Council (UC). The Rural area is administered by Pradeshiya Sabha. Land in the urban area both MC and UC is designated by a UDA as UDA-declared area. Some rural areas are also designated as UDA-declared areas.

| | Urban Area (MC, UC) | | Rural Area (PS) | |
|-----------------|--|--|--|-------------------|
| | UDA Declared Area | | Non UDA Declared Area | Estates |
| | Without Development Plan | With Development Plan | | |
| NBRO | Prepare hazard map showing Yellow/Red zones Support UDA and/or LA in land use planning as a part of SDRRP Support and recommend to implement SDRRP (Early Warning and Evacuation / Structural Measures) | | | |
| UDA | Prepare land use plan based on hazard map | Update land use plan base on hazard map | - | - |
| Estate Company | - | - | - | Cooperate with LA |
| Local Authority | Give development permission based on UDA standards | Issue By-laws to implement the SDRRP Give development permission based on UDA standards and SDRRP | Prepare SDRRP for catchment area with disaster risk areas based no hazard map Give development permission | - |
| DS / GN | Provision of Data | | | |

UDA has authority to develop land use plan for UDA declared area, but UDA has not yet developed land use plan for some parts of UDA declared area. Detail of land use planning in UDA declared area is explained in item (2).

Rural area has generally rural features and is out of UDA declared area. LA (PS) has authority to develop land use plan. Detail of land use planning out of UDA declared area is described in item (3).

A part of rural areas is called as Estates which land is used for tea plantations. Estate companies need to prepare land use plan, but there is no legal mandate in land use planning for the estates. Detail of land use planning in estates is explained in item (4).

LA provides development permission based on UDA standard for UDA declared area and prepares land use plan for catchment areas with disaster risks outside UDA declared area in rural areas. LA does not have any authorization in land use planning for estates. GN plays a role to provide data such as socio-economic data such as population, number of houses to UDA or LA.

As shown in table above, NBRO has a role to prepare hazard map showing Red/Yellow Zones, support UDA, LA, Estate Company in land use planning, and prepare development standard. The followings are consultation menu provided by NBRO.

- Prepare hazard map
- Prepare early warning system
- Prepare development standard

- Inspect land use plan in the aspect of hazard and risk management
- Prepare draft land use plan
- Prepare land use plan and regulation in special projected area
- Hold workshop, seminar, etc. for local residences' understanding of hazard map and regulation
- Prepare evacuation plan
- Hold disaster drill and disaster education program for local people

(2) Land Use Planning in UDA Declared Area

1) UDA Designated Area with Development Plan

The following figure shows interactions among NBRO, UDA, LA, and GN for UDA declared area with development plan. UDA will periodically revise existing land use plan with LA based on inputs such as disaster risk related information from NBRO and inputs such as community information from GN.

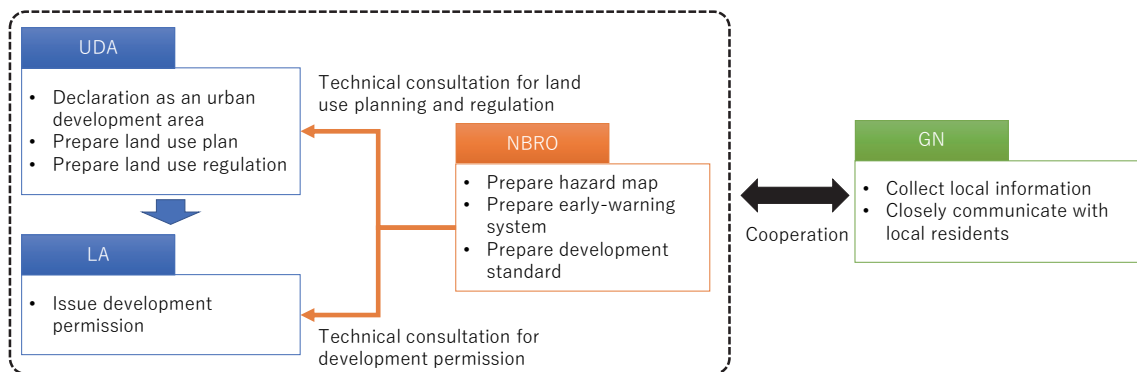


Figure 5-1: Interactions among NBRO, UDA, LA, and GN for UDA declared area with development plan

2) UDA Declared Area without Development Plan

The following figure shows interactions among NBRO, UDA, LA, and GN for UDA declared area without development plan. UDA will develop new land use plan with LA based on inputs such as disaster risk related information from NBRO and inputs such as community information from GN.

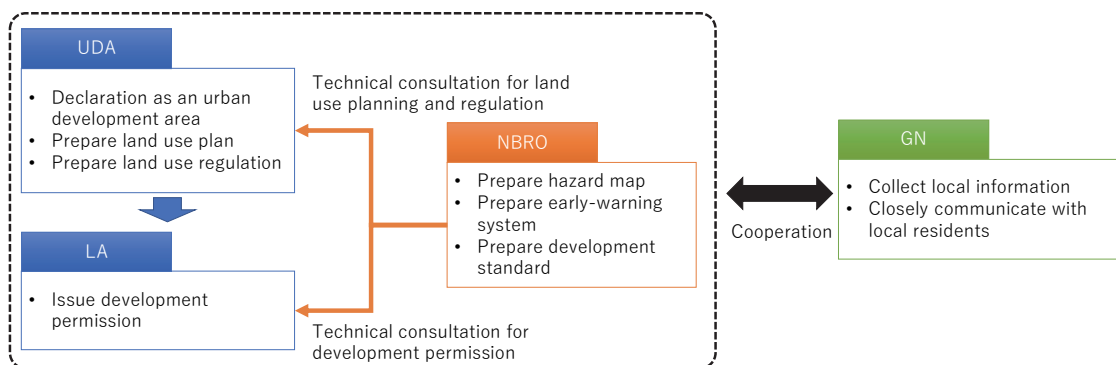


Figure 5-2: Interactions among NBRO, UDA, LA, and GN for UDA declared area without development plan

(3) Land Use Planning out of UDA Declared Area

The following figure shows interactions among NBRO, UDA, LA, and GN out of UDA declared area. LA will revise the existing land use plan where land use plan was already developed or develop new land use plan where land use plan is not yet developed. Inputs such as disaster risk related information from NBRO and inputs such as community information from GN are provided to LA.

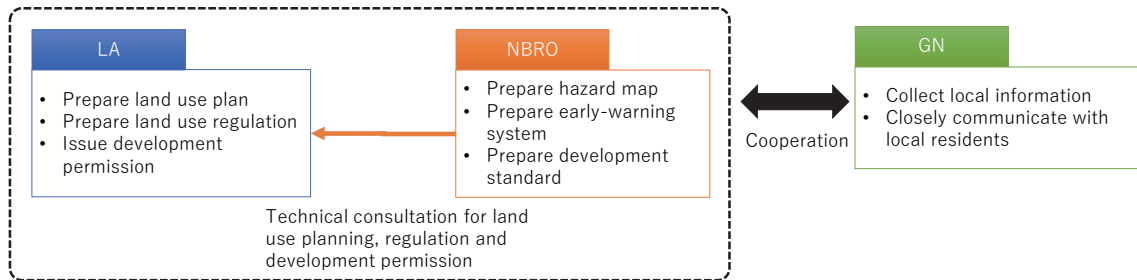


Figure 5-3: Interactions among NBRO, UDA, LA, and GN out of UDA declared area

(4) Estate

Estate will prepare land use plan, resettles residential houses into safer areas, and take necessary countermeasures through technical consultation by NBRO.

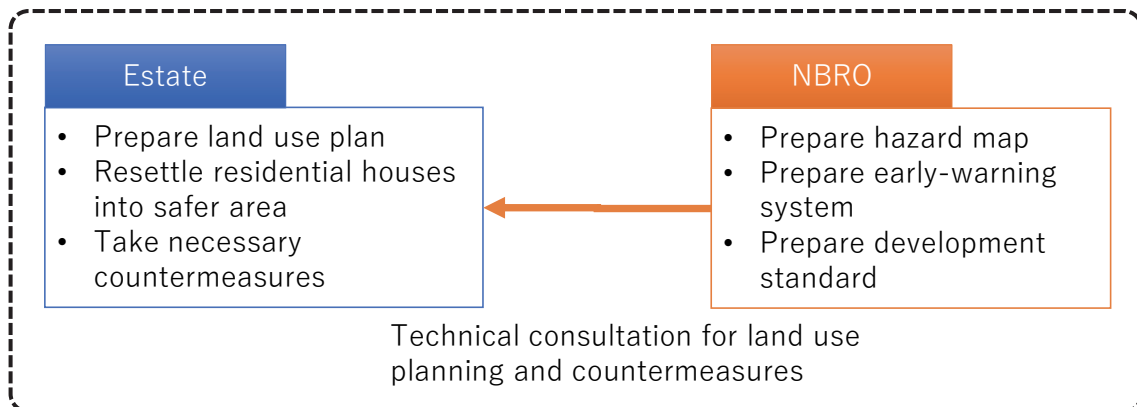


Figure 5-4: Interactions Estate with NBRO

5.4.2 Monitoring and Verification

The planning committee in the Local Authority shall monitor and verify the land use activity for each land use zoning if or not the land is used by following the land use direction in SDRRP. The frequency of the verification is basically one in a year at the same time to discuss the annual budget plan. The objective of the monitoring and verification is to capture the progress of the plan and modify the plan if necessary. The monitoring and verification of the land use activities are to be conducted in conjunction with the monitoring and verification of the action plan of SDRRP.



**Developed by Project for Capacity Strengthening on Development of
Non-Structural Measures for Landslide Risk Reduction in Sri Lanka (2022)**

Local Sediment Disaster Risk Reduction Plan



Morawakakanda

(Kotapola Pradeshiya Sabha , Matara District)

“Creating Disaster Resilient Neighbourhood in Morawakakanda”



Morawakakanda

Local Sediment Disaster Risk Reduction Plan

Towards the Disaster Resilient Neighborhood



Content

| | |
|--|-----------|
| List of Figures and Tables..... | 1 |
| Abbreviations and Acronyms | 3 |
| Executive Summary..... | 4 |
| 1.1. Background | 6 |
| 1.2. Objectives | 6 |
| 1.3. Vision | 6 |
| 1.4. Target Users for the LSDRRP | 6 |
| 2. Current Setting of Morawakkanda..... | 8 |
| 2.1. General Information of Kotapola PS..... | 8 |
| 2.2. General Information of Morawaka GN and Morawakkanda..... | 9 |
| 2.2.1. Geographic information | 9 |
| 2.2.2. Demographic Background | 9 |
| 2.2.3. Housing Conditions | 11 |
| 2.2.4. Essential Public Facilities..... | 12 |
| 2.2.5. Climate Condition | 14 |
| 2.2.6. Disaster Record..... | 16 |
| 2.2.7. Current Land Use | 17 |
| 2.2.8. Current Land Use with Yellow and Red Zone in the target area..... | 20 |
| 2.3. Concept of Yellow/Red Zone..... | 21 |
| 2.4. Categorized Zone based on Yellow/Red zoning and LHM..... | 23 |
| i. Restricted Zone..... | 24 |
| ii. Controlled Zone | 24 |
| iii. Warning Zone..... | 24 |
| iv. Development Zone | 24 |
| 2.5. Possible Land Uses for the Zones..... | 25 |
| 2.6. Approval and Enforcement of the Land Use Plan | 26 |
| 2.6.1. General conditions | 26 |
| Land use zoning..... | 27 |
| Risk Assessment..... | 27 |
| 3. Risk Assessment for Morawakakanda..... | 28 |
| 3.1. Database for Designated Yellow/Red Zones..... | 28 |

| | | |
|------|---|-----------|
| 3.2. | Preparation of Data for Risk Evaluation | 29 |
| 3.3. | Items for Risk Evaluation..... | 29 |
| 3.4. | Risk Evaluation Sheet for Yellow/Red Zone..... | 30 |
| 4. | Land Use Zoning Plan in Morawakkanda | 34 |
| 4.1. | Basic DRR Strategies for Morawakkanda..... | 37 |
| 4.2. | Statistics in Yellow and Red Zone | 37 |
| 5. | Structural Measures..... | 41 |
| | Strengthening Early Warning and Evacuation | 43 |
| 6. | Strengthen Early Warning and Evacuation..... | 44 |
| 6.1. | NBRO Landslide Early Warning..... | 44 |
| 6.2. | NBRO Early Warning Communication Channel in Morawakkanda..... | 46 |
| 6.3. | Emergency Community Committee in Morawakkanda..... | 47 |
| 6.4. | Securing Evacuation Place and Route..... | 48 |
| 6.5. | Awareness Activity for EW | 49 |
| 7. | Management Plan..... | 52 |
| 7.1. | Land use management plan | 52 |
| 7.2. | The land value management plan..... | 52 |
| 8. | Implementation | 54 |
| 8.1. | Action Plan | 54 |
| 8.2. | Role and Responsibilities of Concerned Agencies | 56 |
| 8.3. | Monitoring and Verification..... | 57 |



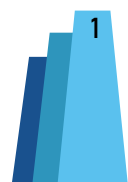
List of Figures and Tables

List of Figure

| | |
|---|----|
| Figure 1: Location Map..... | 8 |
| Figure 2: Ward Map of Kotapola PS | 9 |
| Figure 3: Gender Composition in Morawakakanda GN | 10 |
| Figure 4: Gender Composition in Morawakakanda Target area | 10 |
| Figure 5: Population pyramid in Weeriyapura Project Site..... | 10 |
| Figure 6: People who need assistance for evacuation | 11 |
| Figure 7: Reason to live at Morawakakanda and Surrounding | 11 |
| Figure 8: Housing Condition of Morawakakanda GN..... | 11 |
| Figure 9: Locations of Public facilities..... | 13 |
| Figure 10: Rainfall Distribution..... | 14 |
| Figure 11: Temperation Variation..... | 16 |
| Figure 12: Landuse Pattern..... | 19 |
| Figure 13: Land use percentage in Morawakakanda area | 20 |
| Figure 14: Current Land use Plan | 21 |
| Figure 15: Yellow/Red Zone for Slide | 22 |
| Figure 16: Yellow Zone and Red zone for Slope Failure..... | 22 |
| Figure 17: Yellow Zone and Red Zone for debris flow | 23 |
| Figure 18: Zoning Plan | 25 |
| Figure 19 Concept of Risk Evaluation for the Target Yellow/Red Zone (for Debris Flow) | 30 |
| Figure 20 Filled Risk assesment sheet for debris flow patch in Morawakkanda | 30 |
| Figure 21 Risk Evaluation Map of Morawakakanda..... | 32 |
| Figure 22: Landuse Plan..... | 35 |
| Figure 23: Land use Zoning Plan | 36 |
| Figure 24: Building Statistics | 39 |
| Figure 25: Cause of Landslide and Soil Water Index..... | 44 |
| Figure 26: Dissemination flow of NBRO Landslide Early Warning and Evacuation Order..... | 45 |
| Figure 27: Contact information and the dissemination flow of NBRO Landslide Early Warning in Morawakkanda..... | 46 |
| Figure 28: Location of Rain Gauge in Morawaka GN..... | 48 |
| Figure 29: Location of manual rain gauge and Evacuation Centre..... | 49 |

List of Table

| | |
|---|----|
| Table 1: Monthly Average Rainfall Distribution | 14 |
| Table 2: Annual Temperature..... | 15 |
| Table 3: Basic information of landslide | 17 |
| Table 4: Land use types..... | 18 |
| Table 5: Classification of ranks | 21 |
| Table 6: Categorized zones based on yellow/red and LHM..... | 23 |



| | |
|--|----|
| Table 7. Allowed and not allowed land uses to the area | 25 |
| Table 8. Items for Database for Designated Yellow/Red Zone | 28 |
| Table 9 Items and Scores for Risk Evaluation for Yellow/Red Zone..... | 29 |
| Table 10: Classification of Risk Level | 31 |
| Table 11: Plantation crops in Morawakakanda Area | 34 |
| Table 12: Statistics in Yellow and Red zone..... | 38 |
| Table 13: NBRO Landslide Early Warning Criteria and actions to take..... | 44 |
| Table 14: Members of Emergency Community Committee in Udapotha..... | 47 |
| Table 15: Evacuation centres in Morawakkanda..... | 48 |

Abbreviations and Acronyms

DS-Divisional Secretariat

DDMCU- District Disaster Management Coordinating Unit

DMC- Disaster Management Center

GN- Grama Niladhari

JICA-Japan International Cooperation Agency

LHM- Land Hazard Map

LSDRRP- Local Sediment Disaster Risk Reduction Plan

LUPPD- Land Use Policy Planning Department

LA- Local Authority

NBRO- National Building Research Organisation

NPPD- National Physical Planning Department

PS-Pradeshiya Saba

UDA-Urban Development Authorities

Executive Summary

The Technical Corporation for Landslide Mitigation Project (TCLMP) was initiated in 2014, and the second phase of the project (SABO) was started after completing phase one in 2016. Phase one, TCLMP, was focused on structural measurement, and SABO was focused on non-structural measurements. NBRO initiative to develop this plan as a part of the Project for Capacity Strengthen on Development of Non-structural Measures for Landslide Risk Reduction in Sri Lanka (SABO), a technical cooperation project between NBRO and Japan International Cooperation Agency (JICA).

The SABO project was implemented in three pilot sites in Sri Lanka, Morawakakanda in Matara, Weeriyapura in Badulla and Udapotha in Kegalle. The project has three main outputs: demarcation of the landslide flow-path boundaries using the Yellow-Zone-Red-Zone method, development of landslide early warning threshold levels, and development of land-use guidelines for the sediment disaster-prone areas.

The Sediment Disaster can be identified as one of the severe disasters in Sri Lanka because of intensive rainfall and human interventions. In this circumstance, there is a need for a proper landslide management plan to secure the community and human properties in sediment disaster areas. The Local Sediment Disaster Risk Reduction Plan (LSDRRP) is a comprehensive site-specific plan that focuses on the local level to minimize the impact of sediment disasters by using structural and non-structural mitigations.

This LSDRRP plan comprises the landslide hazard-prone areas, landslide flow based on the Yellow zone and Red zone concept, land use zoning in the area, and actions taken for the risk reduction. The report also included the current risk status of the community and the existing landslide early warning mechanism.

NBRO consulted Kotapola Pradeshiya Sabah, Divisional Secretariat, and residents in Morawakanda during the preparation of the zoning plan. The project report was shared with the relevant stakeholders to bring their feedback to the plan.

This LSDRRP for Morawakakanda is owned by Kotapola Pradeshiya Sabah (PS) will take action with the cooperation of relevant agencies such as Kotapola Divisional Secretariat, District Disaster Management Coordinating Unit (DDMCU), and National Building Research Organization (NBRO) in Matara District to mitigate sediment disaster risk according to the action plan written in Section 6.

1

Introduction



1. Introduction

1.1. Background

Sediment Disaster is one of the most severe natural disasters in Sri Lanka. In the central and southern mountainous areas, sediment disasters such as slope failures, landslides, and debris flow frequently occur in the monsoon period because of the fragile geology and steep topography. In recent years, sediment disasters caused by heavy rainfall in the spring monsoon season have become severer. In addition, increasing exposure to the hazards due to rapid reclamation and development has been raising sediment disaster risks in urban and rural areas. The establishment and improvement of the early warning system and legal arrangement for land use planning and development standards are urgent issues in Sri Lanka.

Morawakkanda is a major landslide (width of 198m and length of 2,085m) in Matara District on 25th May 2017, causing nine deaths and eleven people missing. It is essential to identify landslide susceptible locations and predict the probability of occurrence of each. (K.G. N Saroja, C. S Menikpura & J.Gunathilaka , 2019). Disaster risk assessments, early warning systems, and land use planning assessments are required to mitigate future landslide threats in the country. The Project of “Capacity Strengthening on Development of Non-structural Measures for Landslide Risk Reduction in Sri Lanka” was set up between National Building Research Organization (NBRO) and Japan International Cooperation Agency (JICA). The project aims at strengthening the capacity of NBRO on non-structural measures such as sediment disaster risk assessments, improving early warning systems using existing observation networks, and land use and development standards.

Local Sediment Disaster Risk Reduction Plan (LSDRRP) is a comprehensive plan to promote sediment disaster risk reduction measures at the local level, including non-structural measures developed based on site-specific sediment disaster risk assessment. The LSDRRP also clarifies the role and responsibility of the local organizations.

1.2. Objectives

The objectives of LSDRRP are as follows;

- Reduce landslide vulnerability by 50 % of old landslide valley of Morawakakanda
- Introduce non-structural landslide DRR measures
- Optimum utilization of lands prone to landslide hazard
- Zero the life damages and minimize the casualties due to landslides
- Minimize the economic damage

1.3. Vision

The vision of LSDRRP is;

“Creating A Disaster Resilient-Neighborhood in Morawakakanda”

1.4. Target Users for the LSDRRP

The primary target users of the guideline are the practitioners of land use planning and development control of both the national government and local government, including the officials of Local Authorities (LA), Urban Development Authority (UDA), National Physical Planning Department (NPPD), Land Use Policy Planning Department (LUPPD), and NBRO.

2

Current Setting



2. Current Setting of Morawakkanda

2.1. General Information of Kotapola PS

Morawakkanda is a part of Morawaka Grama Niladari (GN), located southwestern boundary of the Kotapola Pradeshiya Sabaha (PS). Kotapola PS is located in the northern part of Matara District, neighbouring Ratnapura District at north and Galle District at west. The administrative territory of Kotapola PS is about 175.5 km², which overlaps with Kotapola DS Division. The population of Kotapola PS is 63,255 (2012 Census). The average monthly income is about 20,000 LKR.

National highway AA017 goes through the centre of the Morawaka GN from SW to NE. Deniyaya town, another populated area, is along the highway.

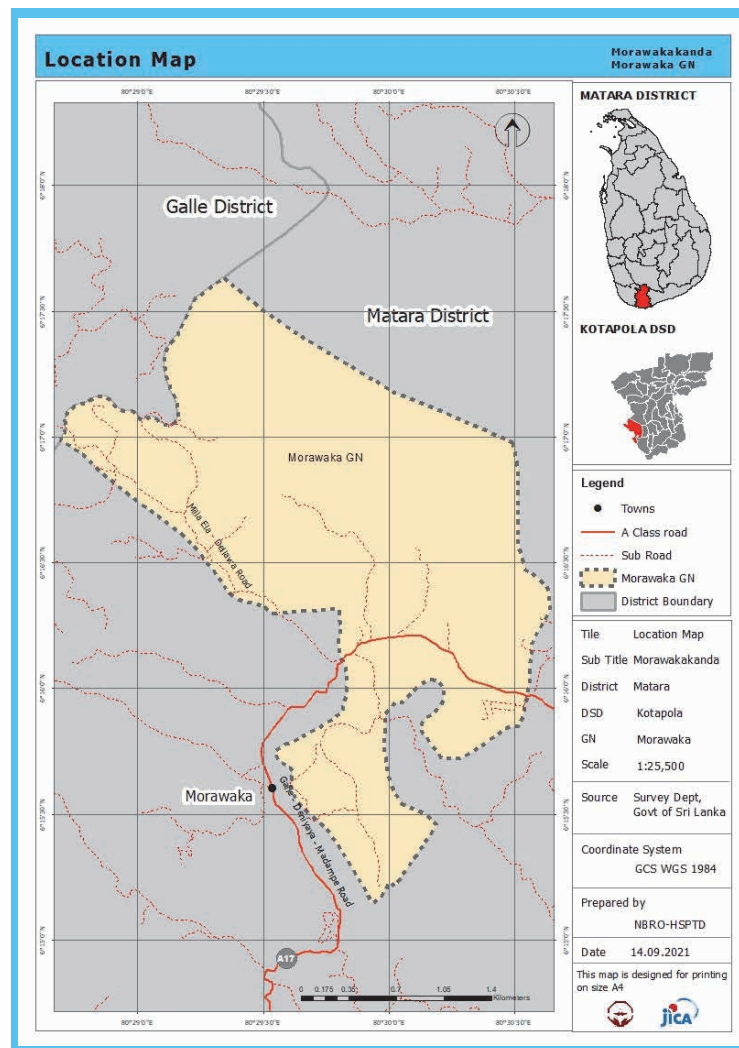


Figure 1: Location Map of Morawaka GN

2.2. General Information of Morawaka GN and Morawakkanda

2.2.1. Geographic information

Morawakkanda is located in the hill area of Morawaka GN. The main town of Morawaka is located along with the National Highway A17.

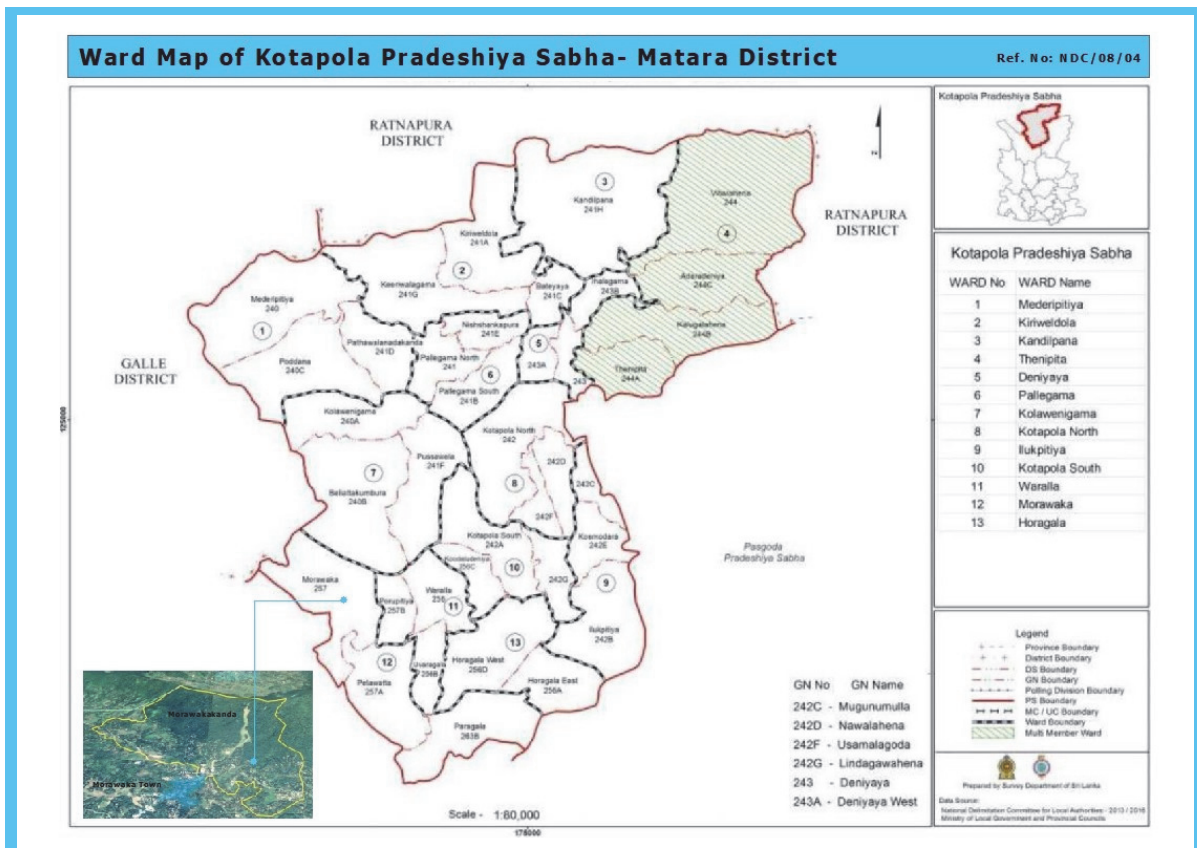


Figure 2: Ward map of Kotapola PS

2.2.2. Demographic Background

The population of Morawaka GN was 2,851 in 2012. The Male population and female population are 1,366, 1,485 respectively. Population Density is sixteen persons per square Kilometer, and building density is sixteen per square Kilometer.

There are 148 population living in the project area. Among them, 67 are Male, and 81 are Female.

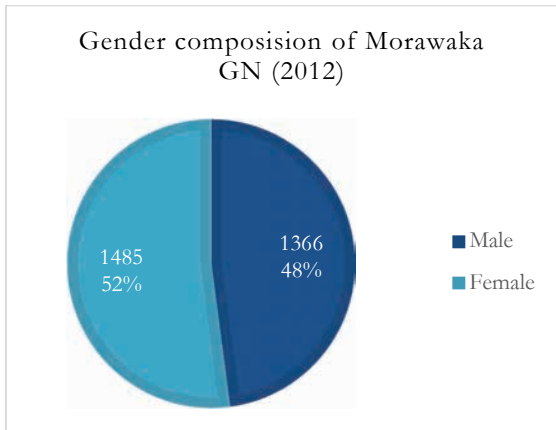


Figure 3: Gender composition in Morawaka GN

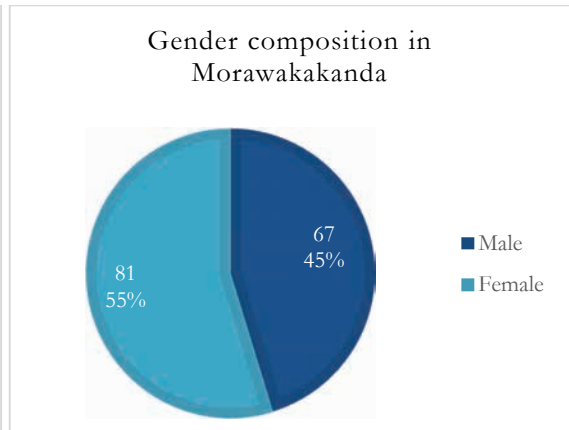


Figure 4: Gender composition in Morawakanda target area

The age category of the Morawakakanda area is distributed as figure 4: 84 (57%) people are fallen under the labour force age (15-64) group, and the dependency (<15 and >64) population are 64 (43%). The working people need to tolerate the damage cost along with the cost of dependent people.

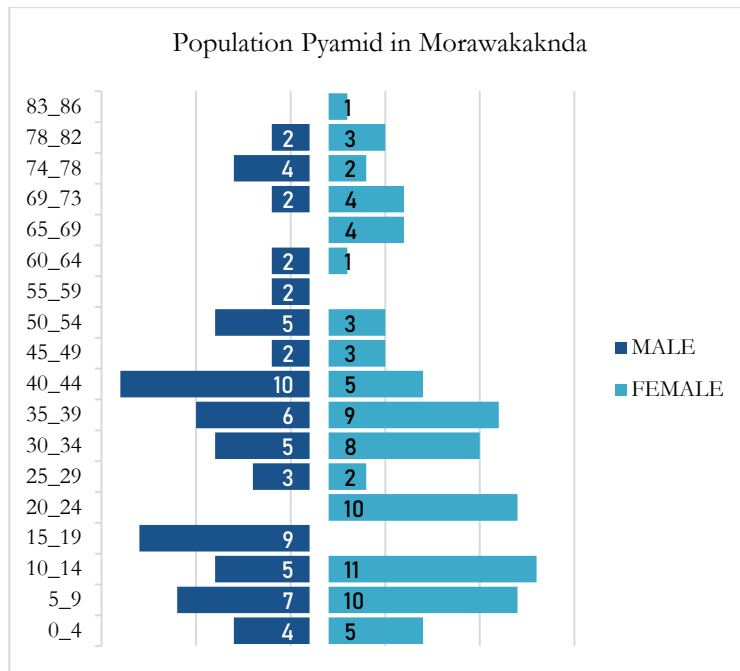


Figure 5: Population pyramid in Morawakakanda hazard zone

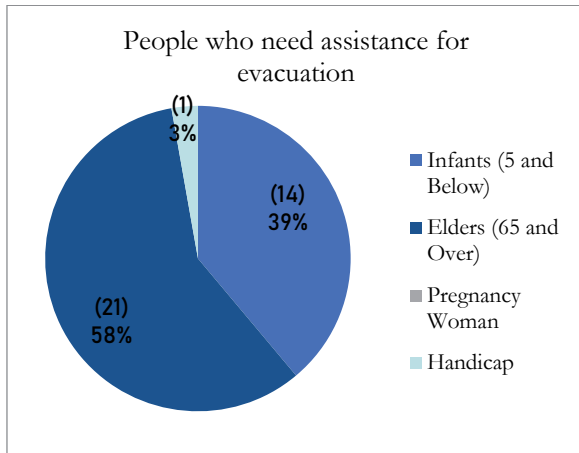


Figure 6: People who need assistance for evacuation

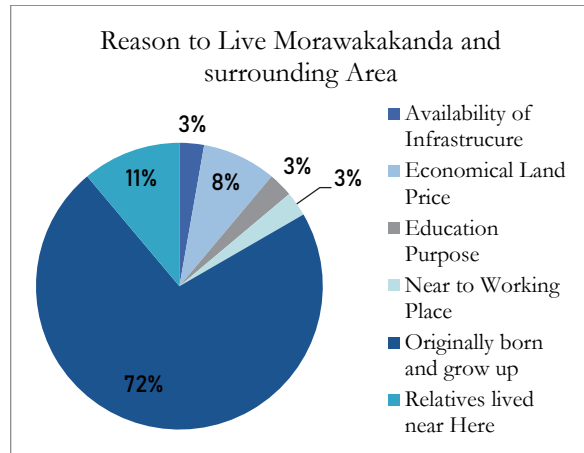


Figure 7: Reasons to live Morawakakanda and surrounding

The majority of the people, 106 (72%), were born and grown up in the project area. The reason behind remaining the communities in the landslide high-risk area may be the adjoining town centres providing adequate services and facilities to the community. Specifically the people, who needs assistance to the evacuate, can be categorized, 58% are elders (The persons who are age 65 and above), 39% are infants (The person who are age 5 and under), and 3% are Handicap.

2.2.3. Housing Conditions

The Morawakakanda GN consisted of 753 housing units (2012 Census & Statistic Survey), and out of these, 643 are permanent dwellings, 103 are semi-permanents and 7 housing units are improvised. There are thirty-eight housing units in the yellow zone and two houses are in red zone area. All these housing units are constructed by using permanent materials.

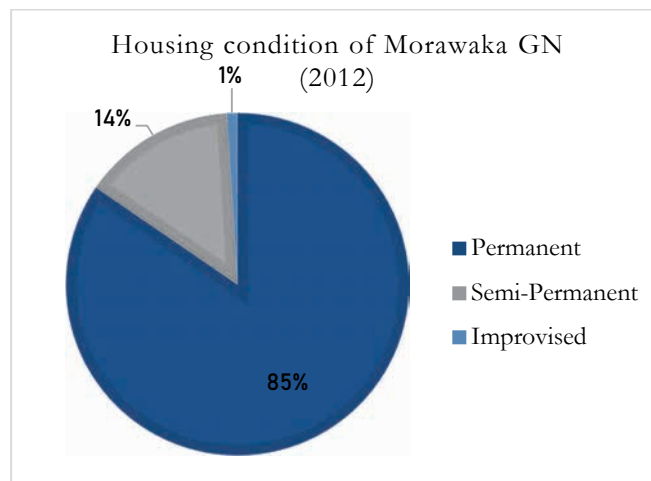


Figure 8: Housing Condition of Morawakakanda GN

2.2.4. Essential Public Facilities

Majority of important public facilities are located along the national highway A17:(Galle, Imaduwa, Akuressa, Deniyaya to Madampe). The following table shows the public facilities exist in Morawaka DS area. Location of those facilities are shown in Figure 9.

| | |
|------------------|---|
| School | Morawaka Kanishta Vidyalaya (Primary School) Morawaka Primary School (Primary School) Morawaka Keerthi Abeywickrama National School (High School) |
| Institutions | Zonal Education Office Vocational Training Center |
| Health center | District Hospital Morawaka Nuruwa Rural Hospital |
| Police Station | Police Station Morawaka |
| Public Market | Public Market Morawaka |
| National Highway | A17 |

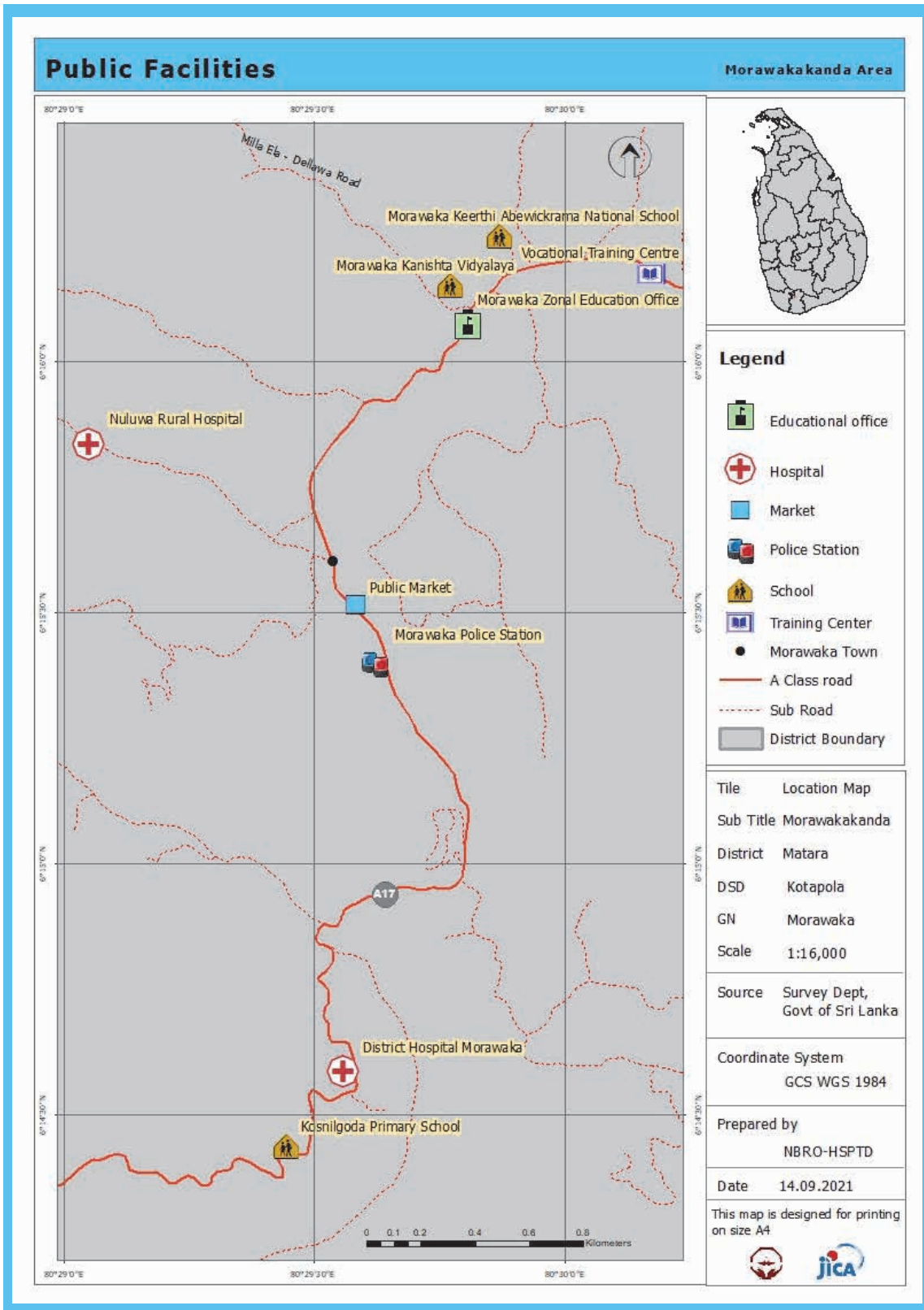


Figure 9: Public facilities

2.2.5. Climate Condition

Rainfall pattern

Morawakkanda is located at an intermediate climate zone of the country, and annual rainfall is between 1750-2500 mm. The area gets frequent rain from South West Monsoon. The below table shows the monthly rainfall variation for 2013-2016 in the Morawakkanda surrounding area.

Table 1: Monthly rainfall distribution

| Month | Rainfall (mm) | | | |
|-----------|---------------|--------|--------|--------|
| | 2013 | 2014 | 2015 | 2016 |
| January | 410.2 | 2.28 | 8.39 | 1.27 |
| February | 158.7 | 0 | 37.34 | 37.85 |
| March | 98.7 | 104.9 | 54.11 | 43.69 |
| April | 243.2 | 13.46 | 140.46 | 39.88 |
| May | 100.4 | 80.01 | 52.58 | 173.72 |
| June | 42.2 | 20.06 | 22.86 | 11.17 |
| July | 59.9 | 6.6 | 32 | 34.53 |
| August | 70.1 | 46.74 | 160.51 | 7.11 |
| September | 77.2 | 35.54 | 292.1 | 8.15 |
| October | 171.1 | 257.54 | 151.88 | 29.21 |
| November | 201.1 | 196.34 | 194.81 | 167.12 |
| December | 232.3 | 323.83 | 137.42 | 104.64 |

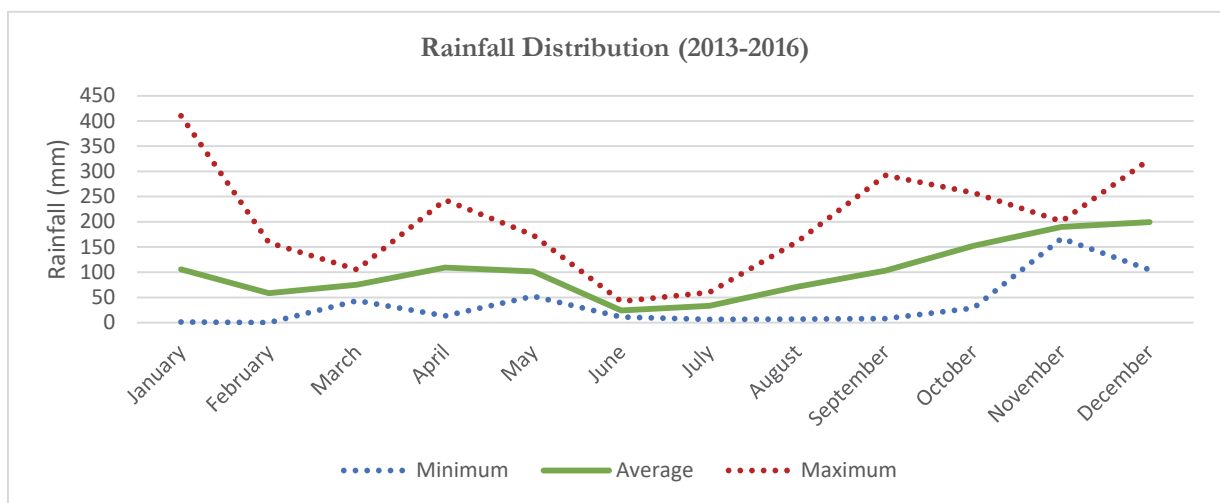


Figure 10: Rainfall Distribution

The above figure shows the rainfall distribution in the Morawakakanda, and it was categorized into minimum, maximum and average rainfall levels. The results show the highest average rainfall received to the area is in November, during the southwest monsoon period, and the lowest rainfall received in June. The higher-level rainfall fluxuation could be identified in different months: January, April and September. The inter monsoon rains occurs in April and October. The deviation in April and September could be resulted due to intermonsoon period. North-East monsoon activates in October to December. The monsoon effects vary El-Nino and La-Nino. The High variation could be resulted due to strength of monsoon event.

Temperature

The average annual temperature of the area is 27°C. The highest average monthly temperature is usually recorded during June, which is around 29°C. The lowest average monthly temperature of the year is encountered during December, which is around 26.7°C. Below table 04 shows the average monthly temperatures for each month 2014-2016 in Southern Province.

Table 2: Annual temperature

| Month | Temperature (Celsius) | | |
|-----------|-----------------------|------|------|
| | 2014 | 2015 | 2016 |
| January | 26.5 | 26.7 | 27.1 |
| February | 26.9 | 26.7 | 27.6 |
| March | 28.1 | 27.4 | 28.6 |
| April | 28.2 | 27.6 | 30.1 |
| May | 28.4 | 28 | 28.5 |
| June | 29.3 | 28.8 | 29.3 |
| July | 29.4 | 25.5 | 29.7 |
| August | 28 | 27.9 | 29.7 |
| September | 27.9 | 27.1 | 29.1 |
| October | 27.2 | 27 | 29 |
| November | 26.5 | 26.7 | 27.3 |
| December | 26 | 26.6 | 27.5 |

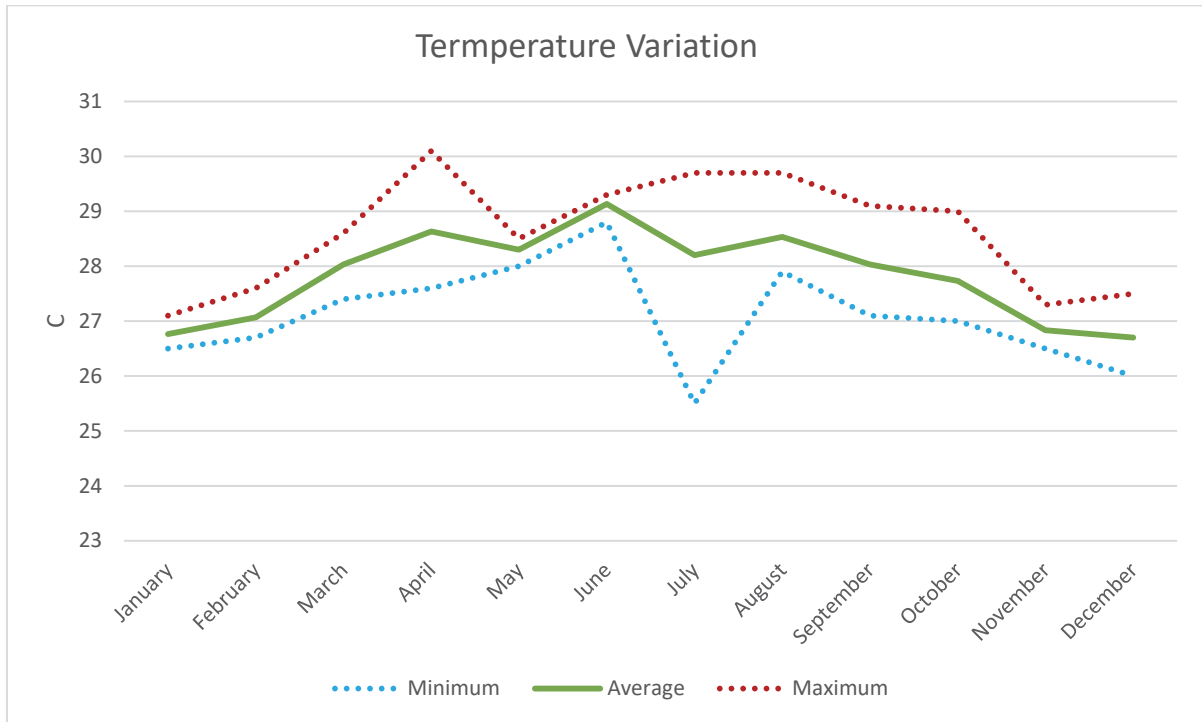


Figure 11: Temperature variation of the area

The temperature variation observes that only 2.5°C changes over the year and highest peak in June and lowest in December/January period.

2.2.6. Disaster Record

In May 2017, there were few landslides occurred in the area, and Morawakakanda was the debris flow in the area. This debris flow transported debris to more than three kilometers with average width of fifty meters. The debris flow travels through a dry or wet valley. There is a stream flows in the valley, and according to residents, the stream flow was temporary stopped for few hours before the incident. The experts justified that, a small landslide was occurred and disrupted the dream water flow and it was created a temporary dam. This small dam breach created a debris flow. Intense rainfall triggers this landslide event in the area.

The highest ever rainfall for the month was record, which cumulative total was 530mm and within 24-hrs rainfall was 440mm. Twenty-three deaths, fourteen houses were destroyed during the incident. Twenty-one families were relocated, and another sixty families are to be relocated. The unstable debris mass remains in the upper slope area.

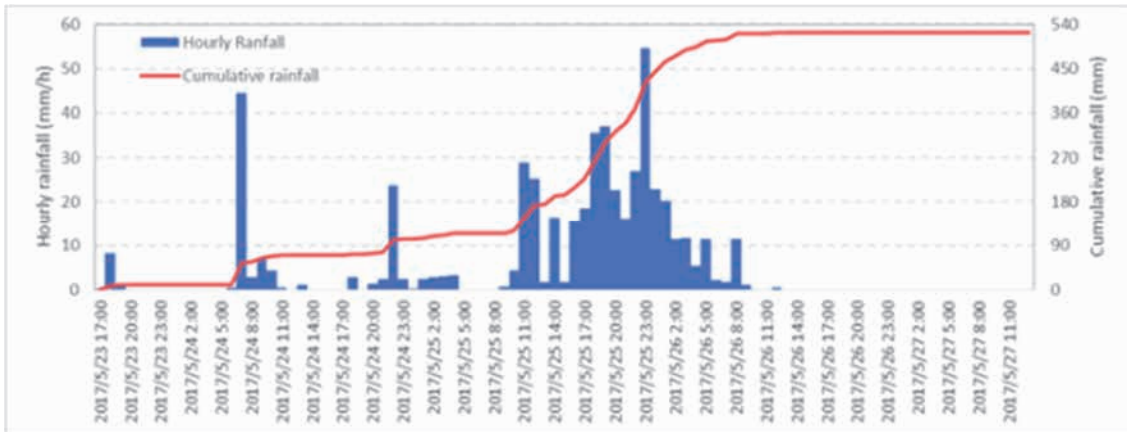


Table 3: Basic information of landslide

| Basic information of landslide | |
|--------------------------------|-------------------|
| Landslide type | Landslide |
| Date of occurrence | May 26,2017 23:30 |
| Date of inspection | May 31,2017 |
| Crown width | 48 m |
| Crown height | 114 m |
| Initiation area length | 221 m |
| Maximum width | 198 m |
| Length of landslide | 2085 m |
| Width at middle | 164 m |
| Slope type | Concave |
| Initiation area slope angle | 17-18 deg |
| Deposited area slope angle | 1.7 deg |
| Erosion type | Straight |
| Hydrology pattern | Stream |

2.2.7. Current Land Use

Kotapola DS Division prepared a Land use map of Morawaka GN in 2010 (Figure 8), and the area statistics are shown in Table 4. The major Land use types in Morawaka GN are Forest, Tea, and Scrub.

Table 4: Land use types

| Land use Type | Area(ha) |
|--------------------|----------|
| Chena | 1,931 |
| Coconut | 201 |
| Ela | 19 |
| Forest | 8,676 |
| Grassland | 23 |
| Home Garden | 3,378 |
| Jeep or Cart Track | 430 |
| Main Road (B) | 1,458 |
| Minor Road | 86 |
| Other Plantation | 82 |
| Paddy | 1,152 |
| River | 347 |
| Rock | 46 |
| Rubber | 74 |
| Scrub | 2,652 |
| Tea | 5,047 |
| Total | 25601 |

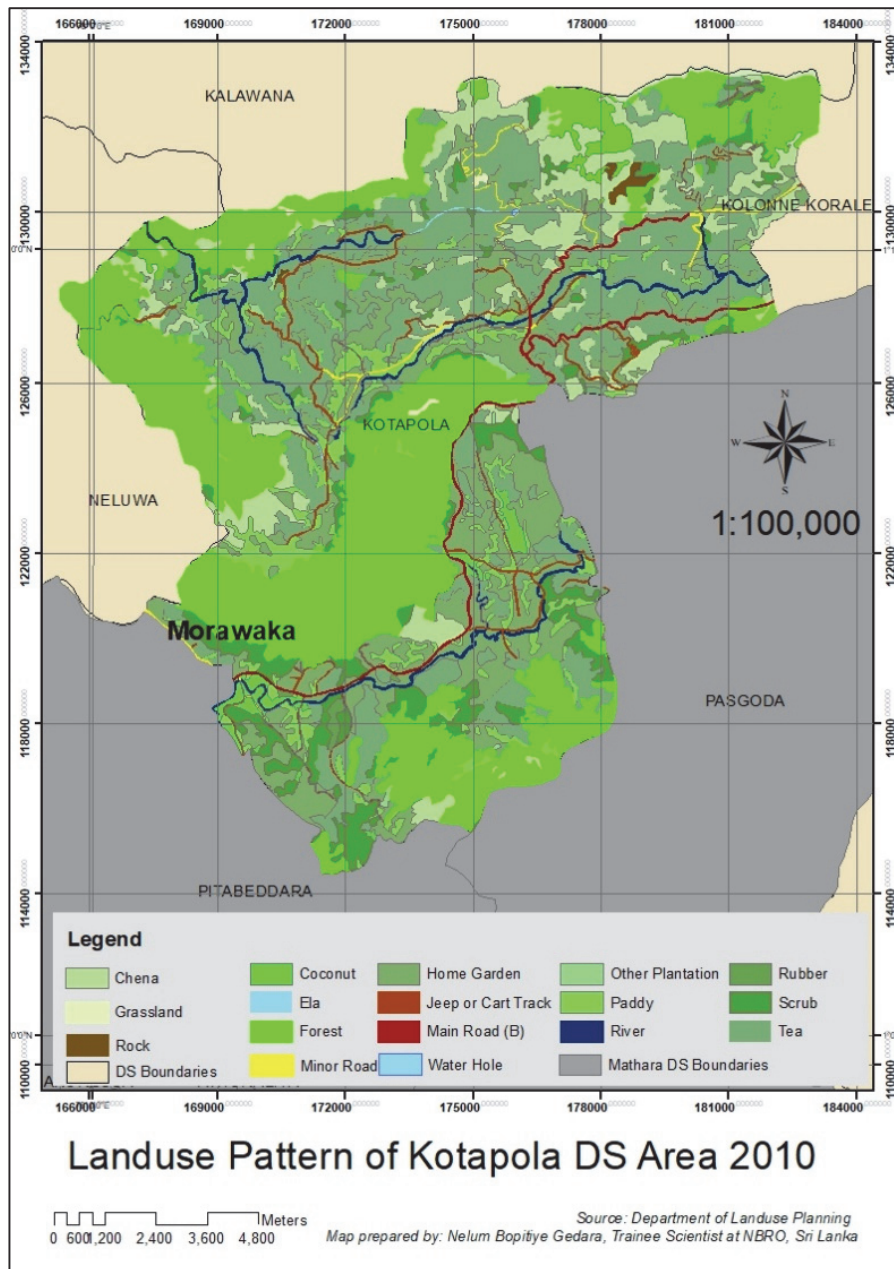


Figure 12: Land use pattern

The above map shows the spatial distribution of land uses in the Morawaka GN division. The mountain area is covered with forest lands, and downstream areas are covered with paddy. 33.9% of total GN land is covered with natural forest, and home gardens coverage is 13.2%. Major agriculture types are tea (19.7%), paddy (4.5%), and chena (7.5%).

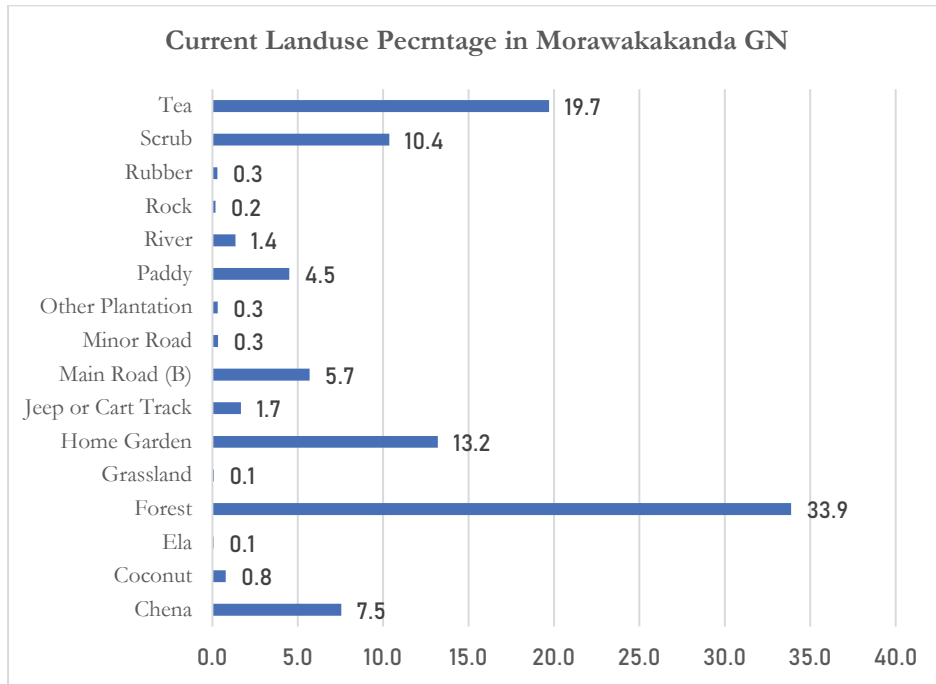


Figure 13: Current land use percentage in Morawakakanda area

2.2.8. Current Land Use with Yellow and Red Zone in the target area

An updated land-use map was prepared using aerial image interpretation captured through drone technology in 2020 by NBRO. The aerial image was classified according to the existing land use classification system used for landslide risk mapping and generated a 1:1000 land use map for the project area. These high-resolution images help to identify the detail various of the ground, and it helps identify the exact building shapes and sizes. The black squares represent the existing building layer, and small buildings were located adjoining to the forest area. Larger-size buildings are located near the main roads, and building density is also higher near the road. The map highlighted the existing landslide flow path and marked the possible landslide debris flow paths generated through the yellow-red zone method described in the next section.

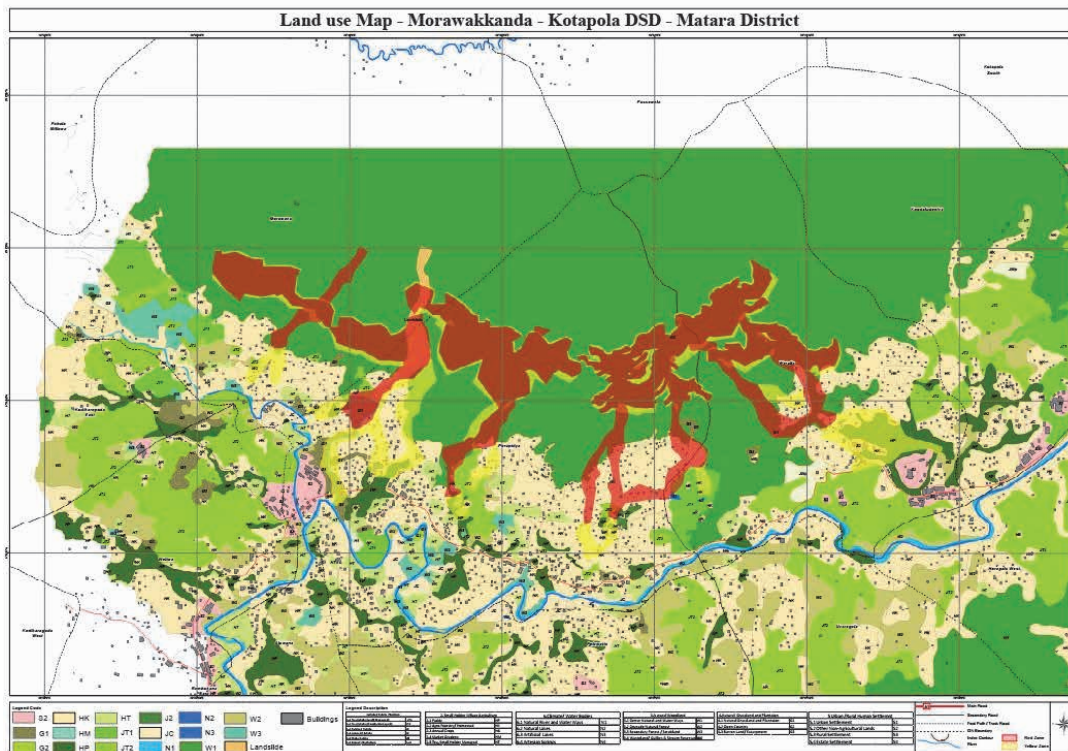


Figure 14: Current land use plan

2.3. Concept of Yellow/Red Zone

Sediment Disaster Hazard Area (Yellow Zone) is defined as an area prone to sediment disaster. If an area is designated as a Yellow Zone: 1) early warning systems should be established, and 2) steps to raise the awareness of local people about sediment disasters should be taken. Special Sediment Disaster Hazard Area (Red Zone) is designated where there is a severe risk of damage to buildings and threat to residents; thus, structural and non-structural measures, including development regulation, should be applied based on the appropriate land use planning.

1. Yellow/Red Zone for Slide

Slide blocks are classified into three ranks, A, B and C, in terms of the clarity of slide topography and its activity based on the topographical interpretation. These ranks are defined and shown in the following table.

Table 5: Classification of ranks

| Classification of Ranks | Definition |
|-------------------------|---|
| Rank A | The slide is confirmed to be completely active at the field survey; and Its shape, including its foot, is identifiable. |
| Rank B | The shape of the slide, including its foot, is identifiable, but the slide is not confirmed to be active at the field survey; or The slide is confirmed to be locally active, and its shape is not identifiable. |
| Rank C | The slide is not confirmed to be active at the field survey, and also its shape, including its foot, is not identifiable. |

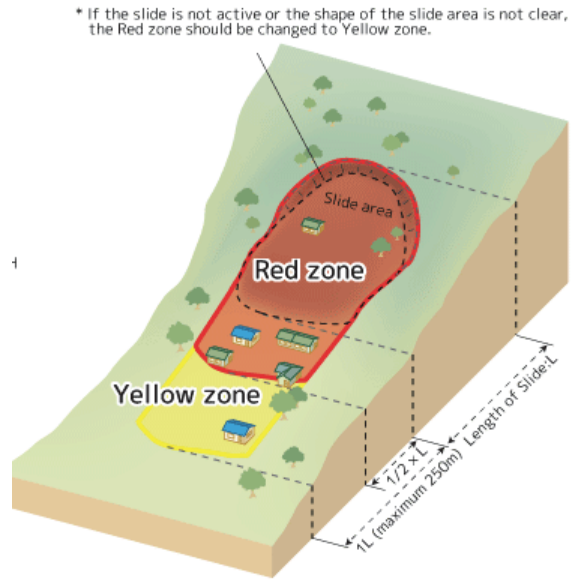


Figure 15: Yellow/red zone for slide

2. Yellow Zone and Red Zone for Slope Failure

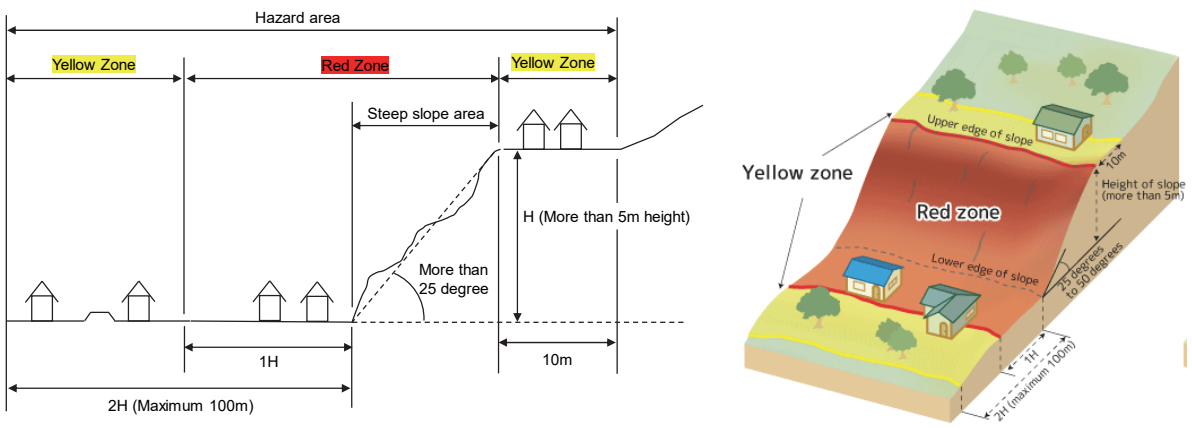


Figure 16: Yellow/red zone for slope failure

3. Yellow Zone and Red Zone for Debris Flow

The lower ends of the Yellow Zone and Red Zone for debris flow shall be determined based on the ground gradient or inclination from the profile of the target area. In addition, the width of the zone shall be determined based on spreading angles such as 30 degrees for Yellow Zone or 15 degrees for Red Zone. The concept of setting the Yellow Zone or Red Zone for debris flow is shown in the following figure.

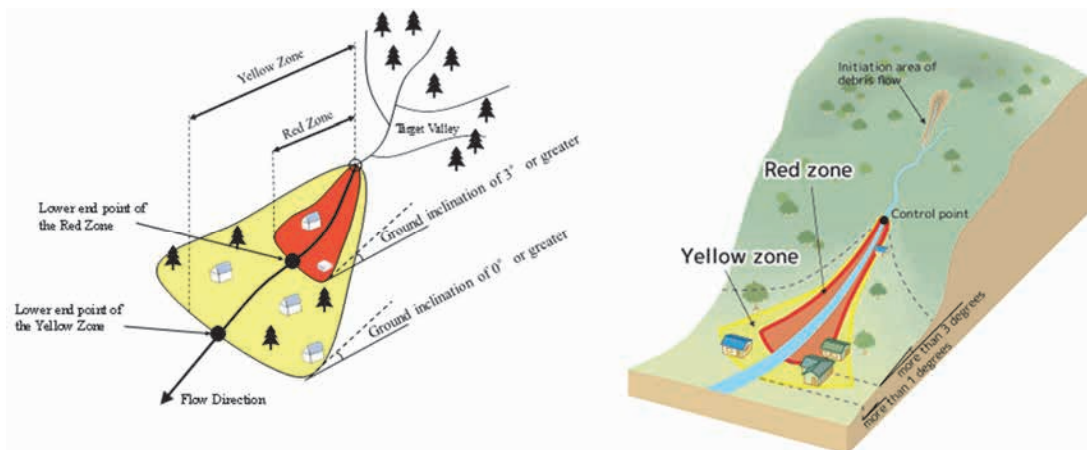


Figure 17: Yellow/red zone for debris flow

2.4. Categorized Zone based on Yellow/Red zoning and LHM

NBRO has developed and distributed Landslide Hazard Map (LHM), in which the area is divided into main four categories; “Landslide not likely to be occurred”, “Modest level landslide risk exists”, “Landslide risk might be existing” and “Landslide can be occurred”. There are fewer restrictions on “Landslide not likely to be occurred” areas, but in other zones, specific construction and structural guidelines need to be followed. However, due to the haphazard planning activities of the country, most of the landslide-prone categories consists of settlements.

The current hazard mapping activities do not consider the debris flow simulations. Therefore, possible debris flow areas are required to identify to incorporate the existing development guidelines. Accordingly, NBRO introduced a new Yellow/Red zone mapping concept for the area to simulate the landslide flow paths. In the concept, more detailed and site-specific hazard risk levels can be indicated to promote appropriate land use.

The Yellow/Red zone concept has four zones, “Restricted Zone”, “Prohibited Zone”, “Warning Zone” and “Development Zone”, which is similar classification with the flood-resilient guideline published by NBRO in 2003. The concept is only applied for the debris flow area, and the rest of the area is followed by the Landslide Hazard Map-based land-use guidelines. The following table shows the yellow/red zone and present LHM categories correlated with development zone categories.

Table 6: Categorized zones based on yellow/red and LHM

| Development Zone Category | Yellow/Red Zoning (Applied for the Y/R zoning prepared area) | Landslide Hazard Map (Applied for the remaining area) |
|---------------------------|--|---|
| Restricted Zone | Red Zone (Sediment Disaster Hazard Area) | Landslides most likely to occur |
| Controlled Zone | | Landslides are to be expected |
| Warning Zone | Yellow Zone (Special Sediment Disaster Hazard Area) | Modest level of landslide hazard exists |
| Development Zone | Else | Landslide not likely occur |

i. Restricted Zone

The “Restricted Zone” is assigned for the lands identified as “Red Zone” and ranked in “Landslides most likely to occur (HR)” in LHM. Any construction or any development shall be prohibited in the zone and the zone is high probability for future landslide events. If any constructions are available in this zone should be relocated, with proper investigations. This land area should be kept as natural areas and required to monitor the environmental condition, water flow and hazard situation in detail manner. In future, this area shall be demarcated as sensitive area and control all kind of human impacts for the area. Landslide flow path area also considered into this zone and considering the feasibility studies, the land should be converted as green area for the settlement. It is required to have detail investigations and proper early warning systems for upper catchments before converting the area as green area.

ii. Controlled Zone

The “Controlled Zone” is assigned for the lands identified as “Red Zone” and ranked in “Landslides are to be expected (HR)” in LHM. This zone is considered as high-risk zone due to landslide events. Therefore, landslide risk should be mitigated through structural mitigation measures when people develop the land and/or construct new building in this zone. Aftermath, the area could be used for the low dense controlled development activities. In addition, this area should have proper early warning system. Detail building codes and designed should be followed by the developers in the area and if any construction didn’t follow the proper guideline, the authority shall be reported to the proper planning agencies to remove such construction by considering its’ impact to the area.

iii. Warning Zone

The “Warning Zone” is assigned for the lands identified as “Yellow Zone”. Development activities are allowed in this zone, but need to follow the resilient construction guideline which was published by the NBRO. This zone can have different building densities depending on the risk levels. However, entire zone should have proper early warning system and continuous awareness programs for the commuters and residents. Controlled land uses are allowed in the zone and management plan of each land uses should be monitored by the respective institutes.

iv. Development Zone

The “Development Zone” is assigned for the lands which are not identified as either Yellow zone or Red zone. This zone is demarcated by considering the importance of development and hazard levels. This zone can be used to develop any kind of constructions, but it should be adhered to the guidelines which are provided by the planning agencies like UDA, NPPD, etc. No resilient construction techniques are mandated for the zone, unless, if disaster management professionals were identified as disaster impacted area. If so, the retrofitting guidelines should be adhered for the constructions.

Based on this, the land area could be divided into main four sections and each section should be clearly monitored by the institute. Furthermore, these main zones could be divided into sub categories by considering the hazard zones and development zone.

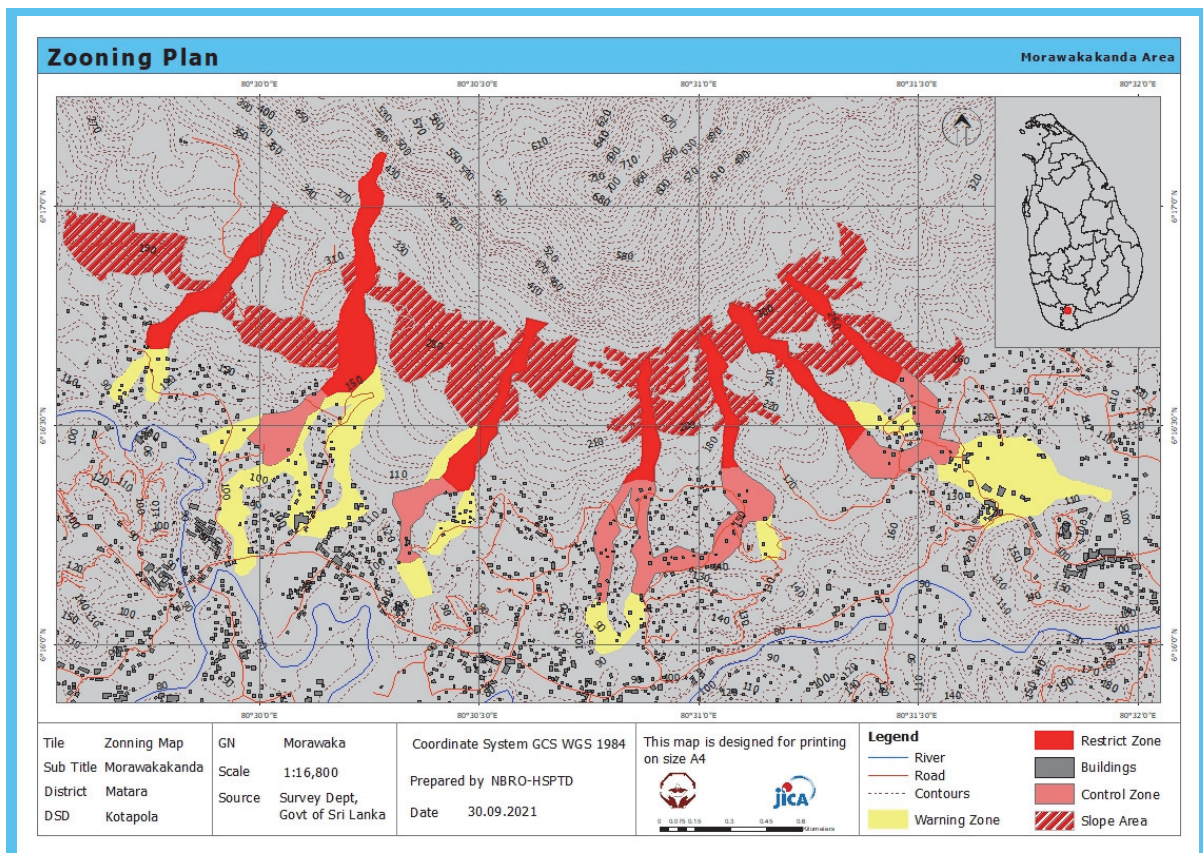


Figure 18: Zoning plan

2.5. Possible Land Uses for the Zones

The following table indicated the allowed and not-allowed land use activities in each zone.

Table 7: Allowed and not allowed land uses to the area

| | Proposed Land use category | | | |
|---------------------|----------------------------|------------------------|------------------------|------------------------|
| | Development Zone | Warning Zone | Controlled Zone | Restricted Zone |
| Residential | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Retail & Commercial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Office | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Industrial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Parks/ Playgrounds | Suitable for Use | Suitable for Use | Detailed Investigation | Not Suitable |
| Agricultural | Suitable for Use | Suitable for Use | Suitable for Use | Detailed Investigation |

2.6. Approval and Enforcement of the Land Use Plan

2.6.1. General conditions

Before doing any development activity need to get the approval from the local authority: Construction activities, Land use changes (Change of use), Land subdivision and amalgamation, and Infrastructure development.

- 1) Local authority should demarcate the boundaries of yellow zone and red zone physically
- 2) An emergency response plan should be in place for every community in yellow zone
- 3) NBRO and DMC should establish early detection instruments within the RedZone



Risk Assessment

3. Risk Assessment for Morawakakanda

The general concept of risk assessment for a landslide is to examine both the likelihood and adverse consequence of a landslide hazard, then thereby address risk in totality and finally compares the level of the resulting risk against predetermined standards, or other criteria to determine risk treatment and management prioritization. To simplify matters, this manual is not intended to cover the overall processes of hazard analysis (frequency and magnitude) to risk evaluation.

3.1. Database for Designated Yellow/Red Zones

The following table shows the criteria that used to assess the existing risk situation within red and yellow zone areas of Morawakakanda.

Table 8: Items for Database for Designated Yellow/Red Zone

| Category | Item | |
|----------------------------------|---|---|
| Basic information | District | |
| | DS Division | |
| | GN Division | |
| | ID No. (District code - GN P code- Landslide type - serial No.) | |
| | Name of PS | |
| | Landslide Type (Slope failure/Slide/Debris flow) | |
| | Area of Yellow/Red Zone (m2) | |
| Elements at risk | Number of facilities for vulnerable people | Facilities for the aged |
| | | Facilities for physically handicapped persons |
| | | Facilities for mentally retarded and disordered persons |
| | | Kindergartens |
| | | Maternity facilities |
| | | Other similar facilities |
| | Number of evacuation places | |
| | Number of hospitals | |
| | Number of schools | |
| | Number of other important facilities | |
| | Traffic network | |
| Number of residential houses | | |
| Impact of past sediment disaster | Land devastation situation (nothing/slight/significant) | |
| | Impacts of past sediment discharge on nearby facilities | |
| Local request | Request from residents and/or local authorities for risk reduction measures | |
| Countermeasures | Existing structural countermeasures | |
| | Existing non-structural countermeasures | |
| Land development plan | Presence of land development plan / land use plan | |

3.2. Preparation of Data for Risk Evaluation

The relevant data for further risk evaluation is collected and assessed for each of the designated Yellow/Red Zones in accordance with the actual site-specific and local conditions, as sorted and listed below:

- a) Basic information
 - Yellow/Red Zone hazard maps (1:2,500 or 1:5,000 scale)
 - Location information (ID No., District, GN division, Landslide type)
- b) Information on important and vulnerable elements at risk
 - Number of facilities for vulnerable people
 - Number of evacuation places for a disaster
 - Number of public facilities except for road networks
 - Class of road networks
 - Number of residential houses, within red and yellow zones, respectively
- c) Information on impact of past landslide disasters
 - Land devastation situation
 - Impact of past landslide disasters on nearby facilities
- d) other information
 - Request of implementation of measures from residents and/or local authorities

3.3. Items for Risk Evaluation

The risk evaluation for each of the designated Yellow/Red Zones will be conducted in accordance with such items as given in Table 8, and then the level of risk for each of the designated Yellow/Red Zone will be evaluated as very high, high, moderate or low according to the total scores using the risk evaluation sheet shown in Table 9 below. Figure 18 shows a concept of risk evaluation for the target zone

Table 9: Items and Scores for Risk Evaluation for Yellow/Red Zone

| Item | Maximum Score (Total: 100) |
|---|-------------------------------|
| 1) Number of facilities for vulnerable people | 10 |
| 2) Evacuation places | 10 |
| 3) Public facilities | 10 |
| 4) Number of facilities of the above items 1) to 3) within the Red Zone | 10 |
| 5) Traffic network | 10 |
| 6) Number of residential houses within the Yellow/Red Zone | 10 |
| 7) Number of residential houses within the Red Zones | 10 |
| 8) Land devastation situation | 10 |
| 9) Impacts of past sediment discharge on nearby facilities | 10 |
| 10) Request from residents | 10 |

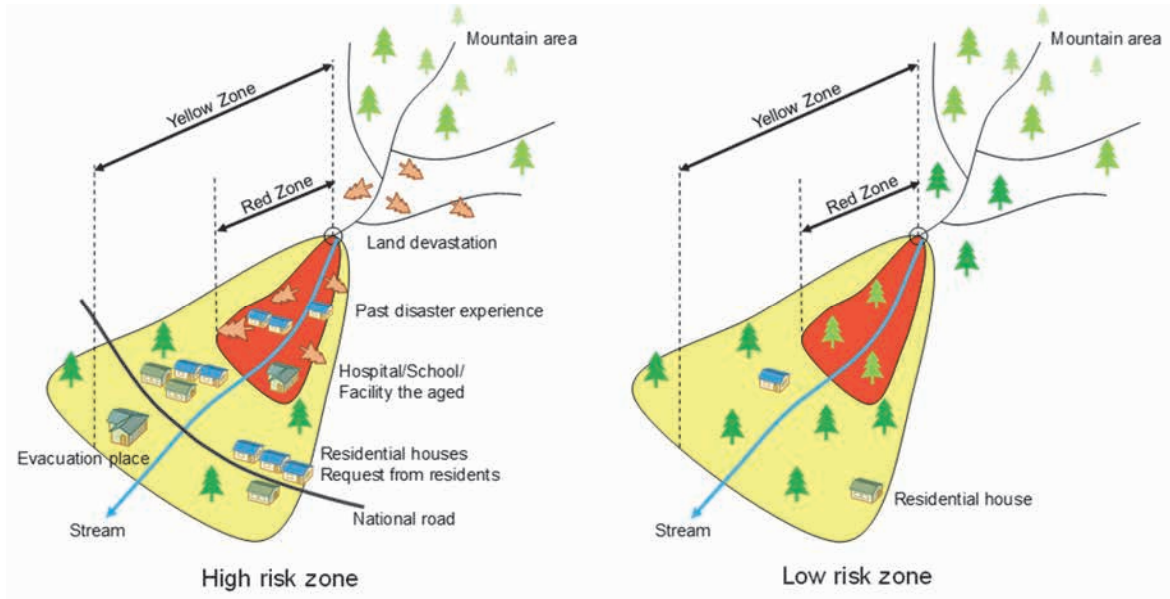


Figure 19: Concept of Risk Evaluation for the Target Yellow/Red Zone (for Debris Flow)

3.4. Risk Evaluation Sheet for Yellow/Red Zone

| District | Matara | | | Prepared by | | | |
|---------------------------|---|--------------------------------|---|--------------|------------|------------------|-----------------------|
| GN Division | Morawaka | | | Organization | NBRO | | |
| Landslide Type | <input type="checkbox"/> Slope failure | <input type="checkbox"/> Slide | <input checked="" type="checkbox"/> Debris flow | Date | 10.08.2020 | | |
| Designation No. | Yellow Zone Debris Flow Zone 77 | | | | | | |
| Result of Risk Evaluation | | | | | | | |
| No. | Item | Max Score | Allotment Score | | | Evaluation Score | Remarks |
| | | | 0 | 5 | 10 | | |
| 1) | Number of facilities for vulnerable people | 10 | 0 | | | 0 | |
| 2) | Evacuation places | 10 | | | 10 | 10 | School |
| 3) | Public facilities | 10 | | | 10 | 10 | 01 School |
| 4) | Number of facilities of the above items (1to 3) within the Red Zone | 10 | 0 | | | 0 | |
| 5) | Traffic network | 10 | | 5 | | 5 | Madampe-Deniyaya Road |
| 6) | Number of residential houses within the Yellow and Red Zone | 10 | | | 10 | 10 | 47 Residential Houses |
| 7) | Number of residential houses within the Red Zones | 10 | | | 10 | 10 | 20 Residential Houses |
| 8) | Land devastation situation | 10 | | | | 0 | |
| 9) | Impacts of past sediment discharge on nearby facilities | 10 | | | | 0 | |
| 10) | Request from residents | 10 | | | | | |
| Total: | | 100 | | | | 45 | |

Figure 20 Filled Risk assessment sheet for debris flow path in Morawakanda

Explanation and Description:

- 1) Facilities for vulnerable people mean facilities for people who require assistance during a disaster, mainly including a) facilities for the aged, b) facilities for physically handicapped persons, c) facilities for mentally retarded and disordered persons, d) kindergartens, f) maternity facilities, and g) Other similar facilities.
- 2) Evacuation places mean whether evacuation shelters are present or not around or within the Yellow/Red Zone.
- 3) Public facilities include a) Important facilities such as hospitals and schools, and b) others rather than important facilities.
- 8) Land devastation situation means the relevant lands are significantly devastated due to sediment disasters and almost cannot be used, or are slightly devastated and can be used as farm lands or forest land.
- 9) Impacts of past sediment discharge on nearby facilities mean a) presence or absence of past sediment discharge and its impacts on nearby facilities if present.

The risk evaluation for each of the designated Yellow/Red Zones is carried out and rated on the basis of the selected ten (10) items, as explained above. The risk of each of the designated Yellow/Red Zones is scored using the risk evaluation sheet for yellow/red zone shown in Figure 17 and is further classified into four levels, namely, very high, high, moderate or low according to the total scores.

Table 10: Classification of Risk Level

| Risk Level | Total Evaluation Score |
|------------|------------------------|
| Very High | 75 and more |
| High | 50 to 74 |
| Moderate | 25 to 49 |
| Low | 0 to 24 |

The designated Yellow/Red Zones is prioritized by considering these selected items, and this enables risk management, for example, further risk reduction measures, land use planning, to be considered according to priority or risk level. This will facilitate a rational and effective approach to risk treatment and management given the resources available.

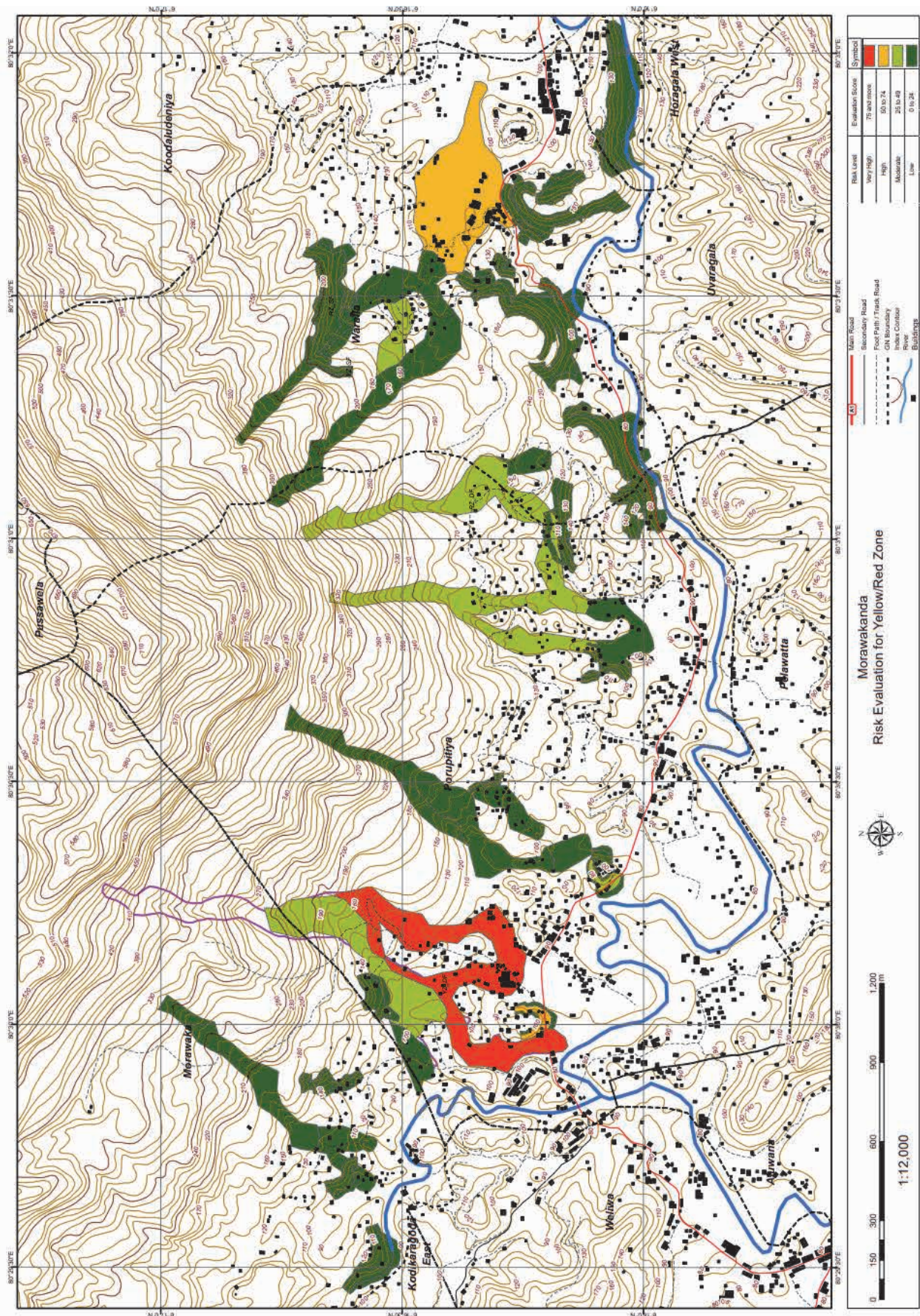


Figure 21: Risk Evaluation Map of Morawakkanda

4. Land Use Zoning Plan in Morawakkanda

As mentioned above concepts, the Yellow zone and Red zone of the target area were created by NBRO in 1:10,000 (Figure 10) and 1:2,500 scales (Figure 15). There are several potential debris flow-prone areas around the Morawakkanda. In this LSDRRP, only the stream of Morawakkanda and its surrounding area are considered. According to the hazard zoning, the debris deposition area in the 2017 disaster falls into the Red zone. The buildings located in the Red zone were destroyed by the 2017 disaster. The mudflow area falls in 2017 disaster into the Yellow zone. Most of the buildings including “Morawaka Keerthi Abeywickrama National School” are located outside of the Yellow zone, however, some houses and a tea factory are located in the Yellow zone. These areas still have potential risks in the Morawakkanda.

Current Land Use Map overlaying red and yellow zone in Morawakkanda is displayed Figure 14. In addition to the current land use displayed in Figure 14, those area covered as Red and Yellow Zone are required to follow the development restriction determined in this LSDRR.

The future land use pattern income could be categorized with the market values, and the below table can be used to estimate the price differences.

Table 11: Plantation crops in Morawakakanda Area

| Plantation Crops | Distance (M) | Average production | Price per 1 kg/ Price per nuts | Current Land Use Extent | Future Land Use Extent |
|------------------|-----------------------|--|--------------------------------|-------------------------|------------------------|
| Tea | | 1500kg/ha/year | 190 | | |
| Rubber | | 2800kg crepe/year/ha | 250 | | |
| Paddy | | 3400kg/ ha/year | 65 | | |
| Cinamon | | 1000kg/ha/year | 1700 | | |
| Peper | | 390kg/he/year | 950 | | |
| Coconut | | 6000 nuts/acres/ year | 70 | | |
| Pinapple | | 33000 per acres | 50 | | |
| Mangusteen | | 1000fruits per year (30-50yrs old tree) | 20 | | |
| Agawood | 2*2 | 2470 tree/hec | | | |
| Beattle | | 1000 sticks- 1200000 | 2000/1kg | | |
| Puwak (පුවක්) | 3*3 | 1100 per hec (3-4 bunches/one tree/year) | 650/1kg | | |
| කිතුල් | | 4-6l of sap for bottle of trecles | 1500 per bottle | | |
| | | 6-8l of sap for jaggery 1kg | | | |
| Dragon Fruit | 2*2 | 10000kg/he/year | 300 /1kg | | |
| | 3*3 | | | | |
| | 1*3 | | | | |
| rambuttan | 100-200 nuts per tree | 35 tree/ acres (200kg/year/tree) | | | |
| Banana | 3*3 | 1100plant/ha | 365/ 1 kg | | |
| Guvava | 3*4 | 350kg per tree | 200/kg | | |
| Goraka | 6*6/4*4 | | 900/1kg | | |
| Turmaric | | 20000-25000 kg/ha | 6000/1kg | | |

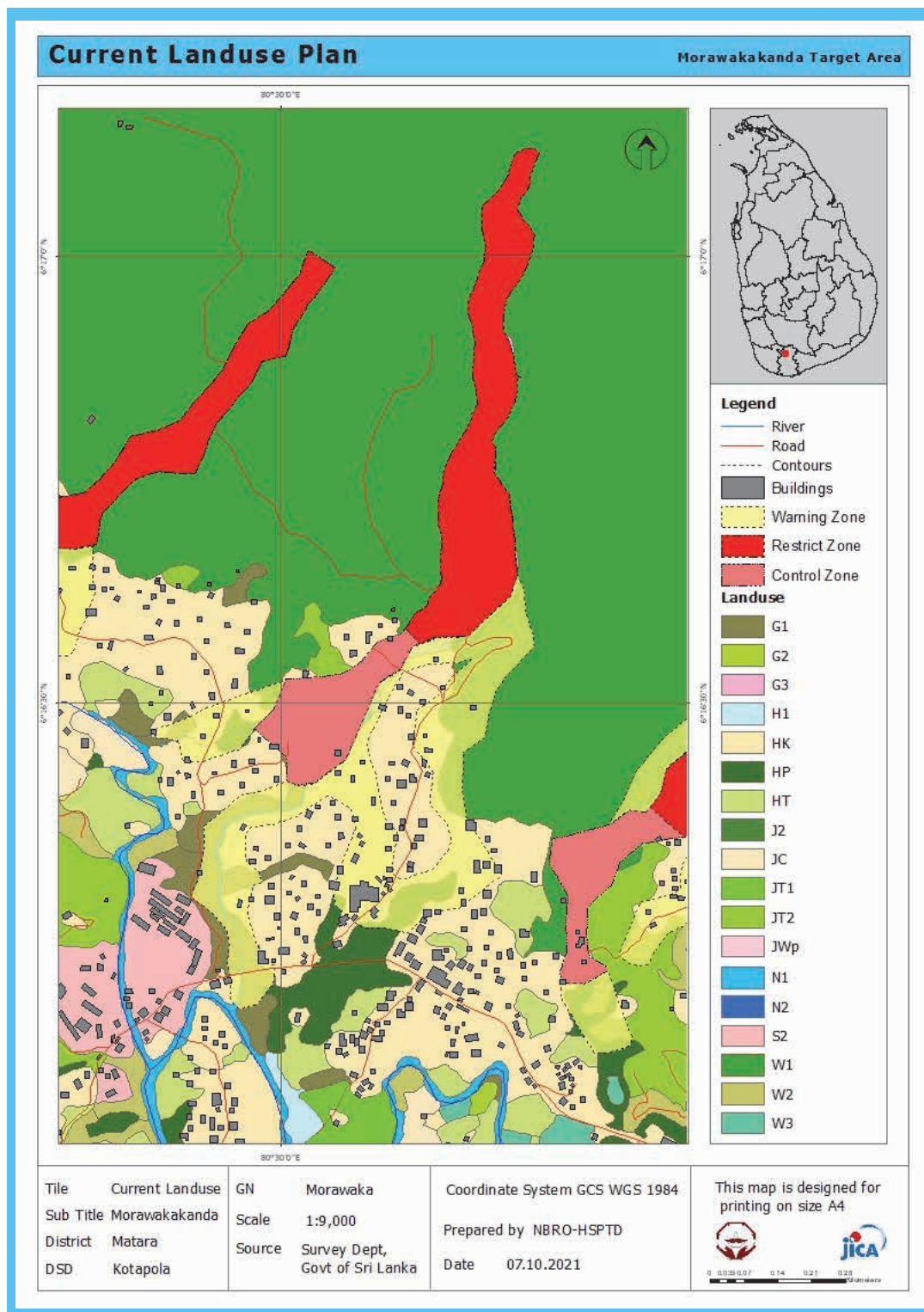
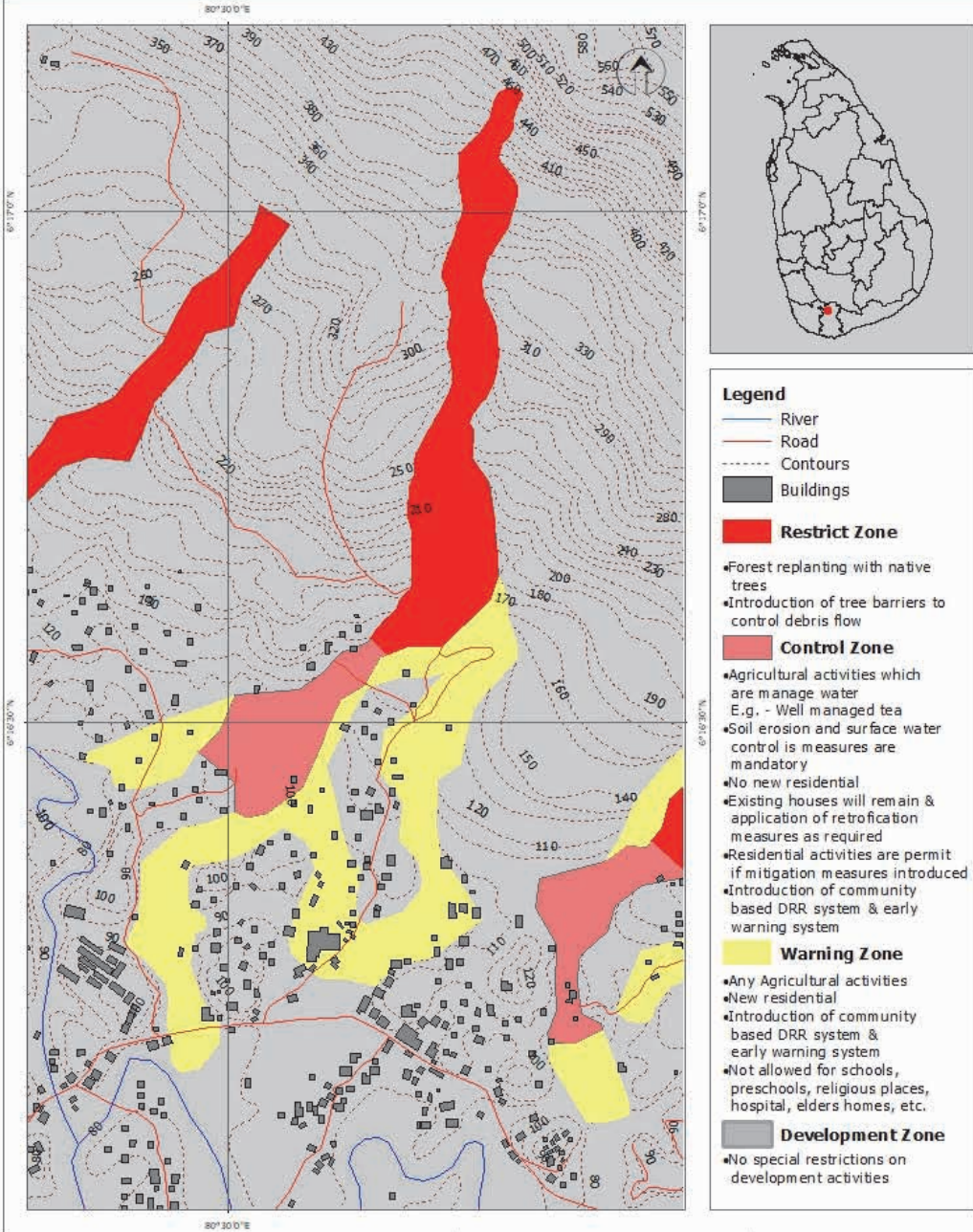


Figure 22: Current land use plan

Land Use Zoning Plan for Morawakkanda is shown in Figure 15. The four zone “Restricted Zone”, “Controlled Zone”, “Warning Zone” and “Development Zone” are illustrated on the map of the figure.

Landuse Zooning Plan

Morawakakanda Target Area



- Legend**
- River
 - Road
 - Contours
 - Buildings
- Restrict Zone**
- Forest replanting with native trees
 - Introduction of tree barriers to control debris flow
- Control Zone**
- Agricultural activities which are manage water
E.g. - Well managed tea
 - Soil erosion and surface water control is measures are mandatory
 - No new residential
 - Existing houses will remain & application of retrofication measures as required
 - Residential activities are permit if mitigation measures introduced
 - Introduction of community based DRR system & early warning system
- Warning Zone**
- Any Agricultural activities
 - New residential
 - Introduction of community based DRR system & early warning system
 - Not allowed for schools, preschools, religious places, hospital, elders homes, etc.
- Development Zone**
- No special restrictions on development activities

| | | | | | | |
|-----------|---------------|--------|--------------------------------|-------------------|--------------|--|
| Tile | Zooning Map | GN | Morawaka | Coordinate System | GCS WGS 1984 | This map is designed for printing on size A4 |
| Sub Title | Morawakakanda | Scale | 1:9,000 | Prepared by | NBRO-HSPTD | |
| District | Matara | Source | Survey Dept, Govt of Sri Lanka | Date | 07.10.2021 | |
| DSD | Kotapola | | | | | |

Figure 23: Land use zoning plan

4.1. Basic DRR Strategies for Morawakkanda

Restricted Zone

- Forest re-planting with native trees.
Use native plants to replant the degraded land. Nature based landslide risk mitigation project, a technical collaboration project of NBRO with Asian Disaster Preparedness Center (ADPC) have developed a plant manual to use for such kind of situation.
- Introduce tree barriers to control debris flow
Introduce tree line as a debris along the border of restricted zone and control zone. it may help to control debris to flow in to residential area to certain extent.
- Sabo structural facilities
- In consultation with the central government such as NBRO and Road Development Authority, debris flow prevention facilities such as Sabo dam, training dyke, channel works.

Controlled Zone

- Promote agricultural activities which are manage water (e.g. well manage tea)
- Soil erosion and surface water control is measures are mandatory.
- Not allow to new residential
- Existing housing will remain and application of retrofication measures as required. There are seven (7) houses in controlled zone in Morawakkanda.
- Residential activities are permit if mitigation measures introduced.
- Introduction of community based DRR system and early warning system.

Warning Zone

- It is suitable for any agriculture activities as well as to establish new residential also.
- Introduction of community based DRR system and early warning system
- Not Allowed for Schools, preschools, religious places, hospital, elder homes and so on.

Development Zone

- No special restrictions on development activities
- Regular development approval process will be taken in to consideration

4.2. Statistics in Yellow and Red Zone

The statistics are based on the filed survey in Morawakakdanda Target area which is conducted on 2021.08.08. by the NBRO, and the following information is utilized to plan relocation of housing, an evacuation drill, and a communication channel to disseminate early warning.

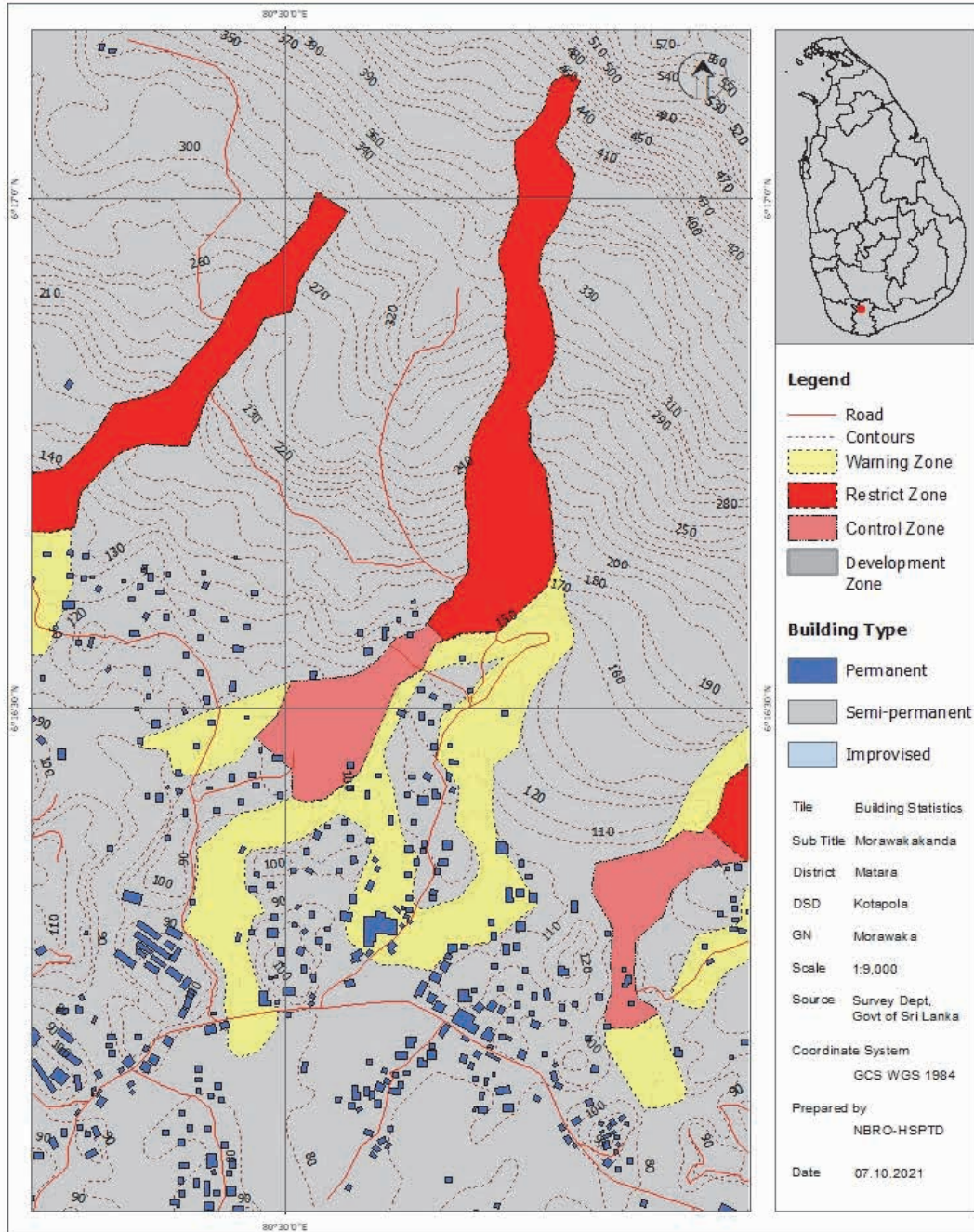
Table 12: Statistics in Yellow and Red zone

| | Number of Housing | Number of Family (people) | Number of people who needs assistance to evacuate (infants, elderly, pregnant woman, people with handicap) |
|-----------------|-------------------|---------------------------|--|
| Restricted Zone | 0 | 0 family (0 people) | No |
| Controlled Zone | 2 | 2 family (7 people) | No |
| Warning Zone | 37 | 37 family (148 people) | 35 people |

| | Total Number of Housing | Permanent | Semi-permanent | Improvised |
|-----------------|-------------------------|-----------|----------------|------------|
| Restricted Zone | 0 | 0 | 0 | 0 |
| Controlled Zone | 2 | 2 | 0 | 0 |
| Warning Zone | 37 | 37 | 0 | 0 |

Building Statistics

Morawakanda Target Area



| | Total Number of Housing | Permanent | Semi-permanent | Improvised |
|-----------------|-------------------------|-----------|----------------|------------|
| Restricted Zone | 0 | 0 | 0 | 0 |
| Controlled Zone | 2 | 2 | 0 | 0 |
| Warning Zone | 37 | 37 | 0 | 0 |

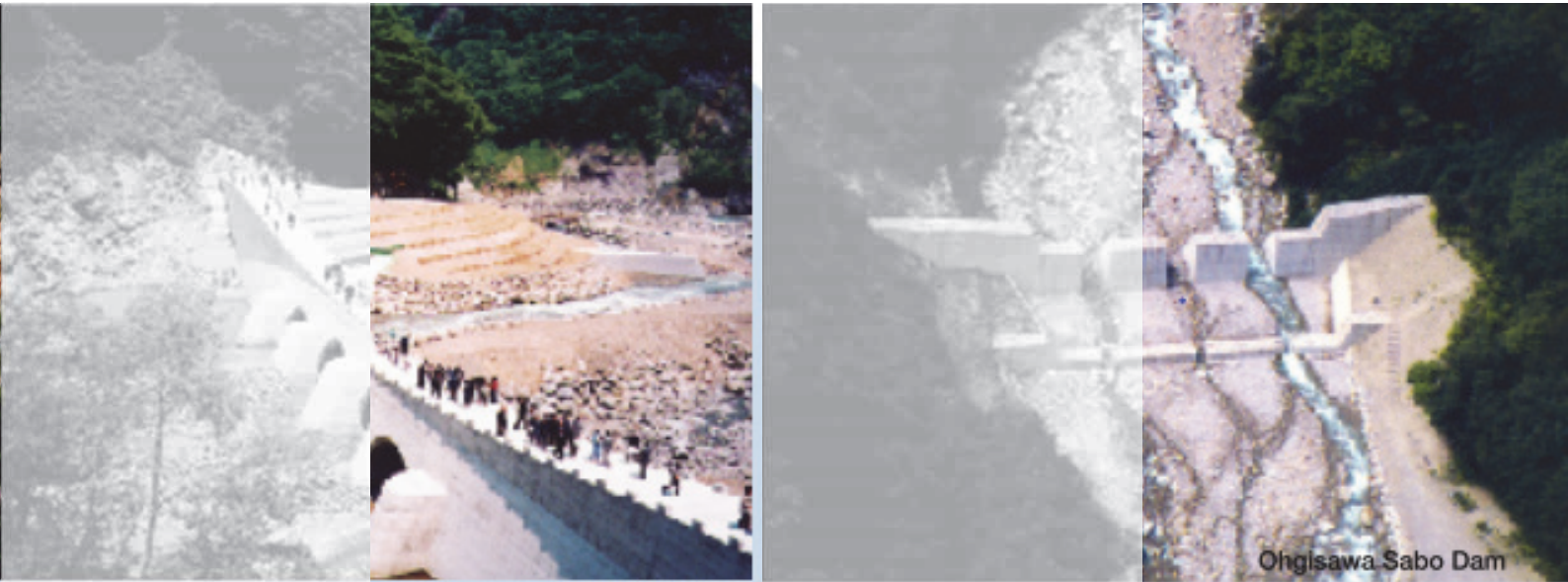
* This map is designed for printing on size A4



Figure 24: Building statistics

5

Structural Measures



5. Structural Measures

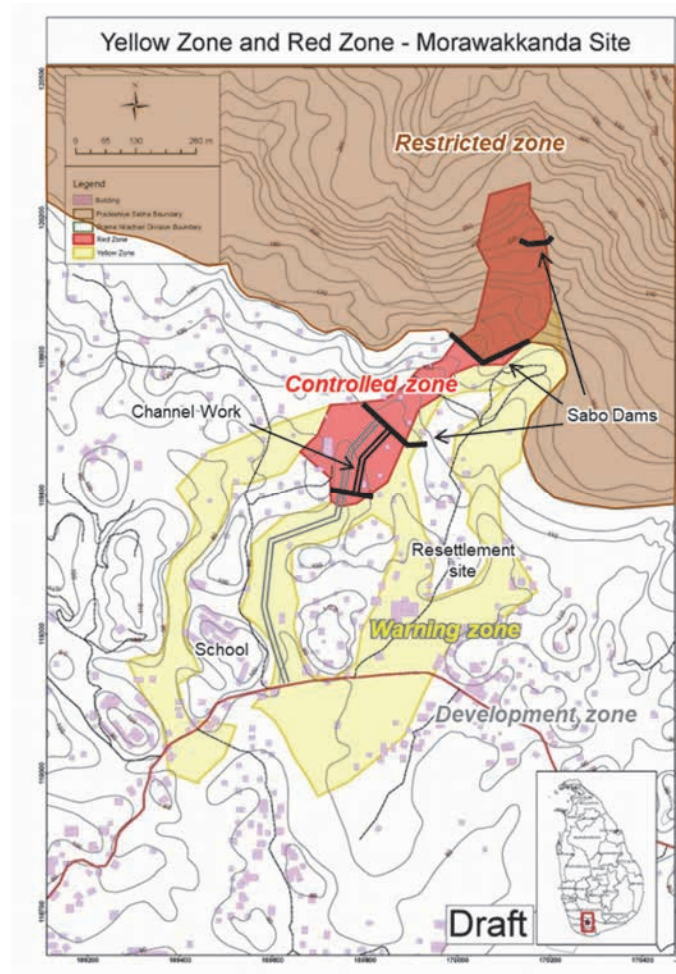
The major disaster type in Morawakkanda is debris flow. Reducing the risk of debris flow is important to secure the safety of residents and sustainable development in the area.

However, at the present, there is no experience practical structural measure against debris flow in Sri Lanka. It is expected to be introduced by central technical agencies such as NBRO. If appropriate structural measures are implemented in Morawakkanda, it is possible to lift the development regulation in the Red zone and restore the livelihoods of residents. In addition, the measure will lead to securing traffic on the national highway A17. It is a benefit not only for Morawakkanda but also for regional development.

Based on the Yellow/Red zoning map, “Restricted zone”, “Controlled zone”, “Warning zone” and “Development zone” will be designated according to the guideline. Upstream of Red zone shall be restricted zone where any construction and development are strongly restricted. Moreover, the highland area is already designated as forest conservation area so it is also designated as Restricted zone.

The lower Red zone shall be Controlled zone. Countermeasures are required for existing houses and new development. The government plans to construct some Sabo facilities in the stream.

Local government shall make efforts to strengthen early warning and evacuation system in both red and yellow zones with consultation of NBRO. Other area is for Development zone, where any construction and development are permitted if LAB/LAD are acquired in advance. Due to above condition, concrete plan of the structural measures cannot be proposed in this LSDRRP.



Generally, there are several structural measures against debris flow such as;

- 1) Sabo dam to directly capture debris from upper stream
- 2) Channel works to train the flow direction to the downstream
- 3) Ground sill to protect river bed erosion when debris flow occurs.

On the other hand, nature-based risk reduction measures such forest re-plantation is also effective to prevent new slope failure in upper stream and to fix unstable sediment in the stream. These measures should be applied in combination with the structural measures. Kotapola PS will cooperate with NBRO and other central agencies to apply the structural measures Morawakkanda.



Strengthening Early Warning and Evacuation

6. Strength Early Warning and Evacuation

6.1. NBRO Landslide Early Warning

NBRO Early Warning Centre (EWC) issues landslide warnings based on real-time observed rainfall data from NBRO automation rain gauge. Warning criteria and actions to take during the respective warning level is as shown in the following table. In addition to 24 hours rainfall, NBRO EWC considers Soil Water Index (SWI) which indicates how much water is accumulated in the soil since landslide is caused when water in the soil gets saturated by heavy rainfall. It is important to remember that there is cases that NBRO keeps the warning even if the rainfall become little since there is high risk of landslides due to high water saturation in the soil (high SWI).

Table 13: NBRO Landslide Early Warning Criteria and actions to take

| Warning Level | | 24 hours rain fall | Actions to take |
|---------------|------------|--------------------|---|
| | (None) | | |
| 1 | Watch | More than 75 mm | Be watchful on the possibility of landslide |
| 2 | Alert | More than 100 mm | Be on alert, prepare to evacuate |
| 3 | Evacuation | More than 150 mm | Evacuate to a safe location |

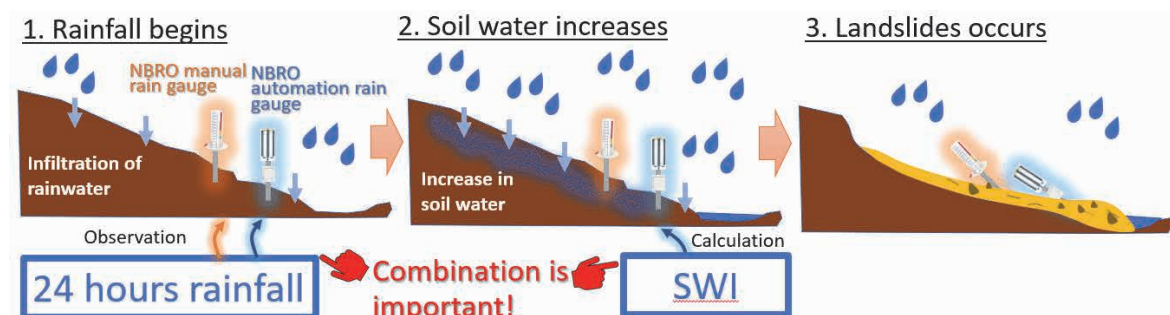


Figure 25: Cause of Landslide and Soil Water Index

After NBRO EWC transmits the warning messages to Disaster Management Center (DMC), DMC is in charge of disseminating the NBRO warning to DDMCU in Matara District, Kotapola DS division, Morawaka GN Division, and Emergency Community Committee in Morawakkanda as shown in the following figure.

Considering the landslide warnings, DDMCU (or DS division) issues evacuation order to local people. The local people living in Yellow/Red zones shall evacuate to safe place to comply with the section 7.(2) and (3). Certain dissemination of the landslide warnings and evacuation order shall be ensured through the awareness activities. NBRO will continue routine operation and maintenance of the rain gauge.

6.2. NBRO Early Warning Communication Channel in Morawakkanda

The following figure is a NBRO Early Warning dissemination channel in Morawakkanda. The warning is mainly delivered by Calls and SMS. At least 57 households in Morawakkanda are covered through this channel at present. The residents who are not in the channel shall be informed that NBRO early warning information is available at NBRO EW application and website at awareness activities. In addition, as manual rain gauge is at house of Secretary of Emergency Community Committee. When observed rainfall by the manual gauges exceeds the threshold, the Emergency Community Committee shall inform the situation to their local communities and local governments. The local people shall start evacuation based on the information.

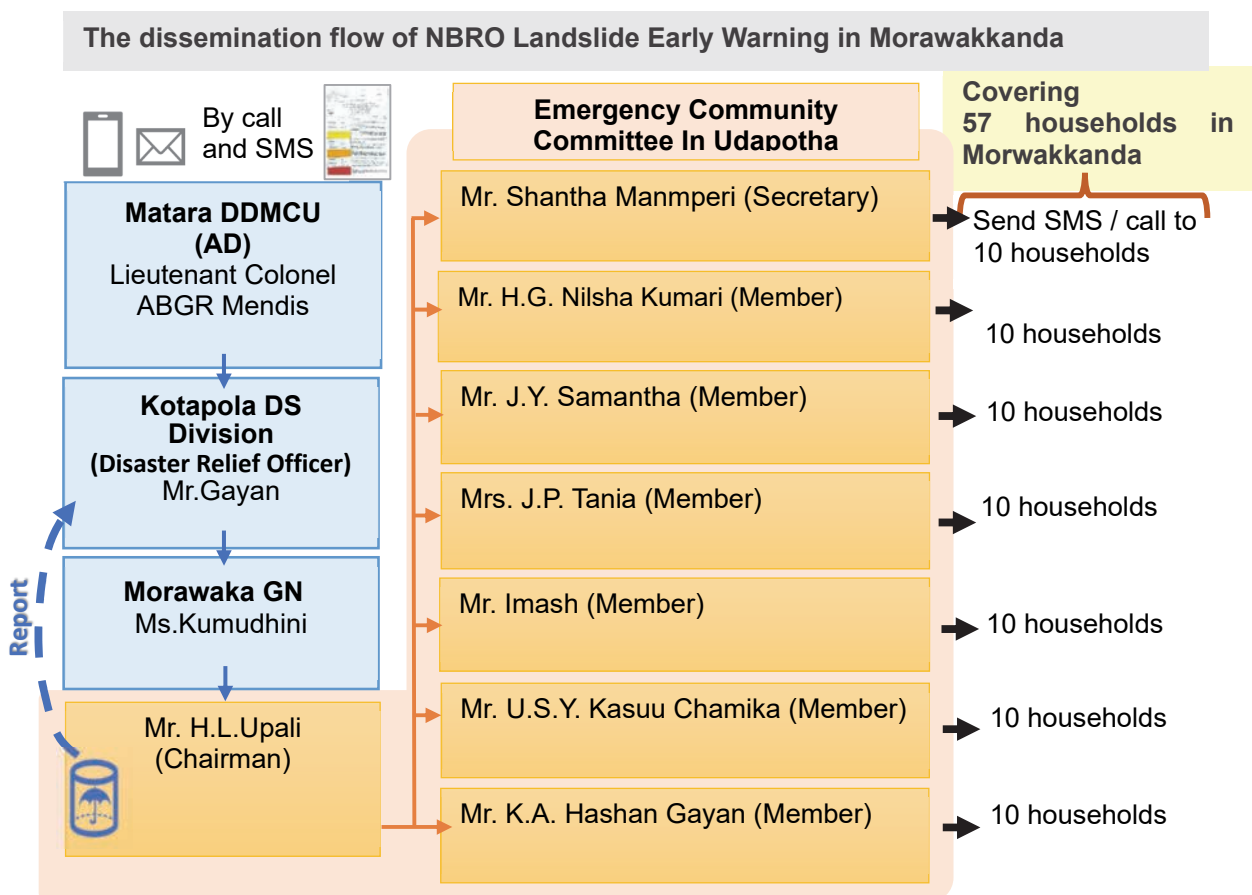


Figure 27: Contact information and the dissemination flow of NBRO Landslide Early Warning in Morawakkanda

6.3. Emergency Community Committee in Morawakkanda

Emergency Community Committee was newly established in Morawakkanda area in November 19th, 2021 with NBRO officers. The following is the committee members. NBRO manual rain gauge was also provided to the Committee, which is placed at the house of Secretary. He is also in charge of making a monthly record of the rain gauge and send it to NBRO EWC.



Table 14: Members of Emergency Community Committee in Morawakkanda

| Position | Name | Role |
|-----------|--------------------------|-------------------|
| Chairman | Mr. H.L.Upali | Contact person |
| Secretary | Mr. Shantha Manmperi | Manual rain gauge |
| Member | Mr. H.G. Nilsha Kumari | |
| Member | Mr. J.Y. Samantha | |
| Member | Mrs. J.P. Tania | |
| Member | Mr. Imash | |
| Member | Mr. U.S.Y. Kasuu Chamika | |
| Member | Mr. K.A. Hashan Gayan | |

1. Mr. Shantha Manmperi
Secretary of Emergency Community
Committee

An automatic rain gauge managed by NBRO is at police station in Morawaka town.

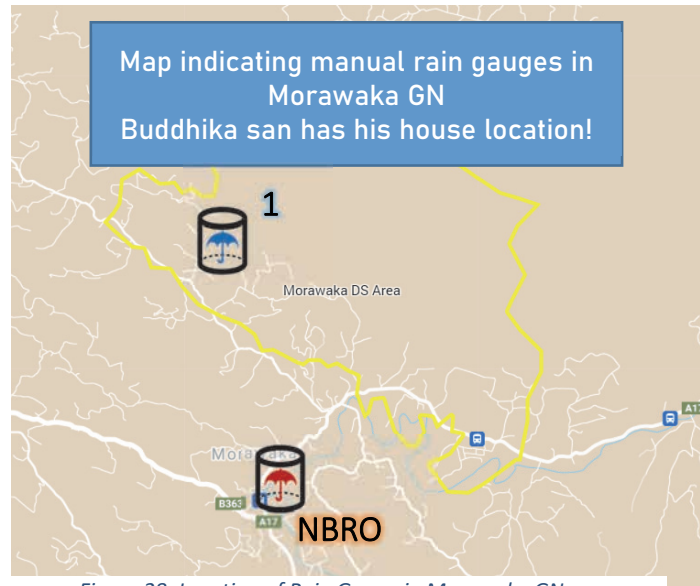


Figure 28: Location of Rain Gauge in Morawaka GN

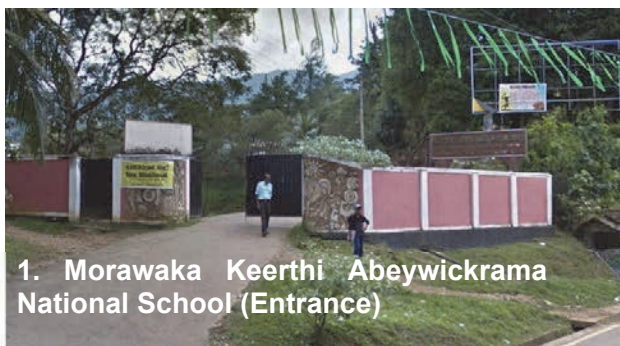
6.4. Securing Evacuation Place and Route

Evacuation places are designated on ahead. The evacuation places must be located outside of the Yellow/Red areas as well as other disaster risky areas. Safeness of evacuation routes shall be also considered when the evacuation places are designated. Information of the designated evacuation place, evacuation route and appointments are archived by DS division and DDMCU. Necessary appointments, such as generators, blankets and emergency provisions, shall be stored in the evacuation places.

The following issues regarding evacuation routes are identified at the workshop with Morawakkanda community members on November 2021 and March 2022. When there is a heavy rain, residents cannot reach to the school due to abundant roads and rain overflowing over the evacuation route. Therefore, residents would like to request other evacuation centers.

Table 15: Evacuation centres in Morawakkanda

| Evacuation centres in Morawakkanda | | | | |
|------------------------------------|------------------------------|---------|-------------|--|
| No | Place | | Capacity | Issue |
| 1 | Morawaka | Keerthi | 50 | A road to access the school gets flooded during evacuation |
| | Abeywickrama National School | | Households? | |



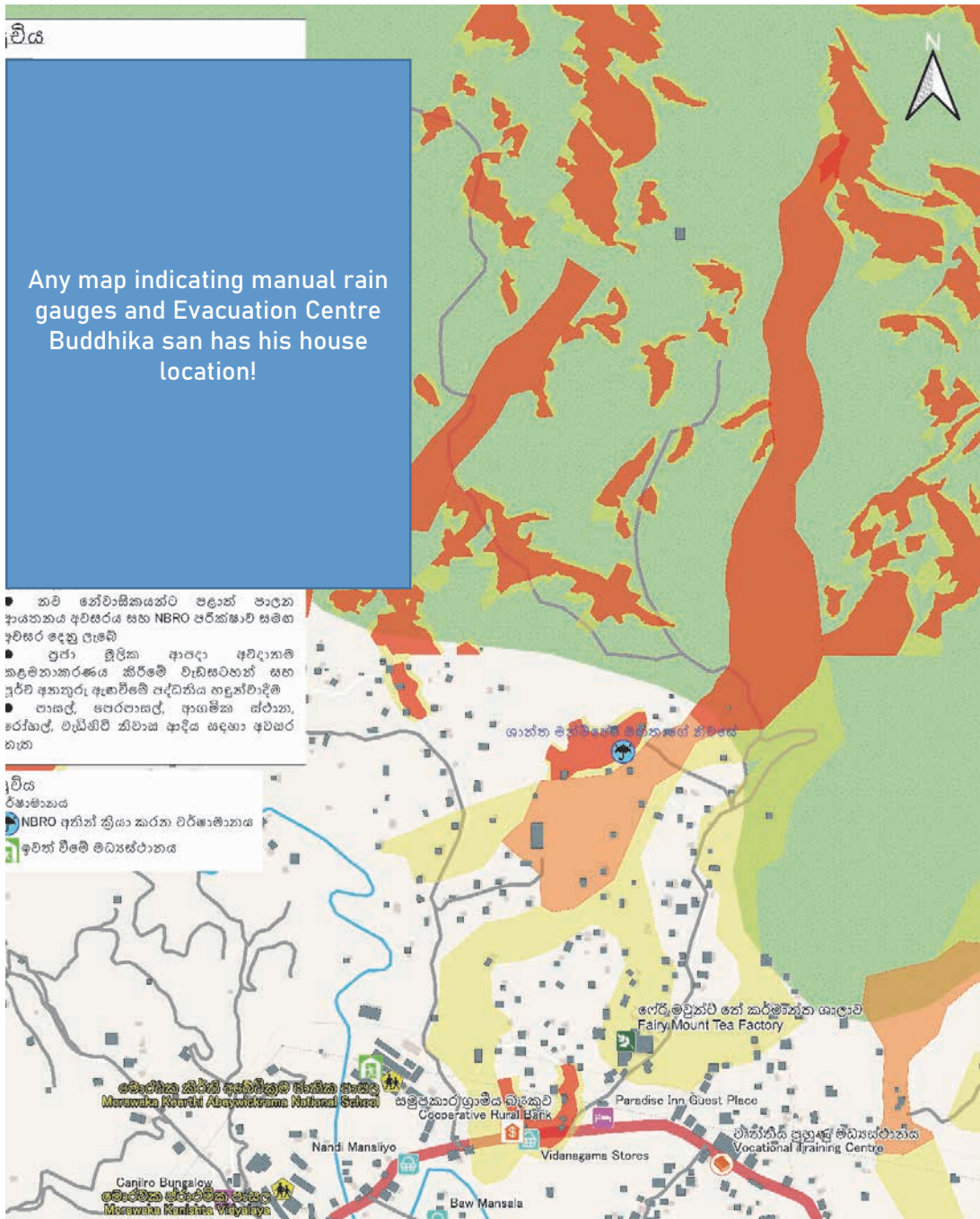


Figure 29: location of manual rain gauge and Evacuation Centre

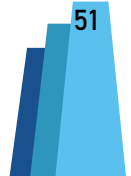
4.5. Awareness Activity for EW

In Morawakkanda, no evacuation drills are held by DDMCU. Early warning awareness program was held by NBRO in March 16th, 2022. Smooth and timely warning dissemination from NBRO and GN officers to local community through Emergency Community Committee shall be strengthened by the evacuation drill. Awareness activity is needed to train for local peoples to understand meaning of landslide hazard maps, NBRO landslide early warning, LRMS equipment warning and necessary preparedness. Necessary actions to strengthen early warning and evacuation are;

- Designation of safe evacuation places and routes considering landslide hazard maps with DDMCU and NBRO
- Procurement of necessary appointments in the evacuation places
- Awareness activity and evacuation drill once a year to ensure the warning dissemination and evacuation



Management plan



7. Management Plan

7.1. Land use management plan

The Restricted zone and Control zone should be free from the settlements, and it has high risk due to sediment disaster. The future land use plan should be aimed to convert the existing land uses in the Restricted and Control zone into forestry type land use categories.

7.2. The land value management plan

The council should be posed to implement a land value management plan for the Morawakakanda area by producing legal by-laws. These by-laws should be including the following key Articles.

Article 1: Principles.

- Public interests in land are superior to private interests
- Land-uses shall be in accordance with uses appropriate to an area's natural, social, economic, and cultural conditions
- Speculative investments in land shall be restrained
- "Appropriate burdens" shall be placed on parties profiteering from increases in land prices

Article 2: Land price

- Limited and vital resource for citizens and forms a fundamental basis for citizen activities.
- Price of land affects trends in population, industry, land-use, social capital, and facilities, and can change social and economic conditions.
- Land prices affect the public interests.

Article 3: Land use plan should be area specific.

- Land-use must be in accordance with uses appropriate to an area's natural, social, economic, and cultural conditions.

Article 4: Speculative investments shall be restrained.

- Some authorities have interpreted "speculative investment" as buying for the sake of selling at a later date.
- purpose of controlling the land market for a purported public good.

Implementation



8. Implementation

8.1. Action Plan

The implementation plan specifies the projects and the project budgets for implementation of land use plan, countermeasure facilities and strengthening early warning and evacuation system in the target area. The target years are also indicated with consideration of terms of PS councils. The main body of implementation is Kotapola PS with supports of DS Divisional Secretariat, NBRO, DMC, UDA and other central agencies

Action Plan for LSDRRP in Morawakkanda

| No. | Item | Contents of the Measures | Responsible Agencies | Budget | Short Plan (to 2023) | Mid Plan (to 2025) | Long Plan (to 2030) |
|---|--|---|----------------------|----------------|----------------------|--------------------|---------------------|
| 1. Implementation of land use plan | | | | | | | |
| 1-1 | Implementation of land use plan and regulation | Kotapola PS organizes stakeholder meeting to introduce land use regulation in Morawakkanda area in collaboration with DS Divisions | LA (DS Division) | to be assessed | | | |
| 1-2 | | Kotapola PS organizes workshops in Morawakkanda in order to raise awareness of the local residents | LA (DS / GN) | to be assessed | | | |
| 1-3 | | Kotapola PS develops By-law to implement the plan and the guide for development regulation | LA | to be assessed | | | |
| 1-4 | | Kotapola PS promotes retrofitting of the existing houses in the control zone in cooperation with NBRO | LA/NBRO | to be assessed | | | |
| 1-5 | Up-scaling LSDRRP into the other area in PS | Kotapola PS expands LSDRRP into the sounding area based on Yellow/Red zoning provided by NBRO | LA (NBRO) | to be assessed | | | |
| 1-6 | | Kotapola PS develops local disaster risk reduction plan in cooperation with Disaster Management Center and incorporate LSDRRP into the plan. | LA (DDMCU/NBRO) | to be assessed | | | |
| 2. Risk reduction measures | | | | | | | |
| 2-1 | Construction of Sabo facilities as the measure to reduce debris flow risks | Kotapola PS officially requests NBRO or other concerned agencies to conduct technical study for Sabo facilities in Morawakkanda. | LA (NBRO) | to be assessed | | | |
| 2-2 | | NBRO and other concerned agencies conduct technical study for Sabo facilities in Morawakkanda | NBRO | to be assessed | | | |
| 2-3 | | Central government secure implement onstruction of Sabo facilities in Morawakkanda | Central Government | to be assessed | | | |
| 2-4 | Promotion of nature-based landslide risk mitigation project | NRBO implements nature-based landslide risk mitigation project in collaboration with ADPC. | NRBO (LA) | to be assessed | | | |
| 2-5 | | Kotapola PS and GN introduce tree barriers along the border of restricted zone in order to prevent migration in the zone and to control the flow. | LA / GN | to be assessed | | | |
| 3. Early warning and evacuation system | | | | | | | |
| 3-1 | Strengthening landslide early warning and evacuation system | DS Divisional Secretariat and NBRO sets up appropriate warning criteria using neighbor rain gauge station, and conduct workshop with GN | DS / NBRO (GN) | to be assessed | | | |
| 3-2 | | Kotapola PS identifies the evacuation shelter in Morawakkanda area and equips necessary facilities with consultation of DDMCU | LA (DDMCU) | to be assessed | | | |
| 3-3 | | Kotapola PS and DS Divisional Secretariat conducts community workshops and evacuation drills in cooperation with DDMCU | LA / DS (DDMCU) | to be assessed | | | |

8.2. Role and Responsibilities of Concerned Agencies

The following figure shows interactions among LA, DS Divisional Secretariat, GN Division and NBRO in non-designated area by UDA. LA will revise the existing land use plan where land use plan was already developed or develop new land use plan where land use plan is not yet developed. Inputs such as disaster risk related information from NBRO and inputs such as community information from GN are provided to LA.

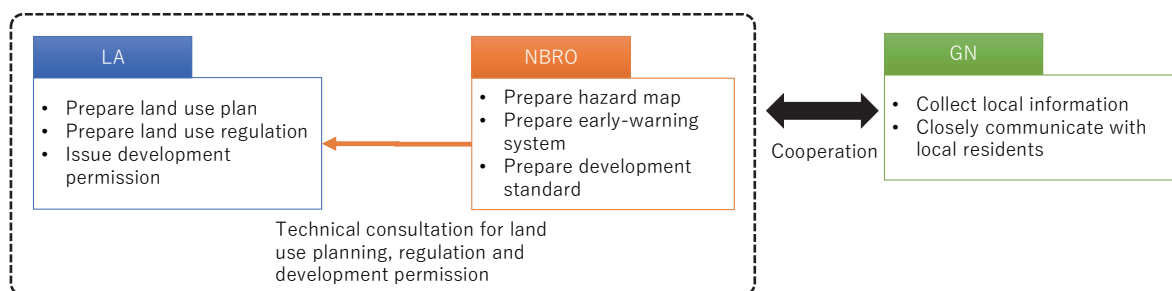


Figure 43: Interaction among LA, DSD, GND and NBRO

Roles & Responsibilities

Table 19: Roles & responsibilities

| Organization | Role and Responsibilities |
|-----------------------|--|
| NBRO | <ul style="list-style-type: none"> ▪ NBRO prepare the sediment disaster hazard map based on the Guideline for Disaster Resilient Land Use Regulation/Development Standards. The map shows red/yellow zone (or 4 zones). ▪ Regarding to land use in high-risk area, NBRO prepares development standard, which is explained in the Chapter 4. ▪ NBRO helps early warning and evacuation system in high-risk area. The early warning system includes installment of rain gauge, alarm, evacuation plan and disaster drill and education together with DDMCU ▪ NBRO provides consultation to LA for land use plan and land use regulation based on the hazard assessment in the planning area. ▪ NBRO provides consultation to the local authority for development permission in red and yellow zone. |
| LAs | <ul style="list-style-type: none"> ▪ LA prepares development plan including land use plan as designated in the Town and Country Planning Ordinance. It is recommended to take into account the hazard map and development regulation prepared by NBRO in this process. ▪ The local authority issues development permission based on the development plan prepared by LA. It is recommended to take into account the hazard map and development regulation prepared by NBRO. If the development plan does not incorporate enough consideration about disaster risk management, it is recommended to add further land use regulation based on the hazard map by bylaw. |
| Grama Niladari | <ul style="list-style-type: none"> ▪ Provision of data |

NBRO consultation menu

- Prepare hazard map
- Prepare early warning system
- Prepare development standard

- Inspect land use plan in the aspect of hazard and risk management
- Prepare draft land use plan
- Prepare land use plan and regulation in special projected area
- Hold workshop, seminar, etc. for local residences' understanding of hazard map and regulation
- Prepare evacuation plan
- Hold disaster drill and disaster education program for local people

LA

LA prepares development plan including land use plan as designated in the Town and Country Planning Ordinance. It is recommended to take into account the hazard map and development regulation prepared by NBRO in this process.

The local authority issues development permission based on the development plan prepared by LA. It is recommended to take into account the hazard map and development regulation prepared by NBRO. If the development plan does not incorporate enough consideration about disaster risk management, it is recommended to add further land use regulation based on the hazard map by bylaw.

GN

GN takes important role to collect information and facilitate understanding and communication with local people. As the hazard mapping is sensitive and influential to local people's life, it is important to have appropriate communication including workshop, seminar and inspection of hazard map between the relevant parties and public.

8.3. Monitoring and Verification

The monitoring and verification of the action plan is fully responsible of Badulla MC. Municipal council members will closely monitor the implementation of each item in the action plan, and necessary countermeasures will be taken by Kotapola PS.

Local Sediment Disaster Risk Reduction Plan



Udapotha

(Bulathkohupitiya Pradeshiya Sabha , Kegalle District)

“Creating Disaster Resilient Neighbourhood in Udapotha”



Udapotha

Local Sediment Disaster Risk Reduction Plan

Bulathkohupitiya Pradeshiya Sabha

Towards the Disaster Resilient Neighbourhood



Content

| | |
|--|-----|
| List of Figures and Tables | v |
| Abbreviations and Acronyms | vi |
| Executive Summary | vii |
| 1. Introduction | 2 |
| 1.1. Background | 2 |
| 1.2. Objectives | 2 |
| 1.3. Vision | 2 |
| 1.4. Owner and Target User of the LSDRRP | 3 |
| 2. Current Setting of Udapotha..... | 5 |
| 2.1. General Information of Bulathkohupitiya PS..... | 5 |
| 2.2. General Information of Udapotha GN & Udapotha Hazard zone..... | 6 |
| 2.2.1. Geographic information..... | 6 |
| 2.2.2. Demographic Background..... | 6 |
| 2.2.3 Housing Condition..... | 7 |
| 2.2.4. Public Facilities..... | 8 |
| 2.2.6. Current Land use | 11 |
| 2.2.7. Current Land Use with Yellow and Red Zone in the target area..... | 12 |
| 2.3. Concept of Yellow/Red Zone..... | 13 |
| 2.4. Categorized Zone based on Yellow/Red zoning and LHM..... | 15 |
| 2.4.1. Land-use zoning in Landslide Prone areas | 15 |
| 2.6. Approval and Enforcement of the Land Use Plan..... | 18 |
| 2.6.1 General conditions | 18 |
| 3. Risk Assessment for Udapotha..... | 20 |
| 3.1. Database for Designated Yellow/Red Zones | 20 |
| 3.2. Evaluation..... | 21 |
| 3.3. Items for Risk Evaluation..... | 21 |
| 3.4. Risk Evaluation Sheet for Yellow/Red Zone | 22 |
| 4. Land Use Zoning Plan in Udapotha | 26 |
| 4.1. Basic DRR Strategies by each Land Use Zoning for Udapotha..... | 27 |
| 4.2. Statistics in Yellow and Red Zone..... | 28 |
| 4.3. Current issues related to housing in hazard area | 29 |
| 5. Structural Measures | 31 |
| 5.1. Site 1 – A Debris Flow Red Zone..... | 31 |

| | |
|--|-----------|
| 1. Hazard and Impacts | 31 |
| 2. Suggested Structural Measures | 31 |
| 5.2. Site 2 – A Slide Red Zone..... | 32 |
| 1. Hazard and Impacts | 32 |
| 2. Suggested Structural Measures | 32 |
| 6. Strength Early Warning and Evacuation | 37 |
| 6.1. NBRO Early Warning Communication Channel in Udapotha..... | 39 |
| 6.2. Emergency Community Committee in Udapotha..... | 39 |
| 6.3. Installed Landslide Remote Monitoring System and EW equipment..... | 40 |
| 6.4. Securing Evacuation Place and Route..... | 44 |
| 6.5. Awareness Activity for EW | 45 |
| 7. Long-term Management Plan | 48 |
| 7.1. Land use management plan..... | 48 |
| 7.2. The land value management plan | 48 |
| 8. Implementation | 50 |
| 8.1. Action Plan | 50 |

List of Figures and Tables

List of Figure

| | |
|--|----|
| Figure 1: Location Map of Udapotha GN..... | 5 |
| Figure 2: Ward Map of Bulathkohupitya Pradeshiya Sabha..... | 6 |
| Figure 3: Gender Composition in Udapotha GN | 7 |
| Figure 4: Gender Composition in Udapotha Project site..... | 7 |
| Figure 5: Population pyramid in Udapotha Project Site..... | 7 |
| Figure 6: Reason to live at Udapotha Project Site | 7 |
| Figure 7: Housing Condition in Udapotha GN..... | 8 |
| Figure 8: Housing Condition in Project Site | 8 |
| Figure 9: Locations of Public facilities | 9 |
| Figure 10: Rainfall Distribution..... | 10 |
| Figure 11: Temperation Variation..... | 11 |
| Figure 12: Current Land use map of Udapotha GN..... | 12 |
| Figure 13: Current Land use percentage in Udapotha Hazard Zone..... | 12 |
| Figure 14: Current Land use Plan in Udapotha Hazard Zone | 13 |
| Figure 15: Yellow/Red Zone for Slide..... | 14 |
| Figure 16: Yellow Zone and Red zone for Slope Failure..... | 14 |
| Figure 17: Yellow Zone and Red Zone for Slope Failure | 15 |
| Figure 18: Zoning Plan in Udapotha Hazard Zone | 17 |
| Figure 19 Concept of Risk Evaluation for the Target Yellow/Red Zone (for Debris Flow) | 22 |
| Figure 20 Filled Risk assesment sheet for debris flow patch in Udapotha..... | 22 |
| Figure 21 Risk Evaluation Map of Udapotha..... | 24 |
| Figure 22: Landuse Plan in Udapotha | 26 |
| Figure 23: Land use Zoning Plan in Udapotha..... | 27 |
| Figure 24: Building Statistics of Udapotha | 28 |
| Figure 25: Conceptual Illustration of Non-permeable SABO Da | 31 |
| Figure 26: Typical Layout of Horizontal Drain Holes..... | 32 |
| Figure 27: Location of the Selected Red Zones for Conceptually Planning Structural Measures in the Udapotha Pilot Site | 33 |
| Figure 28: Layout of the Planned Structural Measures for Site 1 in the Udapotha Pilot Site | 34 |
| Figure 29: Layout of the Planned Structural Measures for Site 2 in the Udapotha Pilot Site | 35 |
| Figure 30: Cause of Landslide and Soil Water Index..... | 37 |
| Figure 31: Dissemination flow of NBRO Landslide Early Warning and Evacuation Order..... | 38 |
| Figure 32: Contact information and the dissemination flow of NBRO Landslide Early Warning in Udapotha | 39 |
| Figure 33: Main equipment of Landslide Remote Monitoring System (LRMS)..... | 40 |
| Figure 34: Locational image of extensometer and multi-point Inclinator..... | 40 |
| Figure 35: Location and warning image of LRMS..... | 41 |
| Figure 36: Location of extensometers and multi-point inclinometers in Udapotha (Overview)..... | 41 |
| Figure 37: Location and image of installed extensometers and multi-point inclinometers in Udapotha (Base Station 1 & 2) | 42 |
| Figure 38: Structure of Warning SMS sent from Base Station and NBRO Server | 42 |
| Figure 39: Example of Warning SMS message | 43 |
| Figure 40: Role of each actor for LRMS maintenance | 44 |
| Figure 41: Images of the evacuation centres in Udapotha | 45 |
| Figure 42: Location of the evacuation centres in Udapotha..... | 45 |

List of Table

| | |
|--|----|
| Table 1: Public Facilities in Bulathkohupitya | 8 |
| Table 2: Monthly Average Rainfall Distribution..... | 9 |
| Table 3: Temperature Pattern in Udapotha..... | 10 |
| Table 4: Land use types..... | 12 |
| Table 5: Slide block Classification..... | 13 |
| Table 6: Relevance with LHM and Yellow/Red zone categories | 15 |
| Table 7: Proposed Land Use Category..... | 18 |
| Table 8. Items for Database for Designated Yellow/Red Zone..... | 20 |
| Table 9. Items and Scores for Risk Evaluation for Yellow/Red Zone..... | 21 |
| Table 10 Classification of Risk Level..... | 23 |
| Table 11: Population statistics in Yellow and Red Zone..... | 28 |
| Table 12: Housing Type Statistics in Yellow and Red Zone | 28 |
| Table 13: Summary of the Suggested Structural Measures at Site 1 | 28 |
| Table 14: Summary of the Suggested Structural Measures at Site 2 | 28 |
| Table 15: NBRO Landslide Early Warning Criteria and actions to take | 37 |
| Table 16: Members of Emergency Community Committee in Udapotha | 40 |
| Table 17: Registered number for Warning SMS at Base Station 1 & 2 and NBRO EWC Server..... | 43 |
| Table 18: Responsible personnel for LRMS maintenance from Udapotha residents..... | 44 |
| Table 19: Evacuation centres in Udapotha..... | 44 |
| Table 20: Action Plan for LSDRRP in Udapotha | 51 |

Abbreviations and Acronyms



DS-Divisional Secretariat

DDMCU- District Disaster Management Coordinating Unit

DMC- Disaster Management Center

GN- Grama Niladhari

JICA-Japan International Cooperation Agency

LHM- Land Hazard Map

LSDRRP- Local Sediment Disaster Risk Reduction Plan

LUPPD- Land Use Policy Planning Department

LA- Local Authority

NBRO- National Building Research Organisation

NPPD- National Physical Planning Department

PS-Pradeshiya Saba

UDA-Urban Development Authorities



Executive Summary



The Technical Corporation for Landslide Mitigation Project (TCLMP) was initiated in 2014, and the second phase of the project (SABO) was started after completing phase one in 2016. Phase one, TCLMP, was focused on structural measurement, and SABO was focused on non-structural measurements. NBRO initiative to develop this plan as a part of the Project for Capacity Strengthen on Development of Non-structural Measures for Landslide Risk Reduction in Sri Lanka (SABO), a technical cooperation project between NBRO and Japan International Cooperation Agency (JICA).

The SABO project was implemented in three pilot sites in Sri Lanka, Morawakakanda in Matara, Weeriyapura in Badulla and Udapotha in Kegalle. The project has three main outputs: demarcation of the landslide flow-path boundaries using the Yellow-Zone-Red-Zone method, development of landslide early warning threshold levels, and development of land-use guidelines for the sediment disaster-prone areas.

The Sediment Disaster can be identified as one of the severe disasters in Sri Lanka because of intensive rainfall and human interventions. In this circumstance, there is a need for a proper landslide management plan to secure the community and human properties in sediment disaster areas. The Local Sediment Disaster Risk Reduction Plan (LSDRRP) is a comprehensive site-specific plan that focuses on the local level to minimize the impact of sediment disasters by using structural and non-structural mitigations.

This LSDRRP plan comprises the landslide hazard-prone areas, landslide flow based on the Yellow zone and Red zone concept, land use zoning in the area, and actions taken for the risk reduction. The report also included the current risk status of the community and the existing landslide early warning mechanism.

NBRO consulted Bulathkohupitiya PS, Divisional Secretariat, and residents in Udapotha during the preparation of the zoning plan. The project report was shared with the relevant stakeholders to bring their feedback to the plan.

This LSDRRP for Udapotha is owned by Bulathkohupitiya Pradeshiya Sabha (PS). PS will take action with the cooperation of relevant agencies such as Bulathkohupitiya Divisional Secretariat, District Disaster Management Coordinating Unit (DDMCU), and National Building Research Organization (NBRO) in Kegalle District to mitigate sediment disaster risk according to the action plan written in Section 6.



Introduction

1. Introduction

1.1. Background

Sediment Disaster is one of the most severe natural disasters in Sri Lanka. In the central and southern mountainous areas, sediment disasters such as slope failures, landslides, and debris flow frequently occur in the monsoon period because of the fragile geology and steep topography. In recent years, sediment disasters caused by heavy rainfall in the spring monsoon season have become severer. In addition, increasing exposure to the hazards due to rapid reclamation and development has been raising sediment disaster risks in urban and rural areas. The establishment and improvement of the early warning system and legal arrangement for land use planning and development standards are urgent issues in Sri Lanka.

Udapotha is a significant landslide susceptible GN in Kegalle District. Therefore, it is essential to identify those landslide susceptible locations and predict the probability of occurrence of each. Disaster risk assessments, early warning systems, and land use planning are required to consider disaster risk status and mitigate the future landslide disaster risks.

A technical cooperation project named "the Project of Capacity Strengthening on Development of Non-structural Measures for Landslide Risk Reduction in Sri Lanka (SABO project)" was established between the National Building Research Organisation (NBRO) and Japan International Cooperation Agency (JICA) from 2016 to 2022. The project aims at strengthening the capacity of NBRO on non-structural measures such as sediment disaster risk assessments, improving early warning systems using existing observation networks, and the Local Sediment Disaster Risk Reduction Plan (LSDRRP), which includes land use and development standards considering sediment disaster risk.

As Udapotha was chosen as one of the pilot sites in the SABO project, a hazard map with yellow and red zone was developed, and an NBRO early warning dissemination channel, including an emergency community committee, was clarified in the area. Moreover, NBRO took the initiative to develop this LSDRRP as a part of SABO project activities. During development, NBRO had discussions with Bulathkohupitiya PS, Divisional Secretariat, and residents in Udapotha.

Local Sediment Disaster Risk Reduction Plan (LSDRRP) is a comprehensive plan to promote sediment disaster risk reduction measures at the local level, including non-structural measures developed based on site-specific sediment disaster risk assessment. The LSDRRP also clarifies the role and responsibility of the local organizations.

1.2. Objectives

The objectives of LSDRRP are as follows;

- Reduce landslide vulnerability of old landslide valley of Udapotha
- Introduce non-structural landslide DRR measures
- Optimum utilization of lands prone to landslide hazard
- Zero the life damage and minimize the casualties due to landslides
- Minimize the economic damage

1.3. Vision

The vision of LSDRRP is

"Creating A Disaster Resilient-Neighbourhood in Udapotha"

1.4. Owner and Target User of the LSDRRP

This LSDRRP belongs to Bulathkohupitiya PS. PS takes action with the cooperation of relevant agencies such as Bulathkohupitiya Divisional Secretariat, District Disaster Management Coordinating Unit (DDMCU), and National Building Research Organisation (NBRO) in Kegalle District to mitigate sediment disaster risk according to the action plan written in Section 6. In addition, this plan includes a land-use plan considering sediment disaster risk, the primary target users of the LSDRRP are the practitioners of land use planning and development control of both the national government and local government, including the officials of Bulathkohupitiya PS, Urban Development Authority (UDA), National Physical Planning Department (NPPD), Land Use Policy Planning Department (LUPPD), and NBRO.

Current Setting



2. Current Setting of Udapotha

2.1. General Information of Bulathkohupitiya PS

Udapotha project area is a part of Udapotha Grama Niladhari (GN), located south-east boundary of the Bulathkohupitiya Pradeshiya Sabaha (PS). Bulathkohupitiya PS is located in the middle part of Kegalle District, neighbouring Kurunegala District in the north and Kandy, Nuwara Eliya Districts in the East. The southern part of the PS adjoins to Rathnapura and Gampaha districts. The administrative territory of Bulathkohupitiya PS is about 127.25 km², and the population of Bulathkohupitiya PS was 47,095 in the 2012 Census. The average monthly income is about 20,000 LKR (field survey,2021).

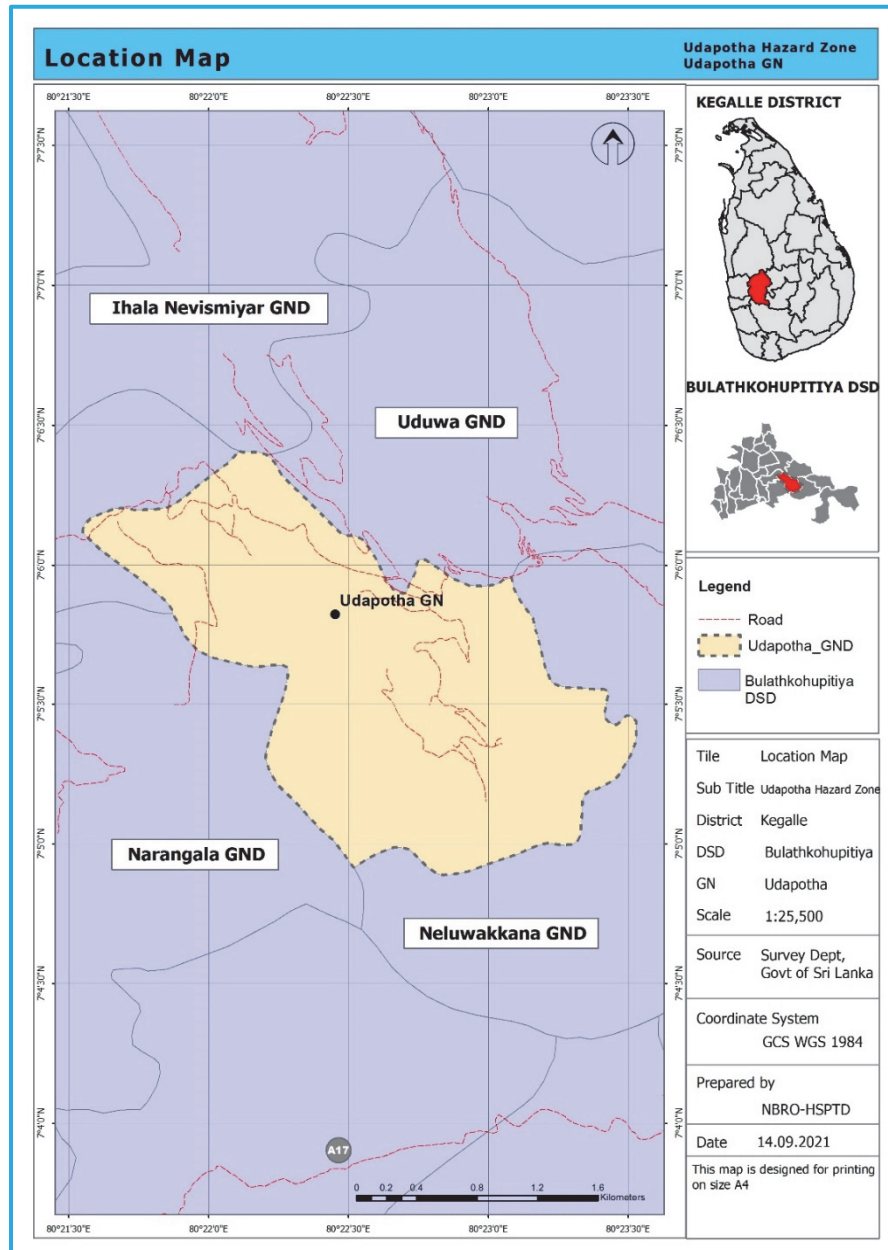


Figure 1: Location Map of Udapotha GN

2.2. General Information of Udapotha GN & Udapotha Hazard zone

2.2.1. Geographic information

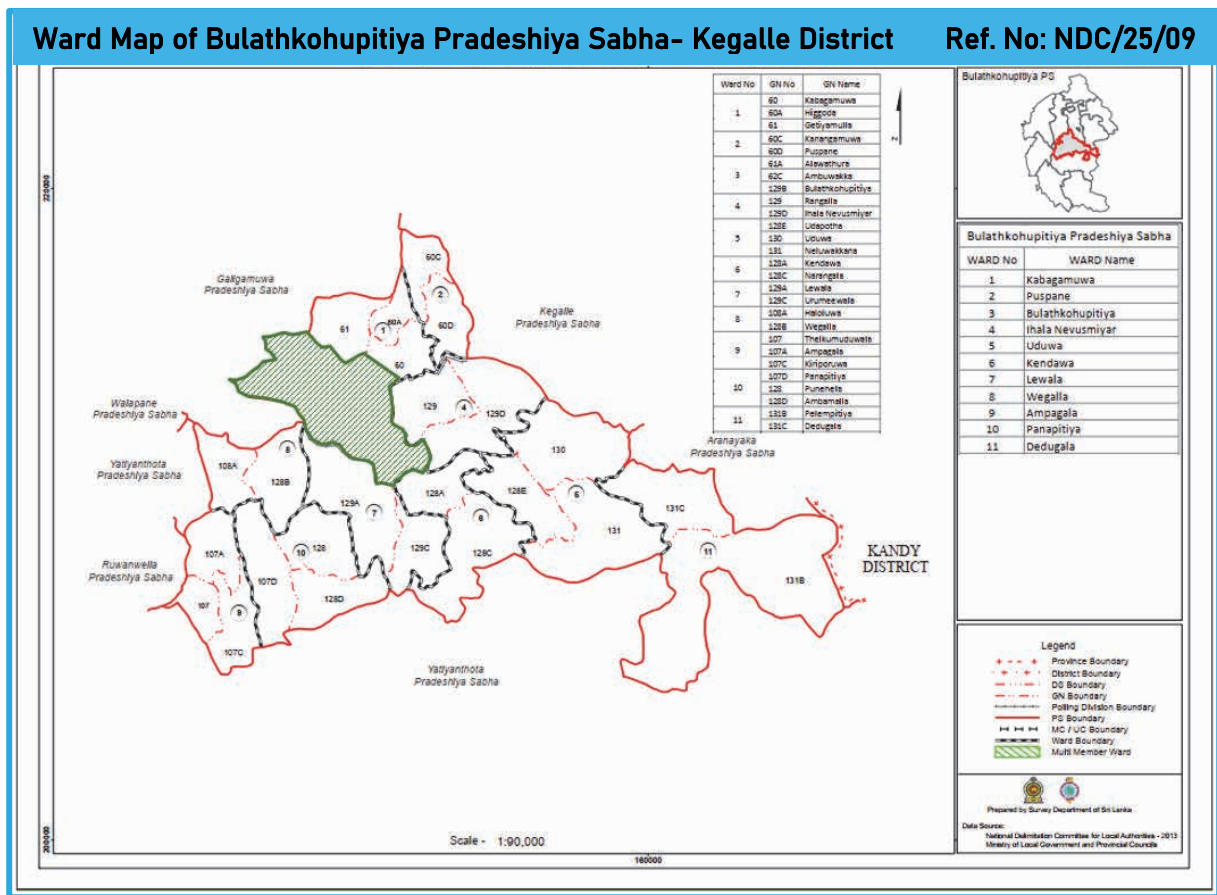


Figure 2: Ward Map of Bulathkohupitiya Pradeshiya Sabha

The Udapotha project area locates in the hilly area of Udapotha GN. Figure 1 and Figure 2 show the Udapotha GND with surrounding GNDs and ward boundaries of Bulathkohupitiya Pradeshiya Sabha.

2.2.2. Demographic Background

The population of Udapotha GN was 1,818 in 2012. The Male population and female population are 861 and 957, respectively. Population Density is 487 per square kilometre, and building density is 129 per square Kilometre.

The 304 people are living in the project area. Among them, 147 are Male, and 157 are Female (SABO survey, 2020). Figure 3 and 4 illustrate the gender composition of both Udapotha GND and the project area. The similar gender ratio is in both areas.

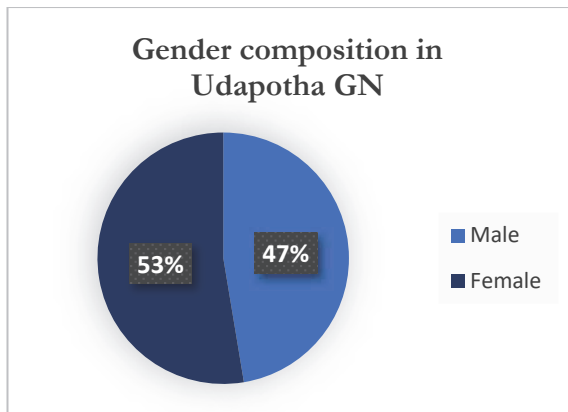


Figure 3: Gender Composition in Udapotha GN

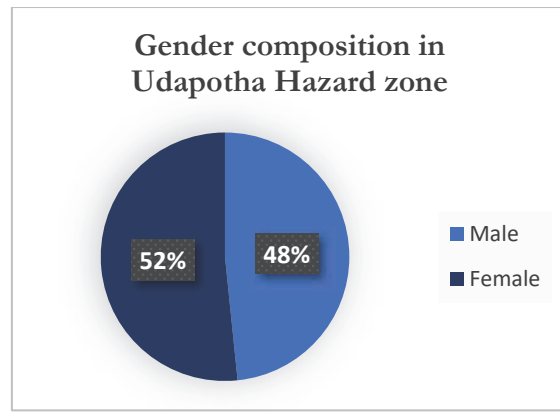


Figure 4: Gender Composition in Udapotha Project site

Figure shows the age distribution of the Udapotha area: 234 (77%) people are fallen under the labour force age (15-64) group, and the dependency (<15 and >64) population are 23%. People's perception of the reasons to live at the Udapotha project site was gathered. Most people mentioned that they have a sentimental value on their site due to their originally born and grew up in the site area. However, 2% mentioned that they have relatives who live closer to their homes. Figure shows the percentage of the reason for living at the project site.

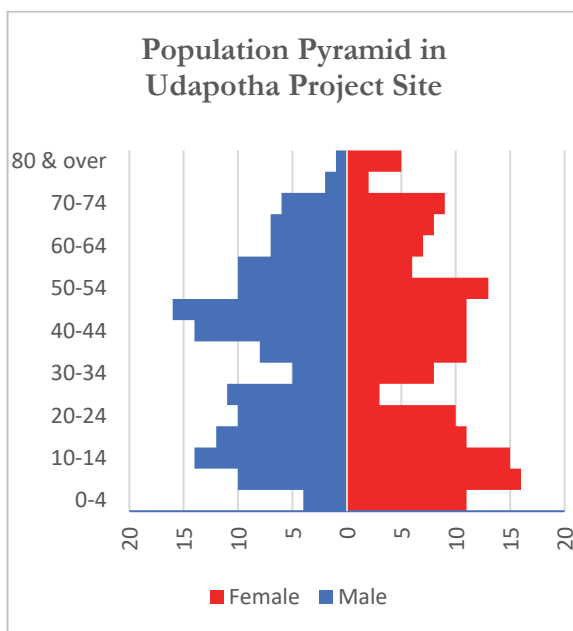


Figure 5: Population pyramid in Udapotha Project Site

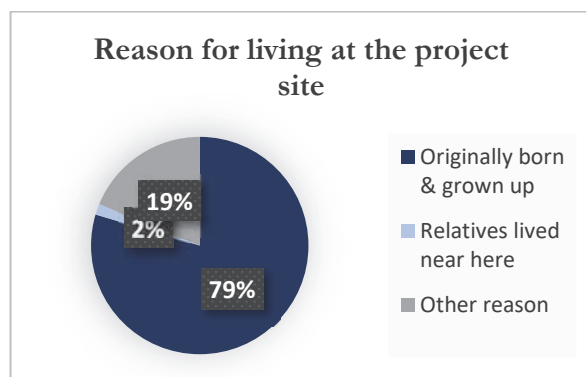


Figure 6: Reason to live at Udapotha Project Site

2.2.3 Housing Condition

The Udapotha GN consisted of 969 housing units (2012 Census & Statistic Survey), and out of these, 485 are permanent dwellings, 257 are semi-permanents, and 227 housing units are improvised. Figure and Figure 8 show the housing condition in the GN and the project site. There are 35 housing units in the yellow zone, and 37 houses are in the red zone area. All these housing units are constructed using permanent materials.

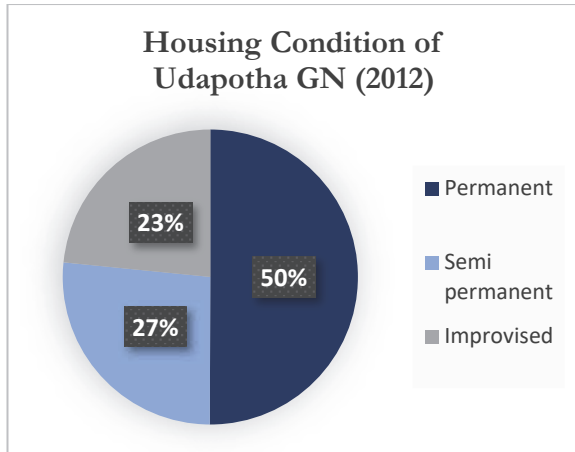


Figure 7: Housing Condition in Udapotha GN

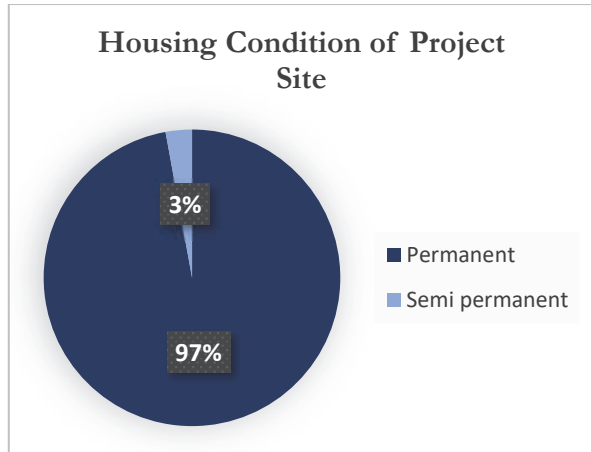


Figure 8: Housing Condition in Project Site

2.2.4. Public Facilities

The majority of critical public facilities are located along the B67 road (Bulathkohupitiya-Dedugala Rd). The following table shows the public facilities in the Bulathkohupitiya DS area. Figure shows the location of public facilities.

Table 1: Public Facilities in Bulathkohupitiya

| | |
|------------------|--|
| School | Uduwa Sri Siddhartha Vidyalaya Udapotha Tissa School Thumbage primary school Sri Silananda school |
| Institutions | Post office, Bulathkohupitiya Urumeewella estate office Ceylon Electricity Board Sub post office, Wegalla |
| Health center | MOH office Bulathkohupitiya |
| Police Station | Police Station Bulathkohupitiya |
| Religious Places | Keerthiaramaya Temple Thumbage Mahindarama Temple Kandawa temple Narangala Sri Vishuddharamaya |

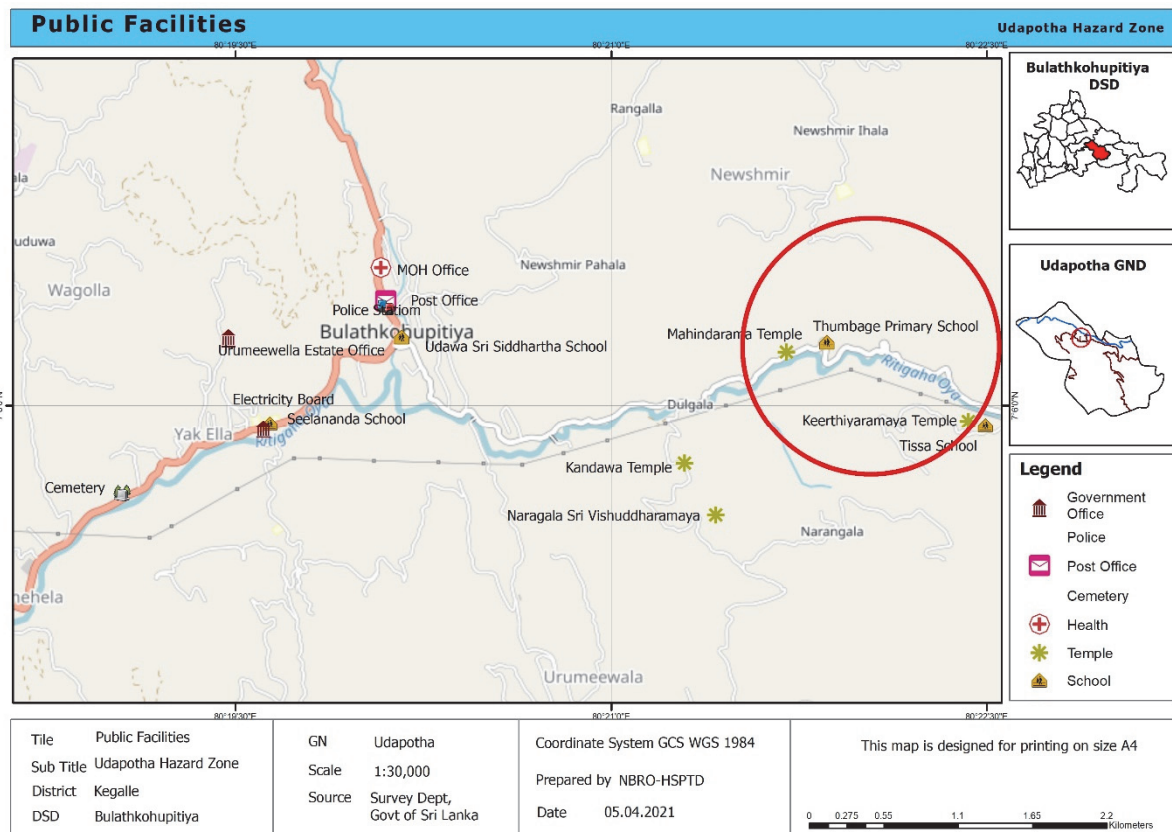


Figure 9: Locations of Public facilities

2.4.5. Climate condition

Rainfall Pattern

Udapotha locates in the wet zone of the country, and annual rainfall is between 1750-2500 mm. The area gets frequent rain from South-West Monsoon. Table 2 shows the monthly average rainfall from 2001 to 2021 in the Udapotha area.

Table 2: Monthly Average Rainfall Distribution

| Rainfall (2001-2021) | | | |
|----------------------|---------|---------|---------|
| Month | Min | Mean | Max |
| January | 16.787 | 90.428 | 215.696 |
| February | 11.925 | 98.962 | 291.863 |
| March | 49.933 | 184.525 | 597.328 |
| April | 124.781 | 317.005 | 555.182 |
| May | 49.706 | 247.952 | 684.619 |
| June | 114.527 | 260.184 | 505.643 |
| July | 99.251 | 189.613 | 307.071 |
| August | 42.489 | 178.599 | 359.005 |
| September | 54.515 | 245.151 | 471.004 |
| October | 85.539 | 412.795 | 657.791 |
| November | 194.289 | 352.572 | 633.474 |
| December | 56.109 | 188.662 | 440.215 |

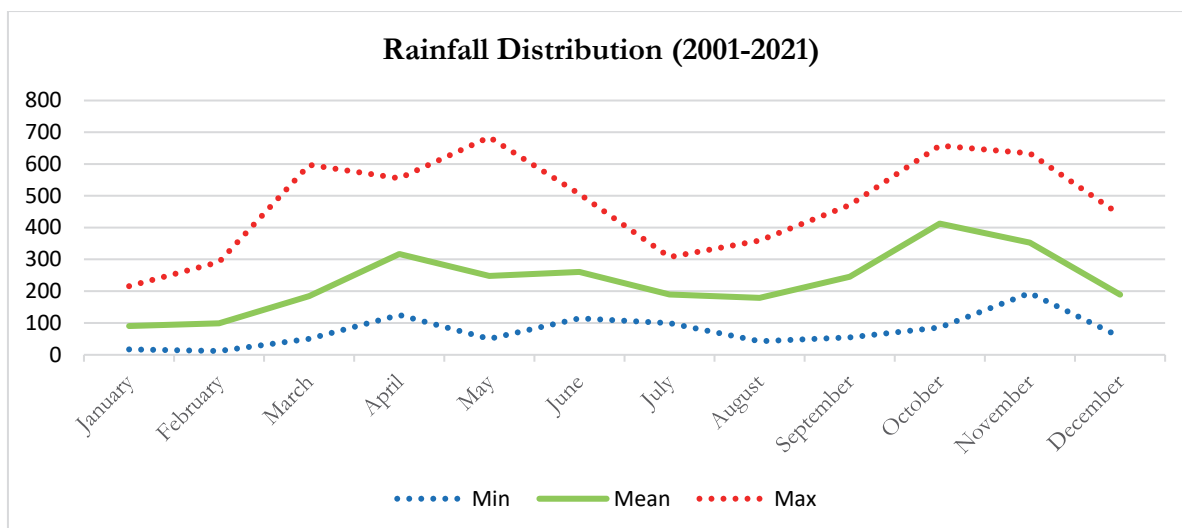


Figure 10: Rainfall Distribution

Figure shows the rainfall distribution in the Udapotha, and it was categorized into minimum, maximum and average rainfall levels. The results show that the highest average rainfall received in the area is in October, during the southwest monsoon period, and the lowest rainfall is received in January. The higher level of rainfall fluctuation could be identified in March, May, October, and November. The inter monsoon rains occur in April and October, and the deviation in April and September could be a result of the intermonsoon period. North-East monsoon activates from October to December, but the monsoon varies on El-Nino and La-Nino effects. The high variation could result from the strength of the monsoon event.

Temperature Pattern

The average annual temperature of the area is 27°C. The highest average monthly temperature is usually recorded during March, which is around 30°C. The lowest average monthly temperature of the year is encountered during June, which is around 26.8°C. Below table 03 shows the average monthly temperatures for each month 2001-2021 in Udapotha Area.

The temperature variation observes that only 3.2°C changes over the year and highest peak in March and lowest in March/January period.

Table 3: Temperature Variation

| Temperature (2001-2021) | | | |
|-------------------------|--------|--------|--------|
| Month | Min | Mean | Max |
| January | 26.497 | 28.52 | 30.16 |
| February | 28.73 | 29.913 | 31.165 |
| March | 28.71 | 30.147 | 31.77 |
| April | 27.463 | 29.427 | 30.79 |
| May | 25.23 | 28.012 | 30.75 |
| June | 24.75 | 26.877 | 28.22 |
| July | 23.81 | 27.596 | 32.11 |
| August | 23.97 | 27.712 | 29.99 |
| September | 26.97 | 29.038 | 33.18 |
| October | 26.41 | 28.319 | 29.77 |
| November | 25.35 | 28.024 | 29.623 |
| December | 24.91 | 27.758 | 28.903 |

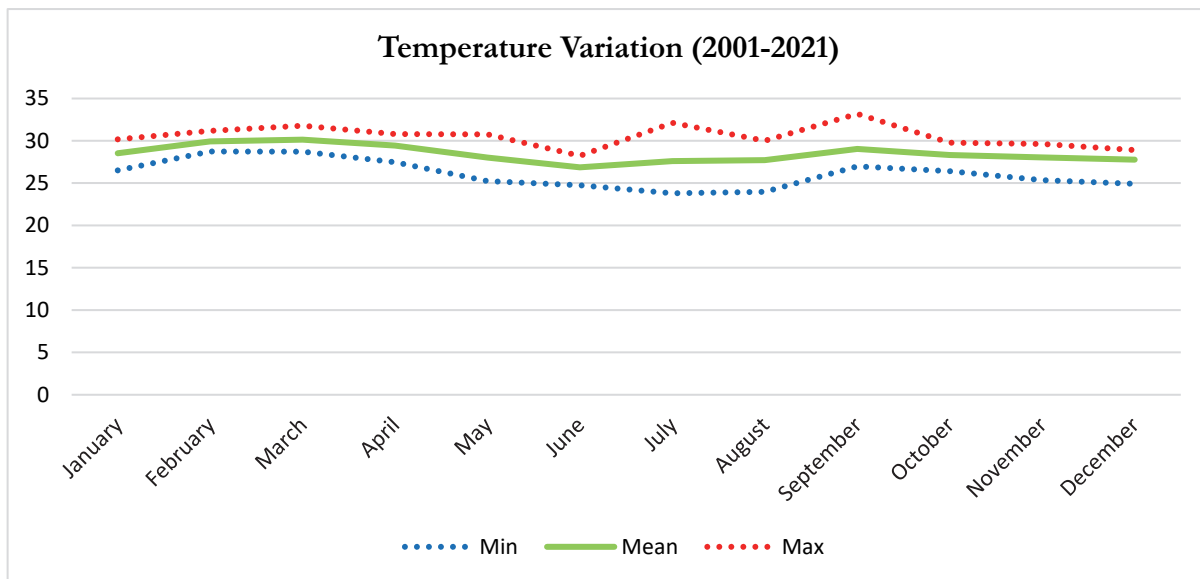


Figure 11: Temperature Variation

2.2.6. Current Land use

Bulathkohupitiya DS Division prepared a Land use map of Udapotha GN in 2010 (Figure), and the area statistics are shown in Table 4. The major land-use types in Udapotha GN are Rubber, Homestead and Paddy.

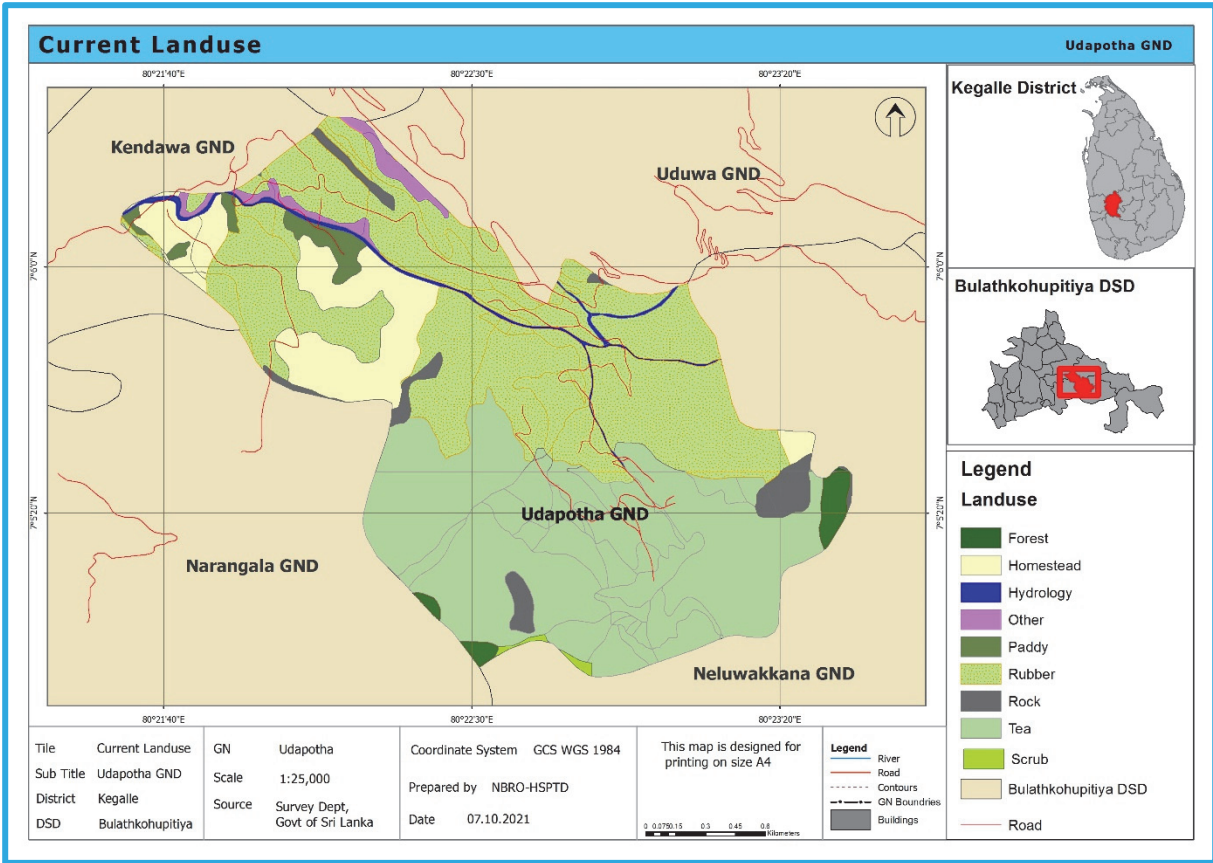


Figure 12: Current Land use map of Udapotha GN

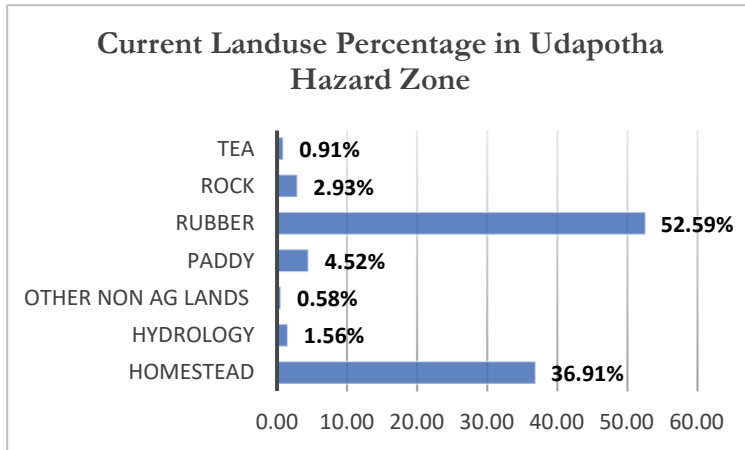


Figure 13: Current Land use percentage in Udapotha Hazard Zone

Table 4: Land use types

| Land use Type | Area (Sqm) |
|--------------------|------------|
| Homestead | 165277 |
| Hydrology | 6992 |
| Other non-Ag lands | 2596 |
| Paddy | 20227 |
| Rubber | 235445 |
| Rock | 13110 |
| Tea | 4094 |

2.2.7. Current Land Use with Yellow and Red Zone in the target area

An updated land-use map was prepared using aerial image interpretation captured through Drone technology in 2020 by NBRO. The aerial image was classified according to the existing land use classification system used for landslide risk mapping and generated a 1:1000 land use map for the project area. These high-resolution images help to identify the detail various of the ground, and it helps identify the exact building shapes and sizes. The building density is higher near the road. The map highlighted the

existing landslide flow path and marked the possible debris flow paths generated through the yellow-red zone method described in the next section.

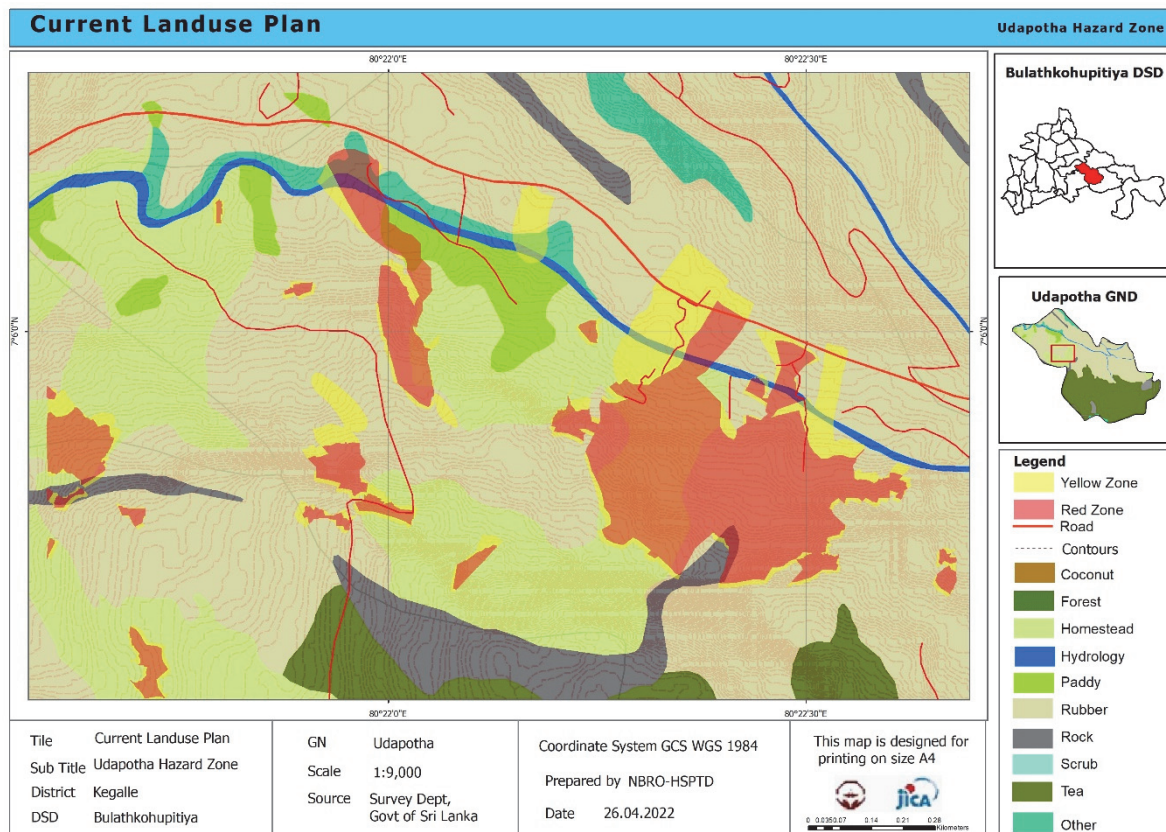


Figure 14: Current Land use Plan in Udapotha Hazard Zone

2.3. Concept of Yellow/Red Zone

Sediment Disaster Hazard Area (Yellow Zone) is an area prone to sediment disaster. If an area is designated as a Yellow Zone: 1) early warning systems should be established, and 2) steps to raise the awareness of local people about sediment disasters should be taken. Special Sediment Disaster Hazard Area (Red Zone) is designated where there is a severe risk of damage to buildings and threat to residents; thus, structural and non-structural measures, including development regulation, should be applied based on the appropriate land use planning.

2.3.1. Yellow/Red Zone for Slide

Slide blocks are classified into three ranks, A, B and C, in terms of the clarity of slide topography and its activity based on the topographical interpretation. These ranks are defined and shown in Table 5.

Table 5: Slide block Classification

| Classification of Ranks | Definition |
|-------------------------|---|
| Rank A | The slide is confirmed to be completely active in the field survey, and Its shape, including its foot, is identifiable. |
| Rank B | The shape of the slide, including its foot, is identifiable, but the slide is not confirmed to be active in the field survey; or The slide is confirmed to be locally active, and its shape is not identifiable. |
| Rank C | The slide is not confirmed to be active in the field survey, and also its shape, including its foot, is not identifiable. |

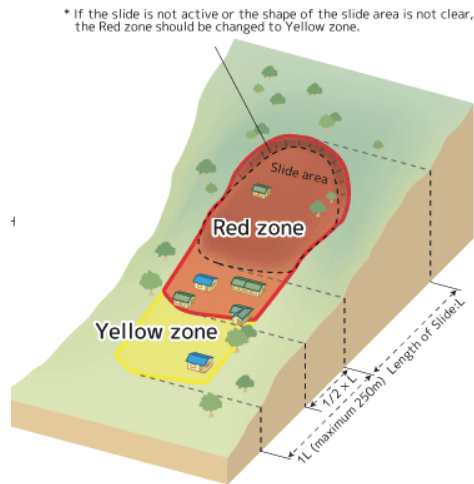


Figure 15: Yellow/Red Zone for Slide

2.3.2. Yellow Zone and Red Zone for Slope Failure

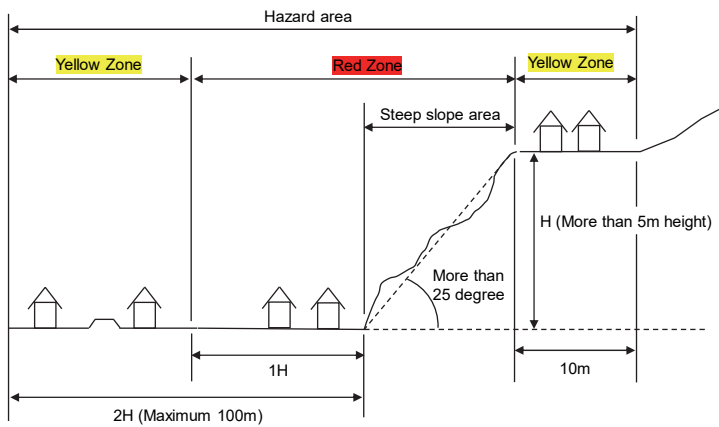
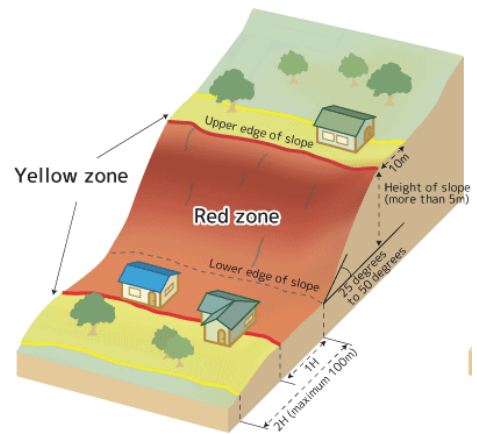


Figure 16: Yellow Zone and Red zone for Slope Failure



2.3.3. Yellow Zone and Red Zone for Debris Flow

The lower ends of the Yellow Zone and Red Zone for debris flow shall be determined based on the ground gradient or inclination from the profile of the target area. In addition, the width of the zone shall be determined based on spreading angles such as 30 degrees for Yellow Zone or 15 degrees for Red Zone. The concept of setting the Yellow Zone or Red Zone for debris flow is shown in the following figure 17

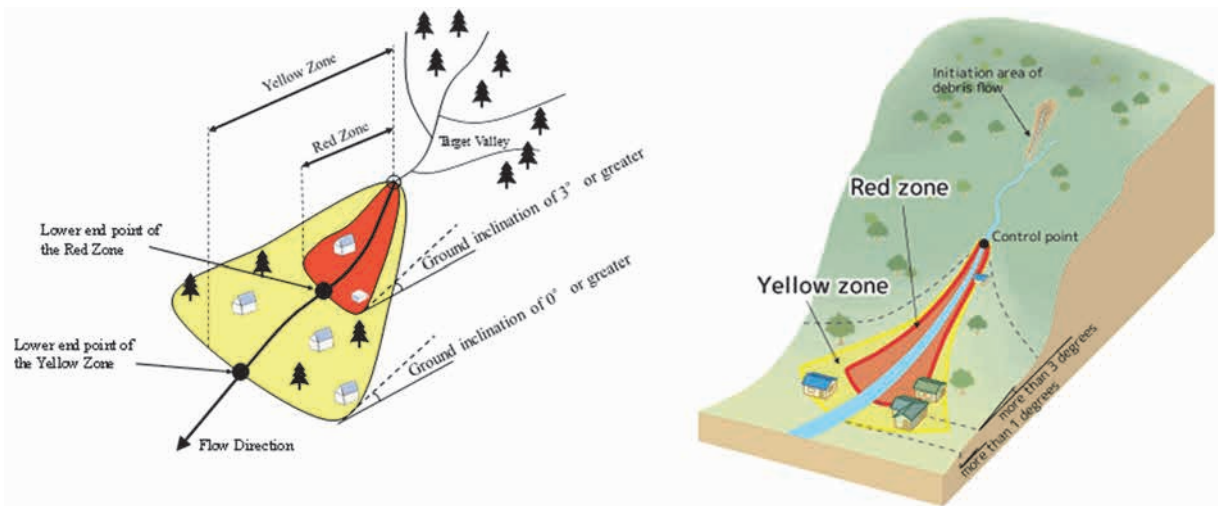


Figure 17: Yellow Zone and Red Zone for Slope Failure

2.4. Categorized Zone based on Yellow/Red zoning and LHM

NBRO has developed and distributed Landslide Hazard Map (LHM), in which the area is divided into main four categories; "Landslide not likely to be occurred", "Modest level landslide risk exists", "Landslide risk might be existing", and "Landslide can be occurred". There are fewer restrictions on "Landslide not likely to be occurred" areas, but in other zones, specific construction and structural guidelines need to be followed. However, due to the haphazard planning activities of the country, most of the landslide-prone categories consist of settlements.

The current hazard mapping activities do not consider the debris flow simulations. Therefore, possible debris flow areas are required to identify to incorporate the existing development guidelines. Accordingly, NBRO introduced a new Yellow/Red zone mapping concept for the area to simulate the landslide flow paths. In the concept, more detailed and site-specific hazard risk levels can be indicated to promote appropriate land use.

2.4.1. Land-use zoning in Landslide Prone areas

The Yellow zone and Red zone were divided into four zones, "Restricted Zone", "Prohibited Zone", "Warning Zone", and "Development Zone". The concept is only applied to the debris flow area, and the rest of the area is followed by the Landslide Hazard Map-based land-use guidelines. Table 6 shows the yellow/red zone and present LHM categories correlated with development zone categories.

Table 6: Relevance with LHM and Yellow/Red zone categories

| Development Zone Category | Yellow/Red Zoning (Applied for the Y/R zoning prepared area) | Landslide Hazard Map (Applied for the remaining area) |
|---------------------------|--|---|
| Restricted Zone | Red Zone | Landslides most likely to occur |
| Controlled Zone | (Sediment Disaster Hazard Area) | Landslides are to be expected |
| Warning Zone | Yellow Zone (Special Sediment Disaster Hazard Area) | Modest level of landslide hazard exists |
| Development Zone | Else | Landslide not likely occur |

1. Restricted Zone

The "Restricted Zone" is assigned for the lands identified as "Red Zone" or ranked in "Landslides most likely to occur (HR)" in LHM. Any construction or development shall be prohibited in the zone and the zone has a high probability of future landslide events. If any constructions are available in this zone should be relocated with proper investigations. This land area should be maintained as a natural area and required to monitor the environmental condition, water flow, and hazard situation in detail. In future, this area shall be demarcated as a sensitive area and control all kinds of human impacts on the area. Landslide flow path initiation area is also considered in this zone, and considering the feasibility studies, the land should be converted into a green area for the settlement. It is required to have detailed investigations and proper early warning systems for upper catchments before converting the area into a green area.

If the failure zone can be identified, nature-based solutions should be adhered to. The bottom of the failure zone should be strengthened by using the deep-rooted trees to increase the toe support for the failure mass. The water flow should be monitored in the zone, and proper drainage networks should be implemented to drain the access water.

Currently, the land-use types in the Restrict zone are paddy, homestead, rock and rubber. The future land use plan should be aimed to convert the existing land uses in the Restricted zone into forestry type land use categories.

2. Controlled Zone

The "Controlled Zone" is assigned for the lands identified as part of the "Red Zone" and ranked in "Landslides are to be expected (HR)" in LHM. This zone is considered a high-risk zone due to landslide magnitude. Therefore, landslide risk should be mitigated through structural mitigation measures when the zone has a high potential for future developments. In addition, this area should have a proper early warning system. The developers should follow detailed building codes and design in the area. If any construction does not follow the proper guideline, the authority should be reported to the appropriate planning agencies to remove such construction by considering its' impact on the area. However, this zone has a high risk due to magnitude, and it encourages depopulating the zone or maintaining the low densities if development is required.

Currently, the land use types in the control zone are rubber and homestead. The future land use plan should be aimed at converting the existing land uses in the control zone to promote agricultural activities which control the water.

3. Warning Zone

The "Warning Zone" is assigned for the lands identified as the "Yellow Zone". Development activities are allowed in this zone but need to follow the resilient construction guideline which the NBRO published. This zone can have different building densities depending on the risk levels. However, the entire zone should have a proper early warning system and continuous awareness programs for the commuters and residents. Controlled land uses are allowed in the zone, and the respective institutes should monitor the management plan of each land.

Currently, the land-use types in the warning zone are rubber and homestead. In the future, it is suitable for any agricultural activities and for establishing new residential.

4. Development Zone

The "Development Zone" is assigned for the lands not identified as either the Yellow zone or the Red zone. This zone is demarcated by considering the importance of development and hazard levels. This zone can be used to develop any kind of construction, but it should have adhered to the guidelines provided by the planning agencies like UDA, NPPD, etc. No resilient construction techniques are mandated for the zone unless disaster management professionals were identified as disaster impacted areas. If so, the retrofitting guidelines should adhere to constructions.

Based on this, the land area could be divided into four main sections, and the institute should monitor each

section. Furthermore, these main zones could be divided into categories by considering the hazard zones and slope categories.

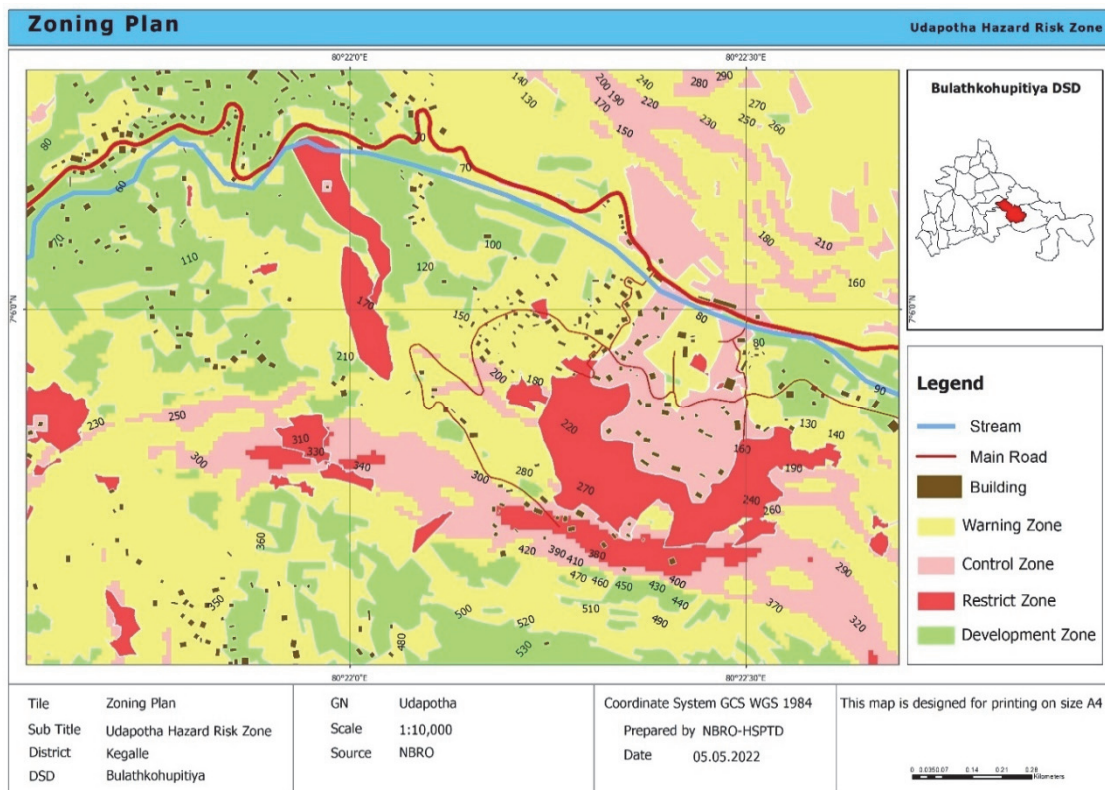
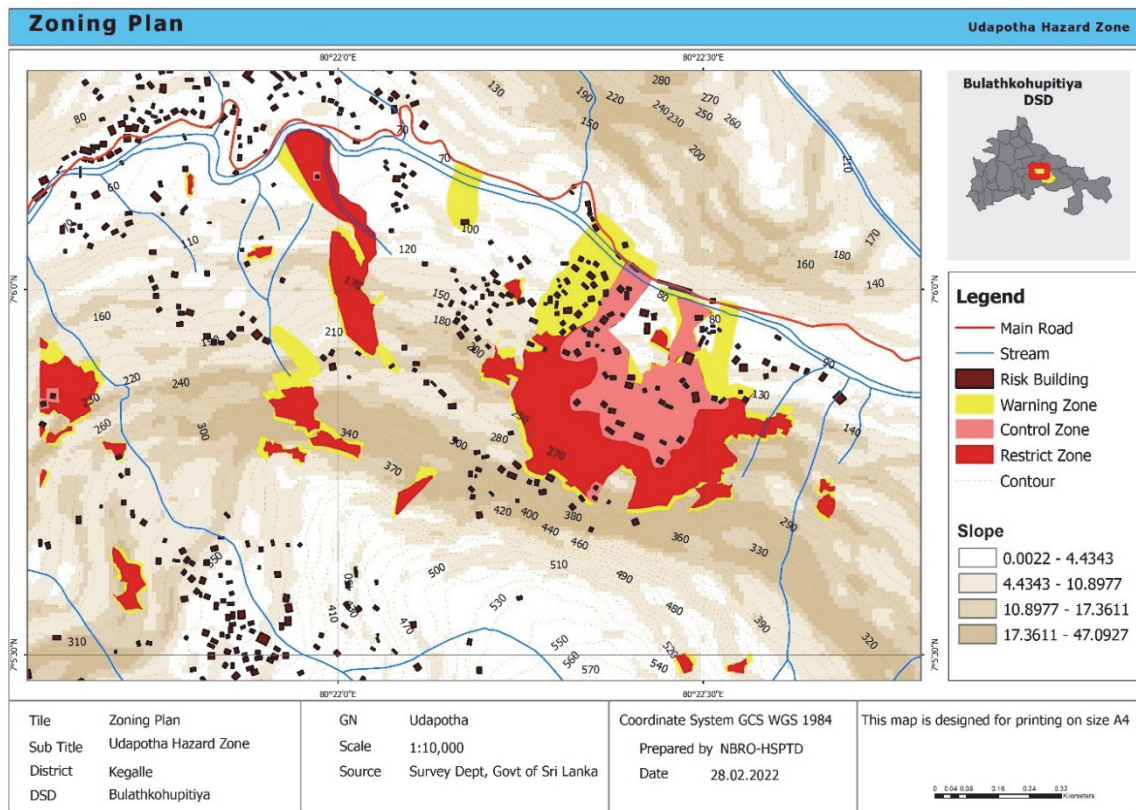


Figure 18: Zoning Plan in Udapotha Hazard Zone

2.5. Possible Land Uses for the Zones

Table indicates the permissible land use activities in each zone.

Table 7: Proposed Land Use Category

| | Proposed Land use category | | | |
|--------------------------------|----------------------------|------------------------|------------------------|------------------------|
| | Development Zone | Warning Zone | Controlled Zone | Restricted Zone |
| Residential | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Retail & Commercial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Office | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Industrial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Parks/ Playgrounds | Suitable for Use | Suitable for Use | Detailed Investigation | Not Suitable |
| Agricultural | Suitable for Use | Suitable for Use | Suitable for Use | Detailed Investigation |

2.6. Approval and Enforcement of the Land Use Plan

2.6.1 General conditions

Before doing any development activity, it needs to get the local authority's approval: Construction activities, Land use changes (Change of use), Land subdivision and amalgamation, and Infrastructure development.

- 1) Local authorities should physically demarcate the yellow zone and red zone boundaries.
- 2) An emergency response plan should be in place for every community in the yellow zone
- 3) NBRO and DMC should establish early detection instruments within the RedZone

Risk Assessment



3. Risk Assessment for Udapotha

The general concept of risk assessment for a landslide is to examine both the likelihood and adverse consequence of a landslide hazard, then thereby address risk in totality and finally compares the level of the resulting risk against predetermined standards, or other criteria to determine risk treatment and management prioritization. To simplify matters, this manual is not intended to cover the overall processes of hazard analysis (frequency and magnitude) to risk evaluation.

3.1. Database for Designated Yellow/Red Zones

The following table shows the criteria that used to assess the existing risk situation within Red and Yellow zone areas of Udapotha

Table 8. Items for Database for Designated Yellow/Red Zone

| Category | Item | |
|---|---|---|
| Basic information | District | |
| | DS Division | |
| | GN Division | |
| | ID No. (District code - GN P code- Landslide type - serial No.) | |
| | Name of PS | |
| | Landslide Type (Slope failure/Slide/Debris flow) | |
| | Area of Yellow/Red Zone (m2) | |
| Elements at risk | Number of facilities for vulnerable people | Facilities for the aged |
| | | Facilities for physically handicapped persons |
| | | Facilities for mentally retarded and disordered persons |
| | | Kindergartens |
| | | Maternity facilities |
| | | Other similar facilities |
| | Number of evacuation places | |
| | Number of hospitals | |
| | Number of schools | |
| | Number of other important facilities | |
| | Traffic network | |
| | Number of residential houses | |
| | Impact of past sediment disaster | Land devastation situation (nothing/slight/significant) |
| Impacts of past sediment discharge on nearby facilities | | |
| Local request | Request from residents and/or local authorities for risk reduction measures | |
| Countermeasures | Existing structural countermeasures | |
| | Existing non-structural countermeasures | |
| Land development plan | Presence of land development plan / land use plan | |

3.2. Evaluation

The relevant data for further risk evaluation is collected and assessed for each of the designated Yellow/Red Zones in accordance with the actual site-specific and local conditions, as sorted and listed below:

- a) Basic information
 - Yellow/Red Zone hazard maps (1:2,500 or 1:5,000 scale)
 - Location information (ID No., District, GN division, Landslide type)
- b) Information on important and vulnerable elements at risk
 - Number of facilities for vulnerable people
 - Number of evacuation places for a disaster
 - Number of public facilities except for road networks
 - Class of road networks
 - Number of residential houses, within red and yellow zones, respectively
- c) Information on impact of past landslide disasters
 - Land devastation situation
 - Impact of past landslide disasters on nearby facilities
- d) Other information
 - Request of implementation of measures from residents and/or local authorities

3.3. Items for Risk Evaluation

The risk evaluation for each of the designated Yellow/Red Zones will be conducted in accordance with such items as given in Table 8, and then the level of risk for each of the designated Yellow/Red Zone will be evaluated as very high, high, moderate or low according to the total scores using the risk evaluation sheet shown in Table 9 below. Figure 19 shows a concept of risk evaluation for the target zone.

Table 9: Items and Scores for Risk Evaluation for Yellow/Red Zone

| Item | Maximum Score (Total: 100) |
|---|-------------------------------|
| 1) Number of facilities for vulnerable people | 10 |
| 2) Evacuation places | 10 |
| 3) Public facilities | 10 |
| 4) Number of facilities of the above items 1) to 3) within the Red Zone | 10 |
| 5) Traffic network | 10 |
| 6) Number of residential houses within the Yellow/Red Zone | 10 |
| 7) Number of residential houses within the Red Zones | 10 |
| 8) Land devastation situation | 10 |
| 9) Impacts of past sediment discharge on nearby facilities | 10 |
| 10) Request from residents | 10 |

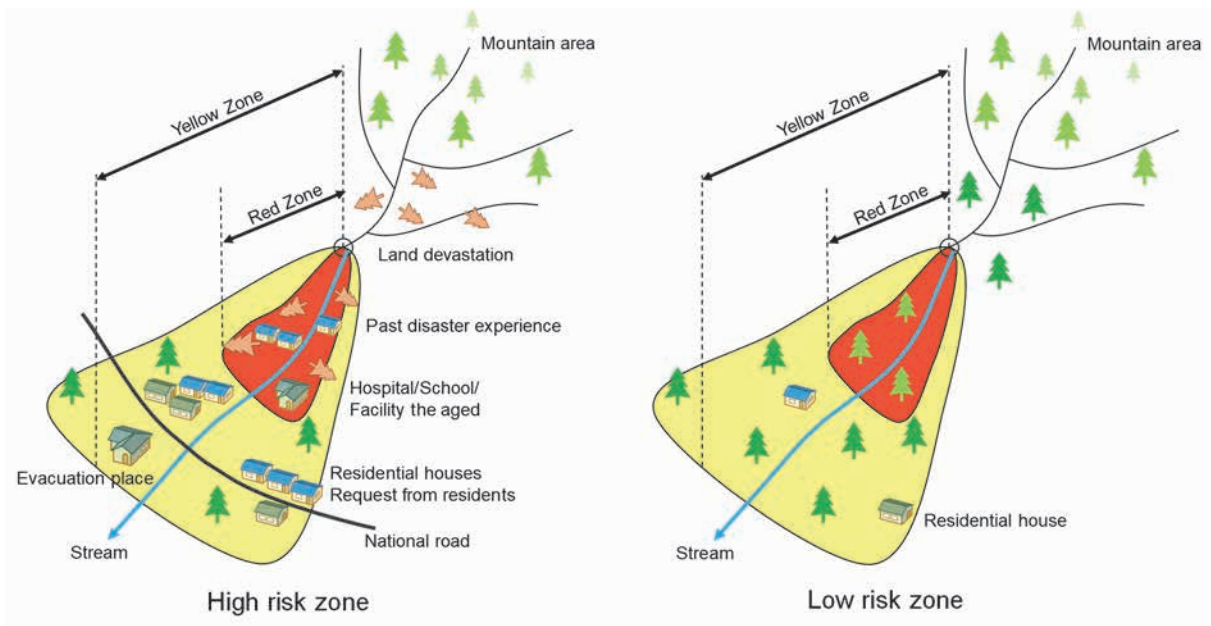


Figure 19: Concept of Risk Evaluation for the Target Yellow/Red Zone (for Debris Flow)

3.4. Risk Evaluation Sheet for Yellow/Red Zone

| | |
|---------------------------|---|
| District | Kegalle |
| GN Division | Udapotha |
| Landslide Type | <input type="checkbox"/> Slope failure <input type="checkbox"/> Slide <input checked="" type="checkbox"/> Debris flow |
| Designation No. | Red Zone - Debris Flow (Z1) |
| Result of Risk Evaluation | Moderate Risk |

| | |
|--------------|----------|
| Prepared by | |
| Organization | NBRO |
| Date | 2020.11. |

| No. | Item | Max Score | Allotment Score | | | Evaluation Score | Remarks |
|---------------|--|------------|-----------------|---|----|------------------|--------------------------------------|
| | | | 0 | 5 | 10 | | |
| 1) | Number of facilities for vulnerable people | 10 | 0 | 0 | 0 | 0 | |
| 2) | Evacuation places | 10 | 0 | 0 | 0 | 0 | |
| 3) | Public facilities | 10 | 0 | 5 | 0 | 5 | boutiques |
| 4) | Number of facilities of the above items 1) to 3) within the Red Zone | 10 | 0 | 0 | 0 | 0 | |
| 5) | Traffic network | 10 | 0 | 5 | 0 | 5 | Other Roads |
| 6) | Number of residential houses within the Yellow and Red Zone | 10 | 0 | 0 | 0 | 0 | |
| 7) | Number of residential houses within the Red Zones | 10 | 0 | 5 | 0 | 5 | 03 residential houses |
| 8) | Land devastation situation | 10 | 0 | 0 | 10 | 10 | Significant (20 houses were removed) |
| 9) | Impacts of past sediment discharge on nearby facilities | 10 | 0 | 0 | 0 | 0 | |
| 10) | Request from residents | 10 | 0 | 0 | 10 | 10 | Yes |
| Total: | | 100 | | | | 35 | |

Figure 20: Filled Risk assessment sheet for debris flow patch in Udapotha

Explanation and Description:

- 1) Facilities for vulnerable people mean facilities for people who require assistance during a disaster, mainly including a) facilities for the aged, b) facilities for physically handicapped persons, c) facilities for mentally retarded and disordered persons, d) kindergartens, f) maternity facilities, and g) Other similar facilities.
- 2) Evacuation places mean whether evacuation shelters are present or not around or within the Yellow/Red Zone.
- 3) Public facilities include a) Important facilities such as hospitals and schools, and b) others rather than important facilities.
- 8) Land devastation situation means the relevant lands are significantly devastated due to sediment disasters and almost cannot be used, or are slightly devastated and can be used as farm lands or forest land.
- 9) Impacts of past sediment discharge on nearby facilities mean a) presence or absence of past sediment discharge and its impacts on nearby facilities if present.

The risk evaluation for each of the designated Yellow/Red Zone is carried out and rated on the basis of the selected ten (10) items, as explained above. The risk of each of the designated Yellow/Red Zones is scored using the risk evaluation sheet for yellow/red zone shown in Figure 21 and is further classified into four levels, namely, very high, high, moderate or low according to the total scores.

Table 10: Classification of Risk Level

| Risk Level | Total Evaluation Score |
|-------------------|-------------------------------|
| Very High | 75 and more |
| High | 50 to 74 |
| Moderate | 25 to 49 |
| Low | 0 to 24 |

The designated Yellow/Red Zones is prioritized by considering these selected items, and this enables risk management, for example, further risk reduction measures, land use planning, to be considered according to priority or risk level. This will facilitate a rational and effective approach to risk treatment and management given the resources available.

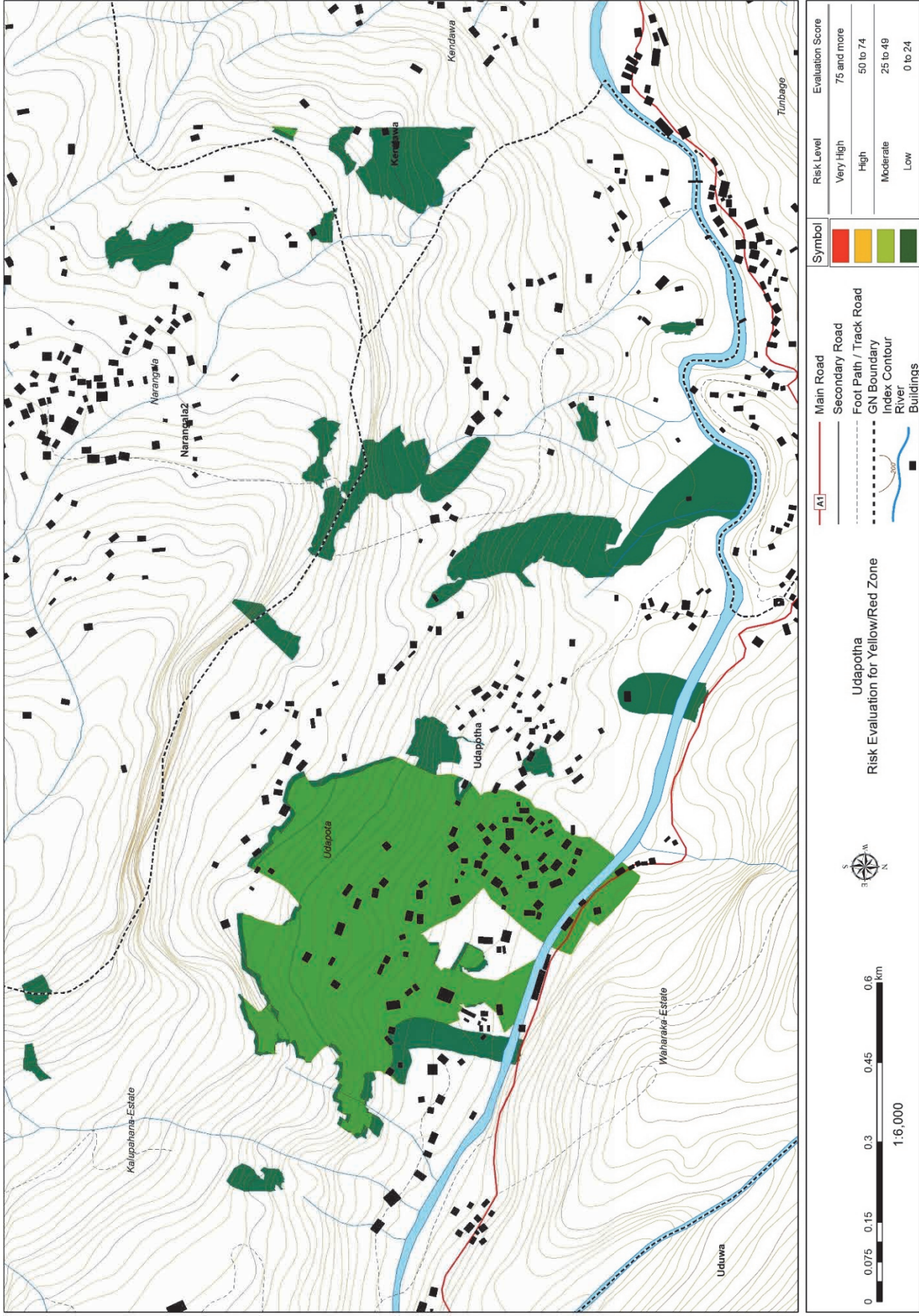


Figure 21: Risk Evaluation Map of Udapotha

Land use Zoning



4. Land Use Zoning Plan in Udapotha

As mentioned above concept, the Yellow zone and Red zone of the target area were created by NBRO on 1:10,000 and 1:2,500 scales. There are several potential debris flow-prone areas around the Udapotha. In this LSDRRP, only the stream of Udapotha and its surrounding area are considered.

The current Land Use Map overlaying the red and yellow zone in Udapotha is displayed in Figure 14. In addition to the current land use displayed in Figure 22, those areas covered as Red and Yellow Zone are required to follow the development restriction determined in this LSDRR.

Land Use Zoning Plan for Udapotha is shown in Figure 23. The four zones, "Restricted Zone", "Controlled Zone", "Warning Zone", and "Development Zone", are marked on the map.

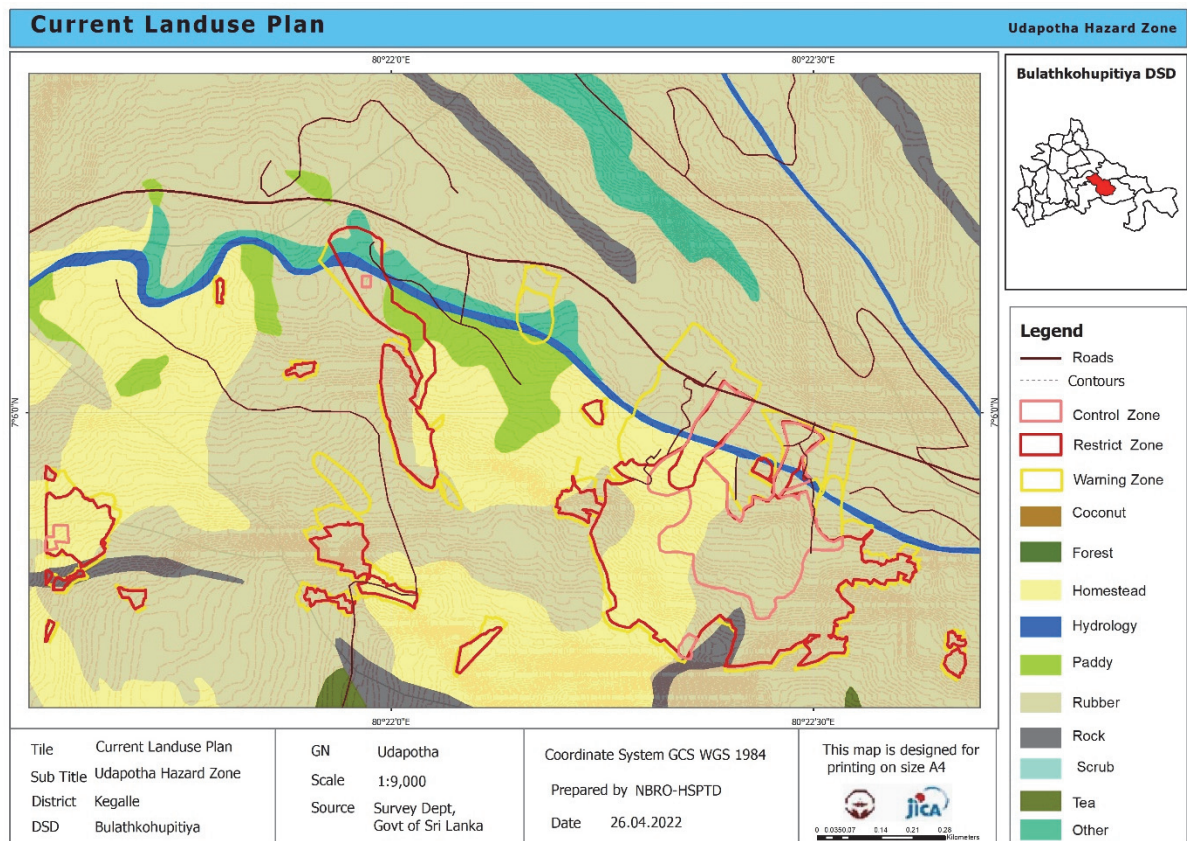


Figure 22: Landuse Plan in Udapotha

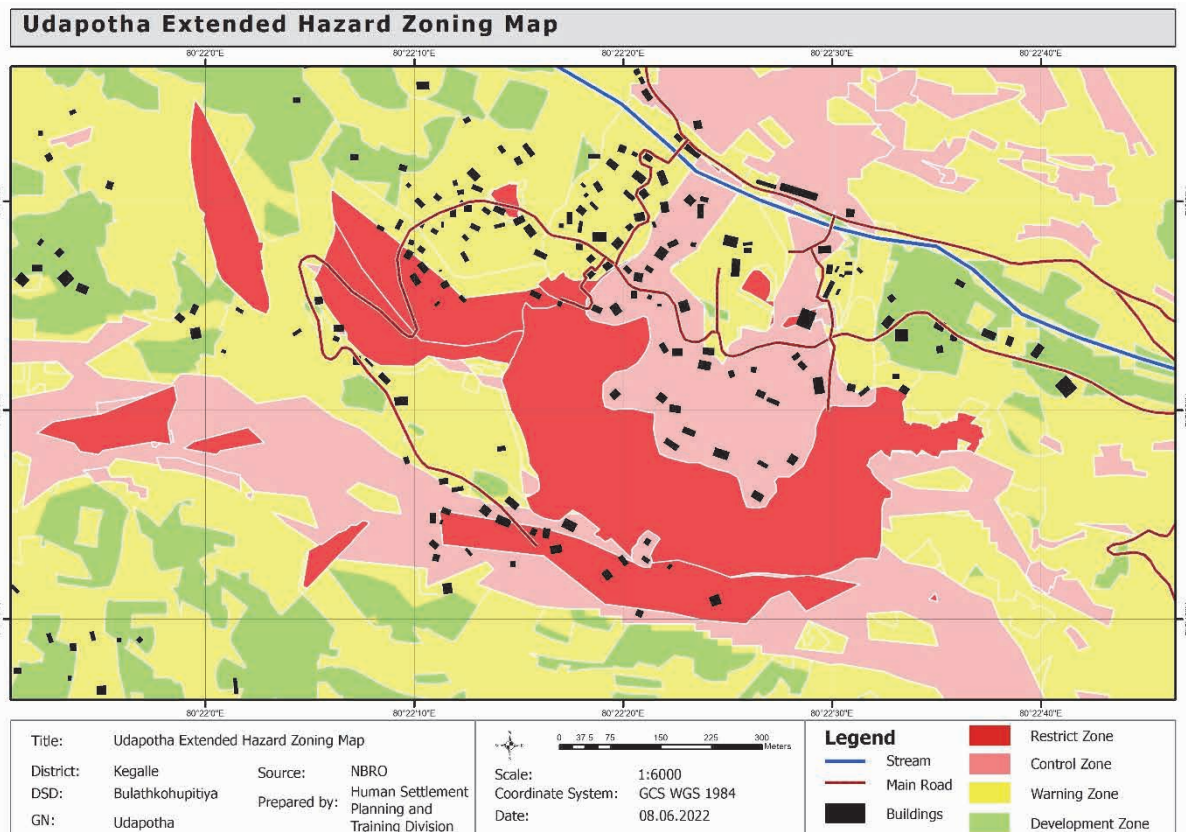


Figure 23: Land use Zoning Plan in Udapotha

4.1. Basic DRR Strategies by each Land Use Zoning for Udapotha

Restricted Zone

- Forest replanting with native trees.
Use native plants to replant the degraded land. Nature-based landslide risk mitigation project, a technical collaboration project of NBRO with the Asian Disaster Preparedness Center (ADPC), has developed a plant manual for this kind of situation.
- Introduce tree barriers to control debris flow
Introduce tree lines as the debris along the restricted zone and control zone border. it may help to control debris to flow in to residential area to certain extent.
- Sabo structural facilities
- In consultation with the central government, such as NBRO and Road Development Authority, debris flow prevention facilities such as Sabo dam, training dyke, channel works.

Controlled Zone

- Promote agricultural activities which manage water (e.g., well manage tea)
- Soil erosion and surface water control is measures are mandatory.
- Not allow new residential
- Existing housing will remain, and application of retrofication measures as required. There are 37 houses in the controlled zone in Udapotha.
- Residential activities are permitted if mitigation measures are introduced.
- Introduction of community-based DRR system and early warning system.

Warning Zone

- It is suitable for any agricultural activities as well as to establish new residential also.
- Introduction of community-based DRR system and early warning system
- Not Allowed for Schools, preschools, religious places, hospitals, elder homes and so on.

Development Zone

- No special restrictions on development activities
- The regular development approval process will be taken in to consideration

4.2. Statistics in Yellow and Red Zone

The statistics are based on the filed survey in Udapotha. Target area which is conducted on 2021.11.30, 2021.12.1 & 2 by the NBRO, and the following information is utilized to plan a relocation of housing, an evacuation drill, and a communication channel to disseminate early warning.

Table 11: Population statistics in Yellow and Red Zone

| | Number of Housing | Number of Family (people) | Number of people who need assistance to evacuate (infants, elderly, pregnant woman, people with handicap) |
|-----------------|-------------------|---------------------------|---|
| Restricted Zone | 0 | 0 | 0 |
| Controlled Zone | 37 | 37 (140) | 0 |
| Warning Zone | 35 | 32 (133) | 0 |

Table 12: Housing Type Statistics in Yellow and Red Zone

| | Total Number of Housing | Permanent | Semi-permanent | Improvised |
|-----------------|-------------------------|-----------|----------------|------------|
| Restricted Zone | 0 | 0 | 0 | 0 |
| Controlled Zone | 37 | 33 | 2 | 0 |
| Warning Zone | 35 | 33 | 4 | 0 |

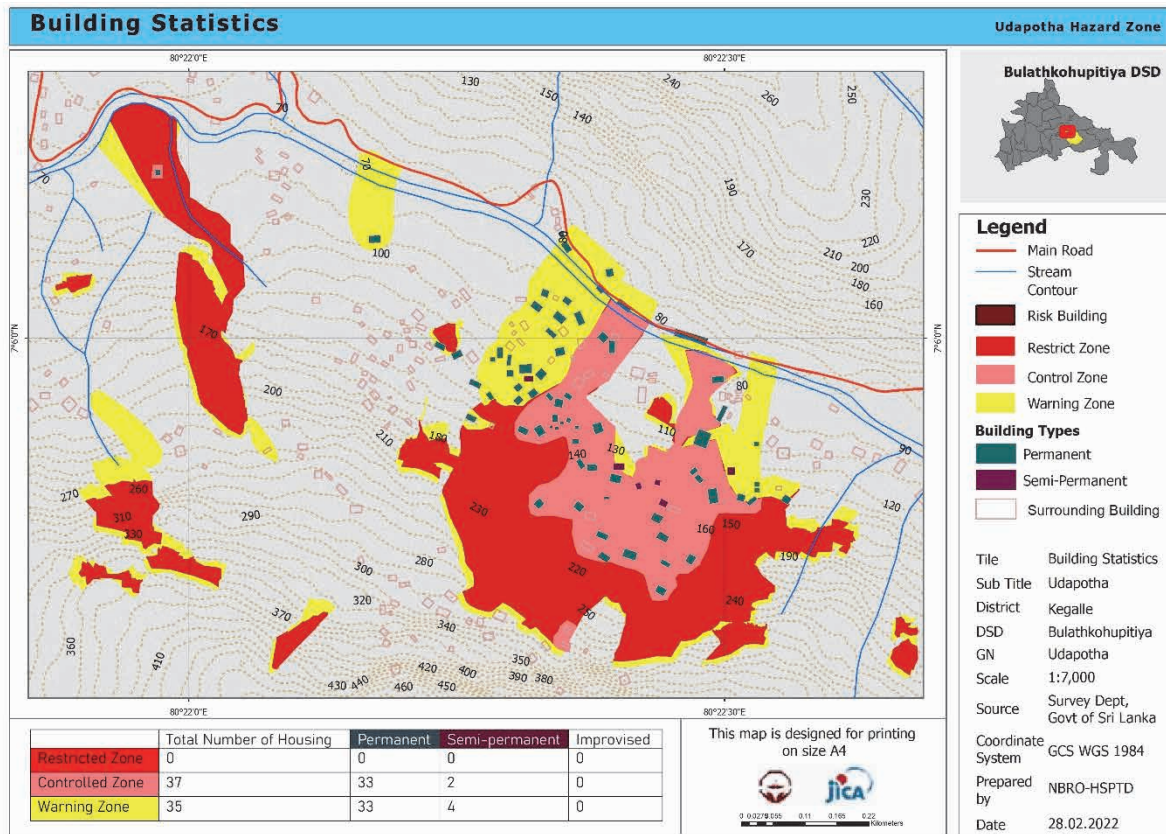


Figure 24: Building Statistics of Udapotha

4.3. Current issues related to housing in hazard area

The following issues regarding housing in hazard areas are identified at the workshop with Udapotha community members on March 2022.

- People at the upper areas with landslide risk have already been resettled; nevertheless, people in the lower areas still live with a high risk.
- Authorities do not have a proper mechanism to prevent new housing construction in the upper area in high risk where houses have been removed.
- The majority of residents do not like to move to another area for resettlement.

As a prevention measure for new housing in the risk area, Bulathkohupitiya PS, a responsible authority for providing land permission, shall develop By-law to implement the plan and guide development regulation. Moreover, the cooperation of neighbours is necessary to prevent new housing construction in the restricted and control area. Furthermore, as most of the residents do not want resettlement to other areas, it is beneficial that Bulathkohupitiya PS promotes retrofitting the existing houses in the control zone in cooperation with NBRO.

In addition, Ihalagama is listed as a high-risk area at the workshop, Bulathkohupitiya PS shall aim to expand LSDRRP to Ihalagama based on Yellow/Red zoning provided by NBRO.

Structural Measures



5. Structural Measures

Structural measures are planned to be implemented at two sites: Site 1 and Site 2 in Udapotha. Hazard and impacts and suggested structural measures for the two sites are delineated below. The location map of the sites is shown in Figure 27.

5.1. Site 1 – A Debris Flow Red Zone

1. Hazard and Impacts

Site 1 is a Red Zone corresponding to debris flow with a source area of slope failure within the Udapotha Pilot Site (Figure 27).

A large red-zone slope failure above the zero valley together with an observable debris fan at the base of the slope indicates that the debris flow is highly expected to occur during or after a heavy rainfall.

A few residential houses are in the depositional area – debris fan. A debris flow, once it occurs, originating from either large slope failure, or sediments of stream erosion, or their combination, would cause a considerable damage to the residential houses in the depositional area, thus posing a high risk to human lives.

2. Suggested Structural Measures

Because of a few residential houses affected, a training wall is recommended to control or guide the debris flow up to a safe place. The training wall is installed behind the populated area of the debris fan for the purpose of avoiding the direct hit of debris flow to the residential houses (Figure 28).

Quantity and specification of the planned SABO dams are summarized in Table 13.

Table 13: Summary of the Suggested Structural Measures at Site 1

| No. | Measure Type | Description/Specification |
|-----|---------------|---|
| 1 | Training wall | 1) Reinforced concrete, 2) L=25 m, H=5 m, T=30 to 50 cm |

Notes: L=length of training wall, H=height of training wall, T= thickness of training wall

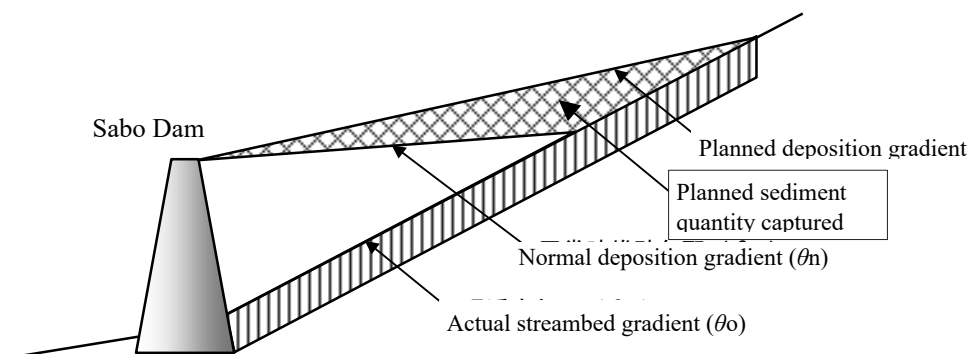


Figure 25: Conceptual Illustration of Non-permeable Sabo Dam

5.2. Site 2 – A Slide Red Zone

1. Hazard and Impacts

Site 2 is a Red Zone corresponding to slide in the Udapotha Pilot Site (Figure 27).

The slide showed a clear landslide topography, including circle-shaped main scarp, hummocky topography and so on. Some ground surface deformations were also observed in the slide slope (Figure 27). Accordingly, the slide is highly expected to occur during or after a heavy rainfall.

Many residential houses are located within and below the slide area. Once moving down, the slide would cause a considerable damage to these residential houses within the slide area (Figure 29).

2. Suggested Structural Measures

Similar to that stated above in 2. of 4.1 Site 1 – A Slide Red Zone, horizontal drain hole work is recommended to drain shallow groundwater effectively and promptly, to stabilize the slide. In addition, drain ditch work is used to collect surface water and then drain out of the slide area (Figures 26 and 29). Quantity and specification of the planned structural measures are summarized in Table 14.

Table 14: Summary of the Suggested Structural Measures at Site 2

| No. | Measure Type | Description/Specification |
|-----|------------------------|--|
| 1 | Horizontal drain holes | 1) 30 m x 6 holes + 30 m x 4 holes = 300 m |
| 2 | Drain ditch | 1) L= 200 m in total |

Notes: L=length of drain ditch

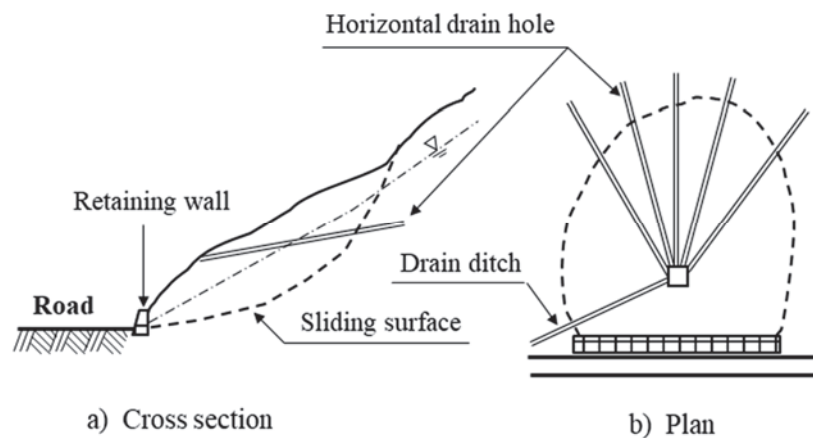


Figure 26: Typical Layout of Horizontal Drain Holes

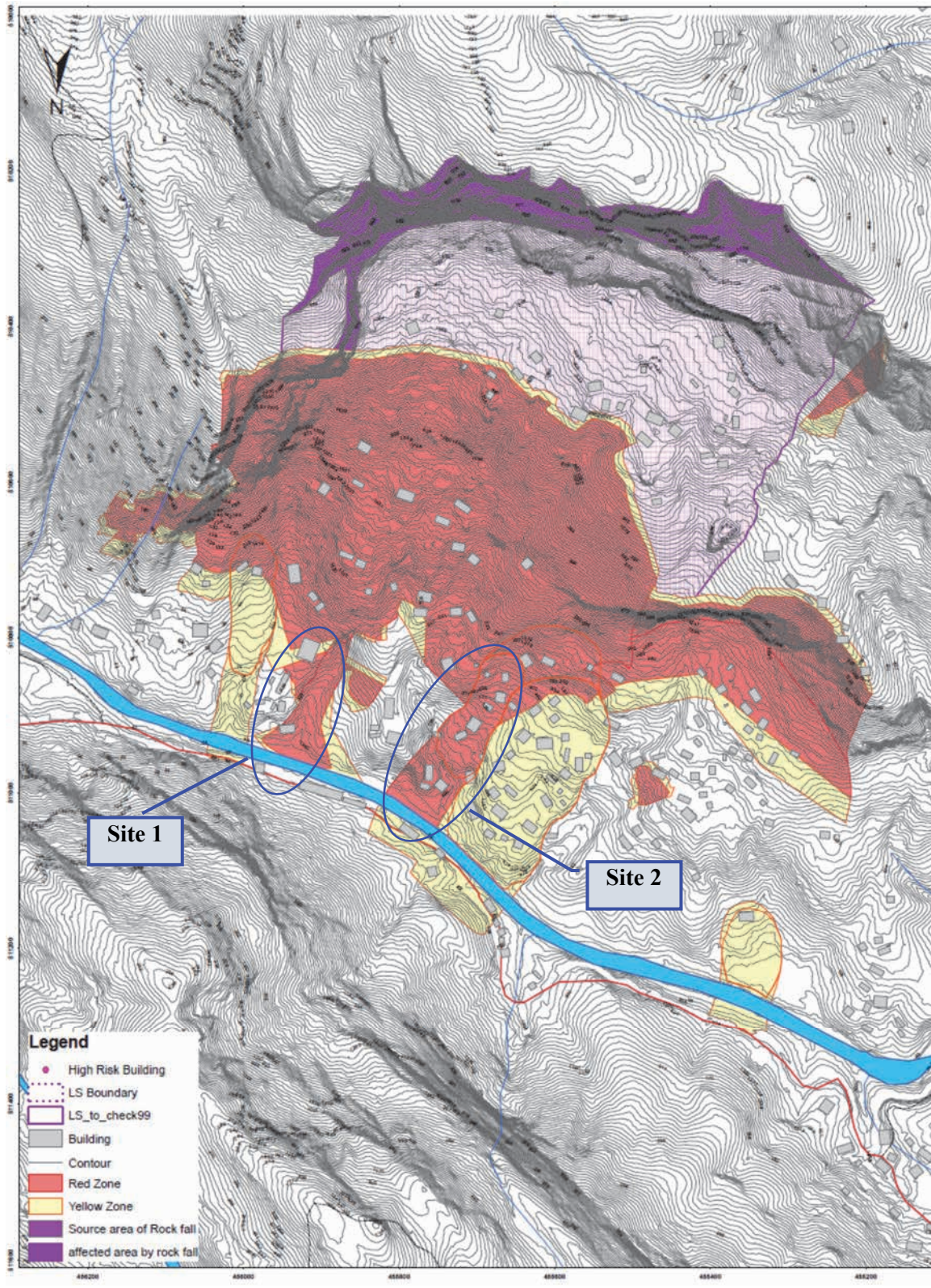


Figure 27: Location of the Selected Red Zones for Conceptually Planning Structural Measures in the Udapotha Pilot Site

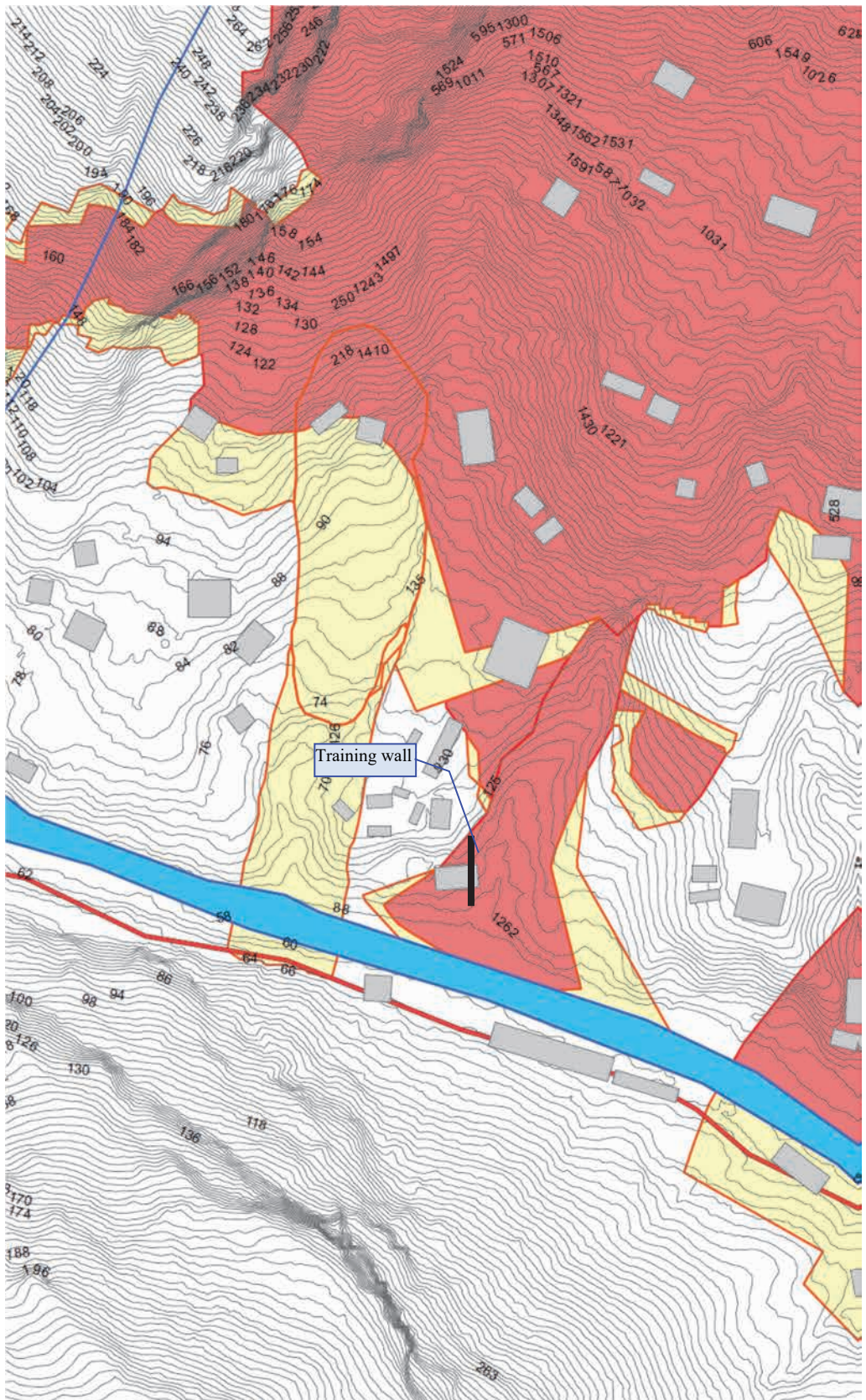


Figure 28: Layout of the Planned Structural Measures for Site 1 in the Udapotha Pilot Site

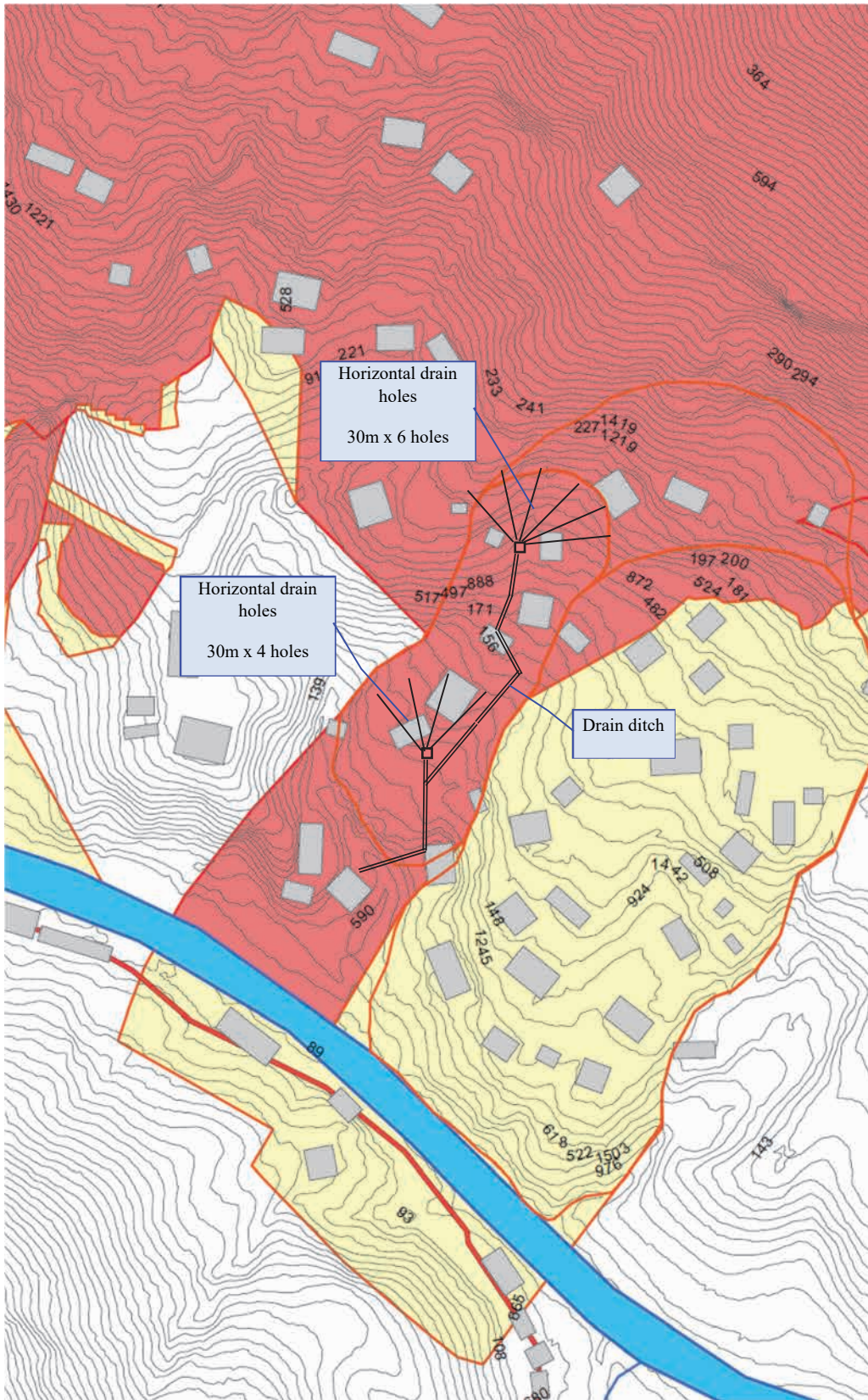


Figure 29: Layout of the Planned Structural Measures for Site 2 in the Udapotha Pilot Site

Strengthening Early Warning and Evacuation



6. Strength Early Warning and Evacuation

NBRO Landslide Early Warning NBRO Early Warning Centre (EWC) issues landslide warnings based on real-time observed rainfall data from the NBRO automation rain gauge. Warning criteria and actions to take during the respective warning level is as shown in the following table. In addition to 24 hours rainfall, NBRO EWC considers Soil Water Index (SWI), which indicates how much water is accumulated in the soil since a landslide is caused when water in the soil gets saturated by heavy rainfall. It is important to remember that there are cases where NBRO keeps the warning even if the rainfall becomes little since there is a high risk of landslides due to high water saturation in the soil (high SWI).

Table 15: NBRO Landslide Early Warning Criteria and actions to take

| Warning Level | | 24 hours rainfall | Actions to take |
|---------------|------------|-------------------|---|
| | (None) | | |
| 1 | Watch | More than 75 mm | Be watchful on the possibility of a landslide |
| 2 | Alert | More than 100 mm | Be on alert, prepare to evacuate |
| 3 | Evacuation | More than 150 mm | Evacuate to a safe location |

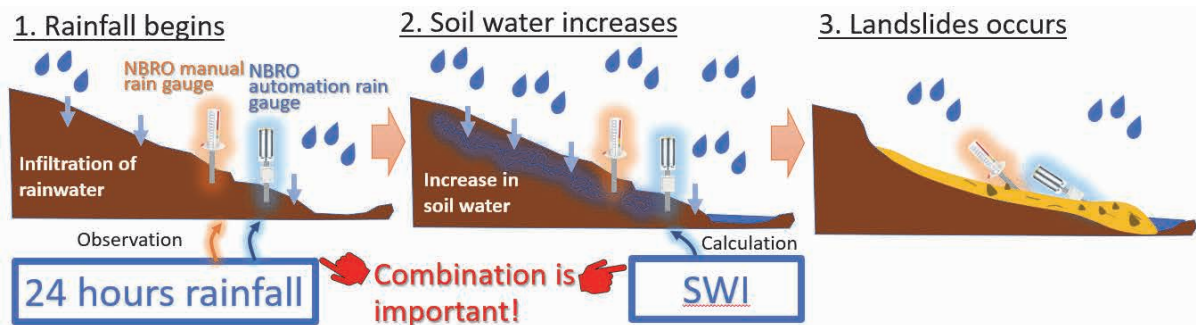


Figure 30: Cause of Landslide and Soil Water Index

After NBRO EWC transmits the warning messages to Disaster Management Centre (DMC), DMC is in charge of disseminating the NBRO warning to DDMCU in Kegalle District Bulathkohupitiya DS division, Udapotha GN Division, and Emergency Community Committee in Udapotha.

DDMCU (or DS division) issues evacuation orders to local people considering the landslide warnings. The local people living in Yellow/Red zones shall evacuate to a safe place to comply with the section 7.(2) and (3). The awareness activities shall ensure specific dissemination of the landslide warnings and evacuation orders. NBRO will continue routine operation and maintenance of the rain gauge.

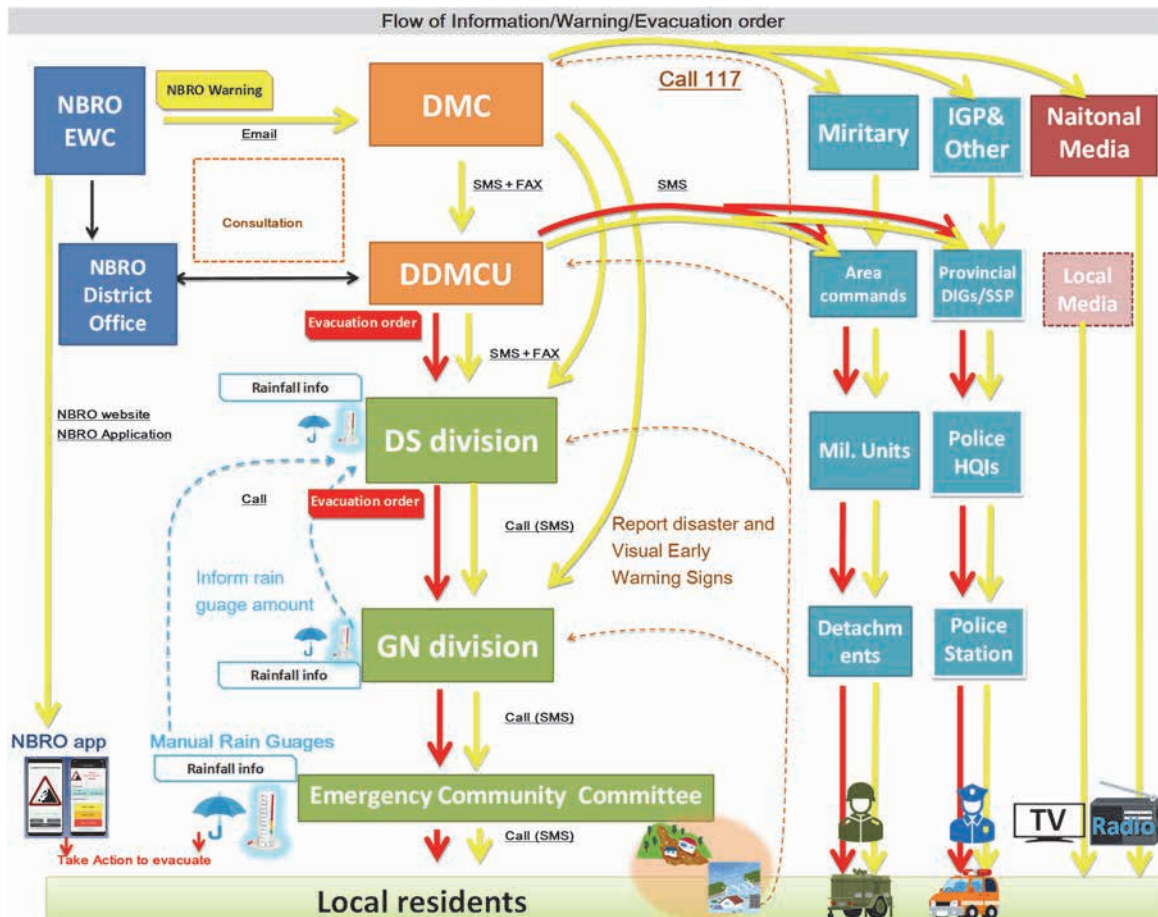
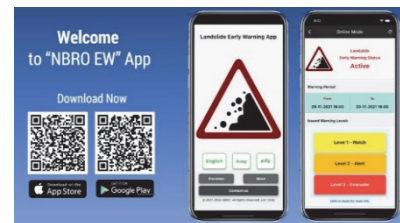


Figure 31: Dissemination flow of NBRO Landslide Early Warning and Evacuation Order

Although the direct Call/SMS comes to only focal people at the respective level, the landslide warnings are also broadcasted by media and published on the NBRO websites (<https://www.nbro.gov.lk/index.php?lang=si>) and NBRO mobile application. Therefore, all residents can check the warning by themselves also. The real-time observed rainfall data by the NBRO automation rain gauge (https://www.nbro.gov.lk/index.php?option=com_content&view=article&layout=edit&id=215&lang=en) is also available at the NBRO website.



Community Based Early Warning

In addition to NBRO EW sent from EWC, a community-based approach on landslide early warning needs to have functioned. NBRO and DMC provided manual rain gauge cylinders to the Disaster relief officer at Bulathkohupitiya DS division, Udapotha GN officer (needs to be confirmed), and Emergency Community Committee in Udapotha. Even if the level of NBRO EW sent through DMC is not at the same level, when observed rainfall by the manual gauges at the field exceeds the threshold, Disaster relief officer or the Emergency Community Committee shall inform the situation to Divisional Secretary and make decision to evacuate if it is over 150 mm per 24 hours. The local people shall start evacuation based on the local information since NBRO EW is not for the site-specific area but the entire district. Emergency Community Committee shall inform the warning to the residents by call, SMS and oral communication to encourage evacuation.

6.1. NBRO Early Warning Communication Channel in Udapotha

The following figure is a NBRO Early Warning dissemination channel in Udapotha. Calls and SMS are the main methods of early warning dissemination. Sixty households in Udapotha are covered through this channel at present. The residents who are not in the channel shall be informed that NBRO early warning information is available at NBRO EW application and website at awareness activities. A manual rain gauge was provided to the community with proper training, and it is handled by the Ven Nilminigama Sumedha, appointed as the chairman of the Emergency Community of Udapotha. The committee chairman can also inform the community when the rain exceeds the threshold limits.

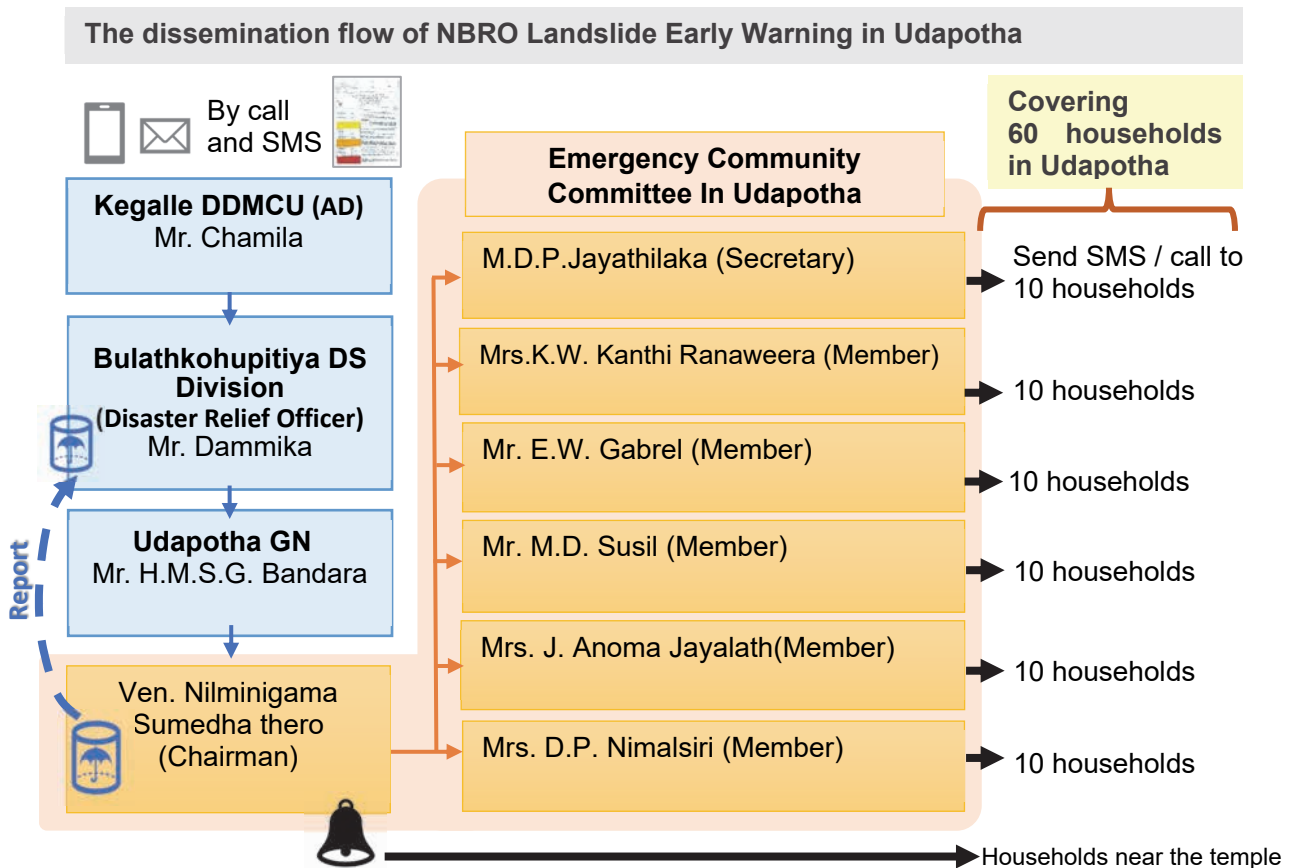


Figure 32: Contact information and the dissemination flow of NBRO Landslide Early Warning in Udapotha

6.2. Emergency Community Committee in Udapotha

Emergency Community Committee was newly established in the Udapotha area in March 2022 by NBRO officers. The following are the committee members. NBRO manual rain gauge was also provided to the Committee, which is placed in the Keerthi Aramaya. The responsible person for the rain gauge is Ven Nilminigama Sumedha thero. He is also in charge of making a monthly rain gauge record and sending it to NBRO EWC.



Table 16: Members of Emergency Community Committee in Udapotha

| Position | Name | Role |
|-----------|-------------------------------|--------------------------|
| Chairman | Ven.Nilminigama Sumedha thero | Thero at Keerthi Aramaya |
| Secretary | M.D.P. Jayathilaka | |
| Member | K.W. Kanthi Ranaweera | NBRO Manual Rain gauge? |
| Member | H.M.S.G. Bandara | GN officer |
| Member | EW Gabrel | |
| Member | MD. Susil | |
| Member | J. Anoma Jayalath | |
| Member | D.P. Nimalsiri | |

6.3. Installed Landslide Remote Monitoring System and EW equipment

Landslide Remote Monitoring System (LRMS)

As slowly moving landslide blocks are found in Udapotha, two sets of Landslide Remote Monitoring System (LRMS) was installed by NBRO. LRMS consists of 4 equipment. At the Base station, there are 1. Alarm device and 2. Rain gauge with a main controller of installed devices and data transmission. Other equipment are 3. Extensometer, which measures the movement of soil mass and 4. Multi-point Inclinometers which measures the inclination of soil-mass.

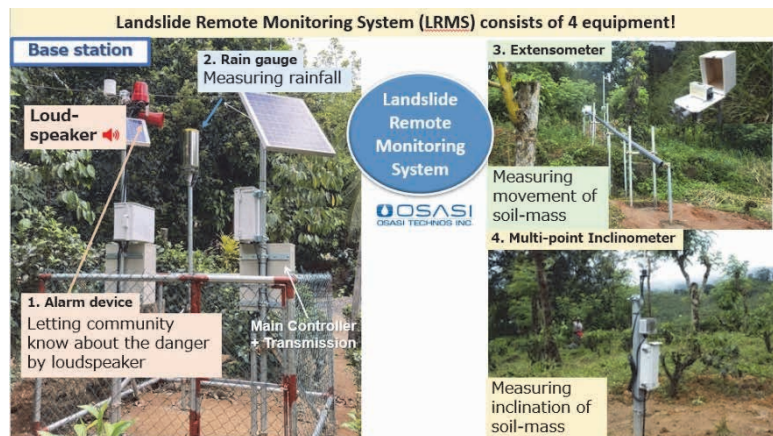


Figure 33: Main equipment of Landslide Remote Monitoring System (LRMS)

The extensometer is a device used to measure the changing distance between two points. A fixed measurement point with a main device is located at upper side of landslide block. The other measurement point at the lower area is placed inside the landslide block. A wire is set from the equipment at the top to the bottom. Therefore, when landslide occurs, the bottom measurement point moves to the lower area and make the wire extend. When the device detects the change over the threshold, the alarm rings and warning message is disseminated to the registered SMS number.

The multi-point inclinometer is located inside the landslide block. It has a sensor used to measure the π data is depicted in degrees. When the change become message is also sent to the registered SMS number.

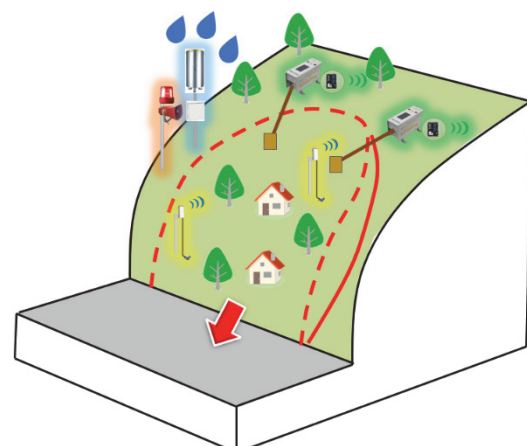


Figure 34: Locational image of extensometer and multi-point Inclinometer

All the observed data by extensometers, inclinometers and automation rain gauge is sent to NBRO EWC server. Therefore, the current condition of each equipment and the site are monitored by NBRO EWC and District office online.

Possibility of a wrong warning by LRMS

It is crucial to note that as the device detects the above changes, a warning occurs not only due to landslide but also other factors, such as when tree branches are fallen onto the wire of extension meter and when residents or monkeys touches the inclinometer. If loudspeaker starts ringing without rainfall, it may be the wrong warning. If the wrong warning occurs frequently, PS shall consult with NBRO EWC and District office about the issue. Awareness activities to residents regarding the LRMS and keep the area clear is also crucial.

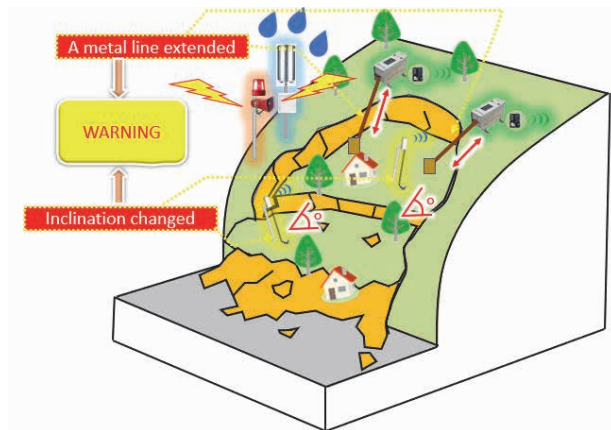


Figure 35: Location and warning image of LRMS

Location of LRMS in Udapotha

Specific location of installed LRMS equipment in Udapotha is shown in the following map.

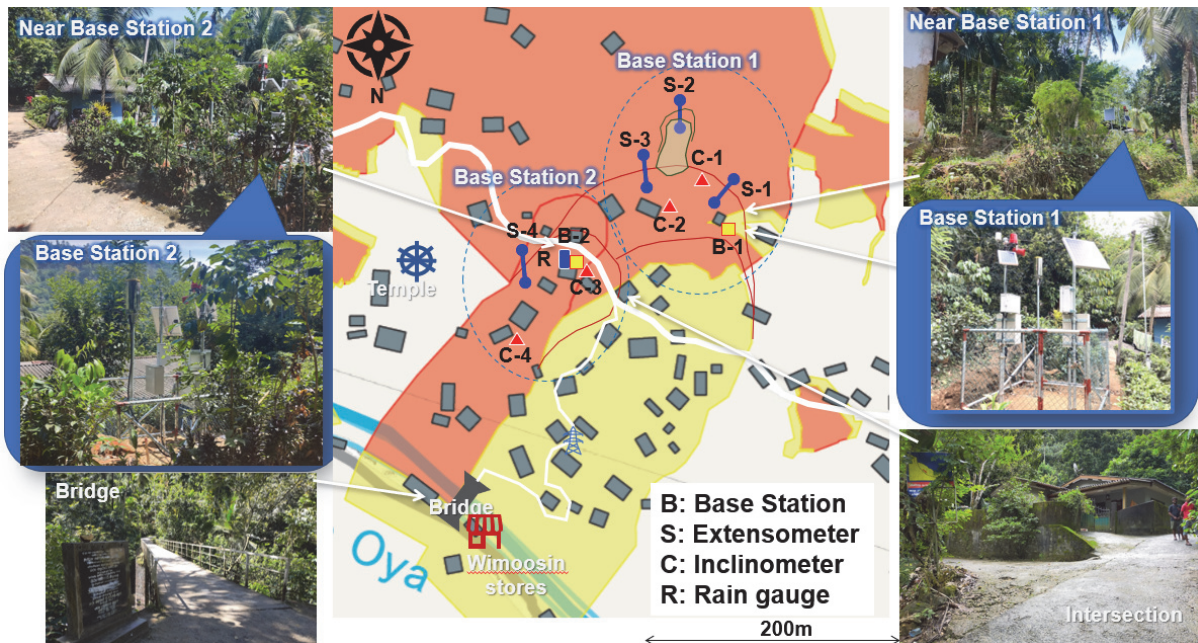


Figure 36: Location of extensometers and multi-point inclinometers in Udapotha (Overview)



Figure 37: Location and image of installed extensometers and multi-point inclinometers in Udapotha (Base Station 1 & 2)

Warning siren and SMS from the LRMS equipment

When extensometers and inclinometers detect the movement over the threshold, the alarm and the loud speaker at the base station start ringing. At the same time, the warning SMS message is also sent from the base station to the registered phone numbers.

As only four numbers can be registered for each base station, the same warning SMS is sent to all other relevant personnel from the NBRO EWC server. The registered numbers for the base stations and NBRO EWC Server are the following numbers in the table.



Figure 38: Structure of Warning SMS sent from Base Station and NBRO Server

Since all the registered number should be updated whenever the responsible personnel from each organization is changed, it should be checked at a regular maintenance meeting lead by NBRO.

Table 17: Registered number for Warning SMS at Base Station 1 & 2 and NBRO EWC Server

| Registered numbers at Base Station 1 & 2 in Udapotha | | | |
|---|---------------------|--------------------------------|------------|
| NBRO EWC | | Dr. Wasantha | 0716874668 |
| NBRO Kegalle District office | | Ms.Nimali | 0773957880 |
| Emergency Community Committee (Chairman) | | Ven. Nilminigama Sumedha thero | 0775647787 |
| Neighbor | | Mr. MD. Sanjeewa Dilip Kumara | 0771357286 |
| Registered numbers at NBRO EWC | | | |
| DDMCU Kegalle | | E.W. Gabrel | 0757201952 |
| Bulathkohupitiya DS Division (Disaster Relief Officer) | | MD. Susil | 0711200567 |
| Emergency (Chairman) | Community Committee | Ven.Nilminigama Sumedha thero | 0775647787 |
| Emergency (Secretary) | Community Committee | M.D.P. Jayathilaka | 0779682810 |
| Emergency (Member) | Community Committee | K.W. Kanthi Ranaweera | 0769361577 |
| Emergency (Member)/ | Community Committee | HMSG Bandara | 0770636511 |
| | Udapotha GN officer | | |
| Emergency (Member) | Community Committee | EW Gabrel | 0757201952 |
| Emergency (Member) | Community Committee | MD. Susil | 0711200567 |
| Emergency (Member) | Community Committee | J. Anoma Jayalath | 0766635808 |

The warning message appears like the next figure. Awareness activities and evacuation drills utilizing the siren with cooperation of DDMCU Kegalle and Bulathkohupitiya DS division are essential for residents to effectively utilize the siren and warning SMS for evacuation.

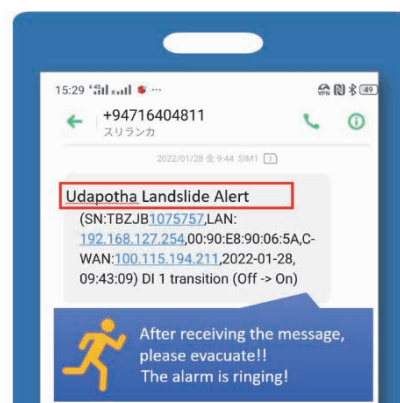


Figure 39: Example of Warning SMS message

Responsible person in maintenance

LRMS needs to be maintained with cooperation efforts among NBRO EWC, NBRO Kegalle District office and residents in Udapotha. Role of each actor is as described in the following figure. The responsible personnel of Udapotha residents are listed in the next table with their respective role.

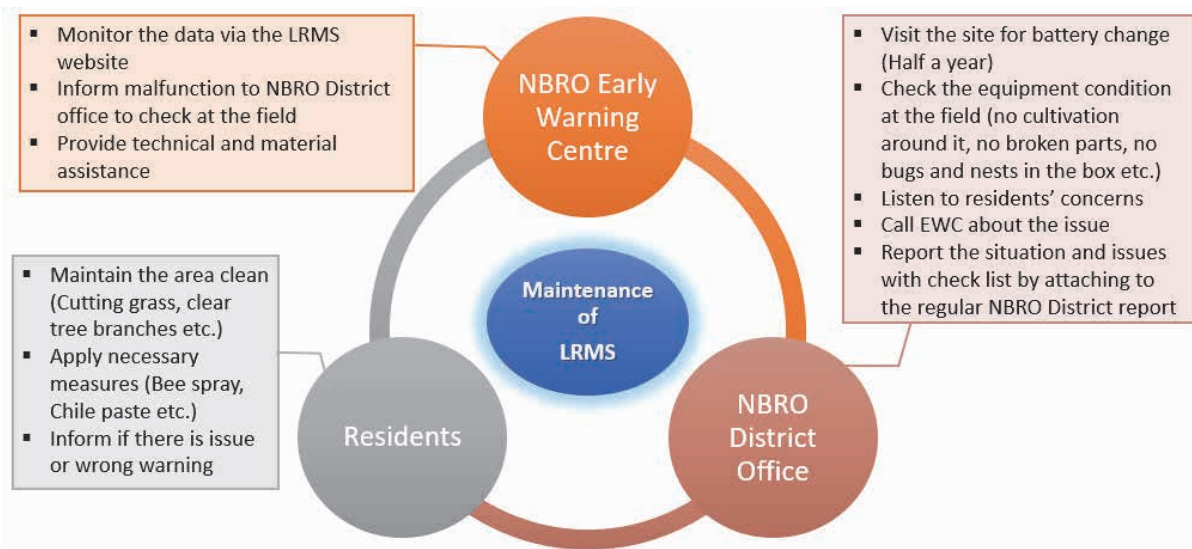


Figure 40: Role of each actor for LRMS maintenance

Table 18: Responsible personnel for LRMS maintenance from Udapotha residents

| Responsible personnel for LRMS maintenance from Udapotha residents | | | |
|--|-----------------------------------|---------------|-----------------------|
| XXXXXXXXXXXX | XXXXXXXXXXXX | XXXXXXX XX | Base Station 1 |
| Neighbor | Mr. M.D. Sanjeewa Dilip Kumara | 0771357286 | Key of Base Station 2 |

6.4. Securing Evacuation Place and Route

Evacuation places are designated on ahead. The evacuation places must be located outside of the Yellow/Red areas as well as other disaster risky areas. Safeness of evacuation routes shall be also considered when the evacuation places are designated. Information of the designated evacuation place, evacuation route and appointments are archived by DS division and DDMCU. Necessary appointments, such as generators, blankets and emergency provisions, shall be stored in the evacuation places.

The following issues regarding each evacuation centre are identified at the workshop with Udapotha community members on March 2022. When there is a heavy rain, some people cannot reach to the temple since streams are overflowing over the evacuation route. Therefore, residents feel that they do not have any safe location nearby to evacuate. There is also no proper land around the area to build a safe evacuation center. Safe evacuation centre and routes shall be discussed with DDMCU, NBRO and residents.

Table 19: Evacuation centres in Udapotha

| Evacuation centres in Udapotha | | | |
|--------------------------------|---------------------------|--------------|--|
| No | Place | Capacity | Issue |
| 1 | Keerthi Aramaya | 7 Households | Less sanitary facilities |
| 2 | Ke/ Thissa Primary School | 7 Households | The place is at sediment disaster risk |



Figure 41: Images of the evacuation centres in Udapotha

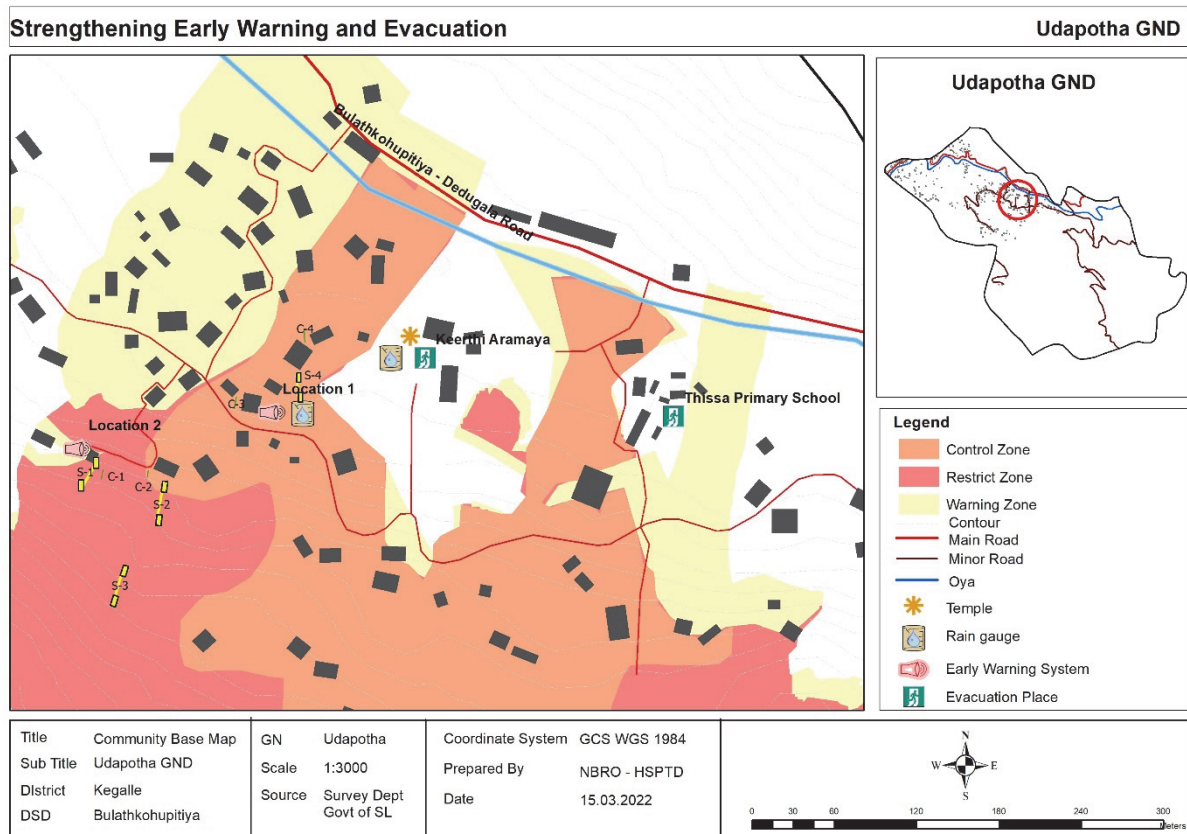


Figure 42: Location of the evacuation centres in Udapotha

6.5. Awareness Activity for EW

In Udapotha, no evacuation drills and awareness programs were held by NBRO and DDMCU. Smooth and timely warning dissemination from NBRO and GN officers to the local community through Emergency Community Committee shall be strengthened by the evacuation drill. In addition, as LRMS was installed in Udapotha, sounds of the alarm, receiving warning SMS, and actual evacuation procedure shall be notified to local people by the drill. Simultaneously, an awareness meeting was held to train local people to understand the meaning of landslide hazard maps, NBRO landslide early warning, LRMS equipment warning and necessary preparedness.

Necessary actions to strengthen early warning and evacuation are;

- Designation of safe evacuation places and routes considering landslide hazard maps with DDMCU and NBRO

- Procurement of necessary appointments in the evacuation places
- Awareness meeting and evacuation drill once a year to ensure the warning dissemination and evacuation



Management

7. Long-term Management Plan

7.1. Land use management plan

The Restricted zone and Control zone should be free from the settlements, and it has a high risk due to sediment disaster. The future land use plan should be aimed to convert the existing land uses such as rubber, homestead, and paddy in the Restricted and Control zone into forestry type land use categories. The settlements in the Yellow zone area should be strengthened by introducing resilient construction guidelines, and new developments should be encouraged in the development zones.

7.2. The land value management plan

The council should be posed to implement a land value management plan for the Udapotha area by producing legal by-laws. These by-laws should be including the following key Articles.

Article 1: Principles.

- Public interests in land are superior to private interests
- Land-uses shall be in accordance with uses appropriate to an area's natural, social, economic, and cultural conditions
- Speculative investments in land shall be restrained
- "Appropriate burdens" shall be placed on parties profiteering from increases in land prices

Article 2: Land price

- Limited and vital resource for citizens and forms a fundamental basis for citizen activities.
- Price of land affects trends in population, industry, land-use, social capital, and facilities, and can change social and economic conditions.
- Land prices affect the public interests.

Article 3: Land use plan should be area specific.

- Land-use must be in accordance with uses appropriate to an area's natural, social, economic, and cultural conditions.

Article 4: Speculative investments shall be restrained.

- Some authorities have interpreted "speculative investment" as buying for the sake of selling at a later date.
- purpose of controlling the land market for a purported public good.



8

Implementation

8. Implementation

8.1. Action Plan

The action plan specifies the activities and the activity budgets for implementation of land use plan, countermeasure facilities and strengthening early warning and evacuation system in the target area. The target years are also indicated with consideration of terms of PS councils. The main body of implementation is Bulathkohupitiya PS with supports of DS Divisional Secretariat, NBRO, DDMCU, UDA and other central agencies.

8.2. Role and Responsibilities of Concerned Agencies

The following figure shows interactions among LA, DS Divisional Secretariat, GN Division and NBRO in non-designated area by UDA. LA will revise the existing land use plan where land use plan was already developed or develop new land use plan where land use plan is not yet developed. Inputs such as disaster risk related information from NBRO and inputs such as community information from GN are provided to LA.

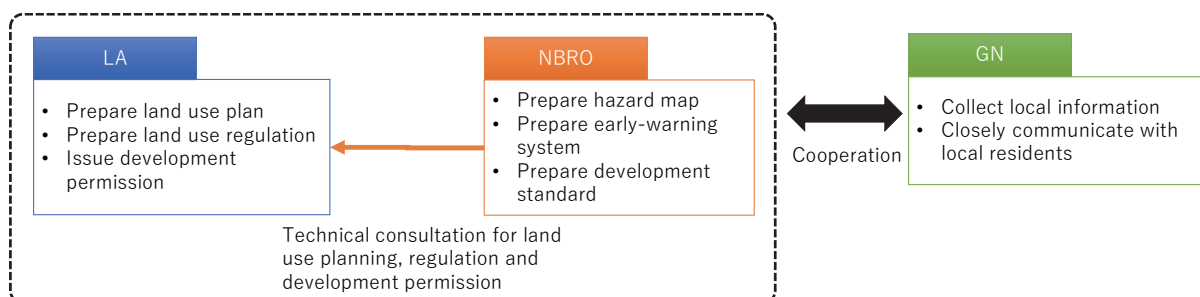


Figure 43: Interaction among LA, DSD, GND and NBRO

Roles & Responsibilities

Table 21: Roles & responsibilities

| Organization | Role and Responsibilities |
|-----------------------|--|
| NBRO | <ul style="list-style-type: none"> ▪ NBRO prepare the sediment disaster hazard map based on the Guideline for Disaster Resilient Land Use Regulation/Development Standards. The map shows red/yellow zone (or 4 zones). ▪ Regarding to land use in high-risk area, NBRO prepares development standard, which is explained in the Chapter 4. ▪ NBRO helps early warning and evacuation system in high-risk area. The early warning system includes installment of rain gauge, alarm, evacuation plan and disaster drill and education together with DDMCU ▪ NBRO provides consultation to LA for land use plan and land use regulation based on the hazard assessment in the planning area. ▪ NBRO provides consultation to the local authority for development permission in red and yellow zone. |
| LAs | <ul style="list-style-type: none"> ▪ LA prepares development plan including land use plan as designated in the Town and Country Planning Ordinance. It is recommended to take into account the hazard map and development regulation prepared by NBRO in this process. ▪ The local authority issues development permission based on the development plan prepared by LA. It is recommended to take into account the hazard map and development regulation prepared by NBRO. If the development plan does not incorporate enough consideration about disaster risk management, it is recommended to add further land use regulation based on the hazard map by bylaw. |
| Grama Niladari | <ul style="list-style-type: none"> ▪ Provision of data |

NBRO consultation menu

- Prepare hazard map
- Prepare early warning system
- Prepare development standard
- Inspect land use plan in the aspect of hazard and risk management
- Prepare draft land use plan
- Prepare land use plan and regulation in special projected area
- Hold workshop, seminar, etc. for local residences' understanding of hazard map and regulation
- Prepare evacuation plan

- Hold disaster drill and disaster education program for local people

LA

LA prepares development plan including land use plan as designated in the Town and Country Planning Ordinance. It is recommended to take into account the hazard map and development regulation prepared by NBRO in this process.

The local authority issues development permission based on the development plan prepared by LA. It is recommended to take into account the hazard map and development regulation prepared by NBRO. If the development plan does not incorporate enough consideration about disaster risk management, it is recommended to add further land use regulation based on the hazard map by bylaw.

GN

GN takes important role to collect information and facilitate understanding and communication with local people. As the hazard mapping is sensitive and influential to local people's life, it is important to have appropriate communication including workshop, seminar and inspection of hazard map between the relevant parties and public.

8.3. Monitoring

The monitoring and verification of the action plan is fully responsible of Badulla MC. Municipal council members will closely monitor the implementation of each item in the action plan, and necessary countermeasures will be taken by Bulathkohupitya Pradeshiya Sabha

Local Sediment Disaster Risk Reduction Plan



Weeriyapura

(Weeriyapura GN, Badulla MC, Badulla District)

“Creating Disaster Resilient Neighborhood in Weeriyapura



Weeriyapura

Local Sediment Disaster Risk Reduction Plan

Badulla Municipal Council

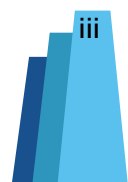
Towards the Disaster Resilient Neighborhood



Content

| | |
|--|-----------|
| List of Figures and Tables..... | 1 |
| Abbreviations and Acronyms | 3 |
| Executive Summary..... | 4 |
| Introduction | 5 |
| 1.1. Background | 6 |
| 1.2. Objectives | 6 |
| 1.3. Vision | 6 |
| 1.4. Target Users for the LSDRRP | 6 |
| Current Setting..... | 8 |
| 2. Current Setting of Weeriyapura..... | 9 |
| 2.1. General Information of Badulla MC..... | 9 |
| 2.2. General Information of Weeriyapura GND..... | 10 |
| 2.2.1. Geographic information..... | 10 |
| 2.2.2. Demographic Background | 10 |
| 2.2.3. Housing Conditions | 12 |
| 2.2.4. Essential Public Facilities..... | 12 |
| 2.2.5. Climate Condition | 14 |
| 2.2.6. Disaster Record..... | 16 |
| 2.2.7. Current Land Use | 16 |
| 2.2.8. Current Land Use with Yellow and Red Zone in the target area..... | 17 |
| 2.3. Concept of Yellow/Red Zone..... | 19 |
| 2.4. Categorized Zone based on Yellow/Red zoning and LHM..... | 20 |
| 1. Restricted Zone..... | 21 |
| 2. Controlled Zone | 21 |
| 3. Warning Zone | 22 |
| 4. Development Zone | 22 |
| 2.5. Approval and Enforcement of the Land Use Plan | 24 |
| 2.5.1. General conditions | 24 |
| Land use zoning..... | 25 |
| Risk Assessment..... | 25 |
| 3. Risk Assessment for Weeriyapura..... | 26 |
| 3.1. Database for Designated Yellow/Red Zones..... | 26 |

| | | |
|---|--|-----------|
| 3.2. | Preparation of Data for Risk Evaluation | 27 |
| 3.3. | Items for Risk Evaluation..... | 27 |
| 3.4. | Risk Evaluation Sheet for Yellow/Red Zone..... | 28 |
| Land use zoning | | 31 |
| 4. | Land Use Zoning Plan in Weeriyapura | 32 |
| 4.1. | Basic DRR Strategies for Weeriyapura..... | 34 |
| 4.2. | Statistics in Yellow and Red Zone | 34 |
| Structural Measures | | 37 |
| 5. | Structural Measures | 38 |
| 5.1. | Site 1 – A Debris Flow Red Zone | 38 |
| 1. | Hazard and Impacts | 38 |
| 2. | Suggested Structural Measures..... | 38 |
| 5.2. | Site 2 – A Debris Flow Red Zone | 39 |
| 1. | Hazard and Impacts | 39 |
| 2. | Suggested Structural Measures..... | 39 |
| 5.3. | Site 3 – A Slide Red Zone within the Weeriyapura Pilot Site..... | 40 |
| 1. | Hazard and Impacts | 40 |
| 2. | Suggested Structural Measures..... | 40 |
| 5.4. | Site 4 – A Slide Red Zone within the Weeriyapura Pilot Site..... | 41 |
| 1. | Hazard and Impacts | 41 |
| 2. | Suggested Structural Measures..... | 41 |
| 5.5. | Current issues in hazard area and required structure and non-structure measures..... | 47 |
| Strengthening Early Warning and Evacuation | | 49 |
| 6. | NBRO Landslide Early Warning..... | 50 |
| 6.1. | NBRO Early Warning Communication Channel in Weeriyapura..... | 52 |
| 6.2. | Emergency Community Committee in Weeriyapura..... | 52 |
| 6.3. | Installed Landslide Remote Monitoring System and EW equipment..... | 53 |
| 6.4. | Securing Evacuation Place and Route..... | 59 |
| 6.5. | Awareness Activity for EW..... | 60 |
| Management plan | | 61 |
| 7. | Long-term management plan | 62 |
| 7.1. | Land use management plan | 62 |
| 7.2. | The land value management plan..... | 62 |
| Implementation | | 63 |



| | |
|---|----|
| 8. Implementation | 64 |
| 8.1. Action Plan | 64 |
| 8.2. Role and Responsibilities of Concerned Agencies..... | 66 |
| 8.3. Monitoring and Verification | 67 |

List of Figures and Tables

List of Figure

| | |
|---|----|
| Figure 1: Location Map..... | 10 |
| Figure 2: Ward Map of Badulla MC | 11 |
| Figure 3: Gender Composition in Weeriyapura GN | 12 |
| Figure 4: Gender Composition in Weeriyapura Target area | 12 |
| Figure 5: Population pyramid in Weeriyapura Project Site | 12 |
| Figure 6: People who need assistance for evacuation | 13 |
| Figure 7: Reason to live at Weeriyapura and Surrounding | 13 |
| Figure 8: Locations of Public facilities..... | 14 |
| Figure 9: Rainfall Distribution | 15 |
| Figure 10: Temperation Variation..... | 11 |
| Figure 11: Current Land use percentage in Weeriyapura area | 12 |
| Figure 12: Current Land use Plan | 19 |
| Figure 13: Yellow/Red Zone for Slide | 20 |
| Figure 14: Yellow Zone and Red zone for Slope Failure..... | 21 |
| Figure 15: Yellow Zone and Red Zone for debris flow..... | 21 |
| Figure 16: Zoning Plan | 24 |
| Figure 17 Concept of Risk Evaluation for the Target Yellow/Red Zone (for Debris Flow) | 29 |
| Figure 18 Filled Risk assesment sheet for debris flow patch in Weeriyapura..... | 29 |
| Figure 19 Risk Evaluation Map of Weeriyapura..... | 31 |
| Figure 20: Landuse Plan..... | 33 |
| Figure 21: Land use Zoning Plan | 34 |
| Figure 22: Building Statistics of Udapotha..... | 37 |
| Figure 23: Location of the Selected Red Zones for Conceptually Planning Structural Measures | 43 |
| Figure 24: Conceptual Illustration of Non-permeable Sabo Dam..... | 44 |
| Figure 25: Typical Layout of Horizontal Drain Holes..... | 44 |
| Figure 26: Layout of the Planned Structural Measures for Site 1 in the Weeriyapura Pilot Site | 45 |
| Figure 27: Layout of the Planned Structural Measures for Site 2 in the Weeriyapura Pilot Site | 46 |
| Figure 28: Layout of the Planned Structural Measures for Site 3 in the Weeriyapura Pilot Site | 47 |
| Figure 29: Layout of the Planned Structural Measures for Site 4 in the Weeriyapura Pilot Site | 48 |
| Figure 30: Cause of Landslide and Soil Water Index..... | 51 |
| Figure 31: Dissemination flow of NBRO Landslide Early Warning and Evacuation Order..... | 52 |
| Figure 32: Contact information and the dissemination flow of NBRO Landslide Early Warning in Weeriyapura..... | 53 |
| Figure 33: Main equipment of Landslide Remote Monitoring System (LRMS) | 54 |
| Figure 34: Locational image of extensometer and multi-point Inclinomter..... | 54 |
| Figure 35: Location and warning image of LRMS..... | 54 |
| Figure 36: Location of extensometers and multi-point inclinometers in Weeriyapura (Overview)..... | 55 |
| Figure 37: Location of extensometers and multi-point inclinometers in Weeriyapura (Overview)..... | 56 |
| Figure 38: Location and image of installed extensometers and multi-point inclinometers in Weeriyapura | |

| | |
|---|----|
| (Overview)..... | 57 |
| Figure 39: Structure of Warning SMS sent from Base Station and NBRO Server..... | 57 |
| Figure 40: Example of Warning SMS message..... | 59 |
| Figure 41: Role of each actor for LRMS maintenance..... | 59 |
| Figure 42: Map indicating evacuation places in Weeriyapura area..... | 60 |
| Figure 43: Interaction among LA, DSD, GND and NBRO..... | 67 |

List of Table

| | |
|--|----|
| Table 1: Monthly Average Rainfall Distribution..... | 15 |
| Table 2: Annual Temperature..... | 16 |
| Table 3: Land use types..... | 17 |
| Table 4: Slide block Classification..... | 20 |
| Table 5: Relevance with LHM and Yellow/Red zone categories..... | 22 |
| Table 6: Allowed and not allowed uses to the area..... | 25 |
| Table 7: Items for Database for Designated Yellow/Red Zone..... | 27 |
| Table 8: Items and Scores for Risk Evaluation for Yellow/Red Zone..... | 28 |
| Table 9 Classification of Risk Level..... | 30 |
| Table 10: Statistics in Yellow and Red zone..... | 36 |
| Table 11: Summary of the Suggested Structural Measures at Site 1..... | 40 |
| Table 12: Summary of the Suggested Structural Measures at Site 2..... | 40 |
| Table 13: Summary of the Suggested Structural Measures at Site 3..... | 41 |
| Table 14: Summary of the Suggested Structural Measures at Site 4..... | 42 |
| Table 15: NBRO Landslide Early Warning Criteria and actions to take..... | 51 |
| Table 16: Members of Emergency Community Committee in Udapotha..... | 53 |
| Table 17: Registered number for Warning SMS at Base Station 1 & 2 and NBRO EWC Server..... | 57 |
| Table 18: Responsible personnel for LRMS maintenance from Udapotha residents..... | 59 |
| Table 19: Roles and responsibilities..... | 67 |

Abbreviations and Acronyms

DS-Divisional Secretariat

DDMCU- District Disaster Management Coordinating Unit

DMC- Disaster Management Center

GN- Grama Niladhari

JICA-Japan International Cooperation Agency

LHM- Land Hazard Map

LSDRRP- Local Sediment Disaster Risk Reduction Plan

LUPPD- Land Use Policy Planning Department

LA- Local Authority

NBRO- National Building Research Organisation

NPPD- National Physical Planning Department

PS-Pradeshiya Saba

UDA-Urban Development Authorities

Executive Summary

The Technical Corporation for Landslide Mitigation Project (TCLMP) was initiated in 2014, and the second phase of the project (SABO) was started after completing phase one in 2016. Phase one, TCLMP, was focused on structural measurement, and SABO was focused on non-structural measurements. NBRO initiative to develop this plan as a part of the Project for Capacity Strengthen on Development of Non-structural Measures for Landslide Risk Reduction in Sri Lanka (SABO), a technical cooperation project between NBRO and Japan International Cooperation Agency (JICA).

The SABO project was implemented in three pilot sites in Sri Lanka, Morawakakanda in Matara, Weeriyapura in Badulla and Udapothe in Kegalle. The project has three main outputs: demarcation of the landslide flow-path boundaries using the Yellow-Zone-Red-Zone method, development of landslide early warning threshold levels, and development of land-use guidelines for the sediment disaster-prone areas.

The Sediment Disaster can be identified as one of the severe disasters in Sri Lanka because of intensive rainfall and human interventions. In this circumstance, there is a need for a proper landslide management plan to secure the community and human properties in sediment disaster areas. The Local Sediment Disaster Risk Reduction Plan (LSDRRP) is a comprehensive site-specific plan that focuses on the local level to minimize the impact of sediment disasters by using structural and non-structural mitigations.

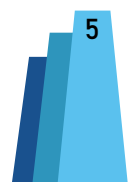
This LSDRRP plan comprises the landslide hazard-prone areas, landslide flow based on the Yellow zone and Red zone concept, land use zoning in the area, and actions taken for the risk reduction. The report also included the current risk status of the community and the existing landslide early warning mechanism.

NBRO consulted Badulla MC, Divisional Secretariat, and residents in Weeriyapura during the preparation of the zoning plan. The project report was shared with the relevant stakeholders to bring their feedback to the plan.

This LSDRRP for Weeriyapura is owned by Badulla Municipal Council (MC). MC will take action with the cooperation of relevant agencies such as Badulla Divisional Secretariat, District Disaster Management Coordinating Unit (DDMCU), and National Building Research Organization (NBRO) in Badulla District to mitigate sediment disaster risk according to the action plan written in Section 6.



Introduction



1. Introduction

1.1. Background

Sediment Disaster is one of the most severe natural disasters in Sri Lanka. In the central and southern mountainous areas, sediment disasters such as slope failures, landslides, and debris flow frequently occur in the monsoon period because of the fragile geology and steep topography. In recent years, sediment disasters caused by heavy rainfall in the spring monsoon season have become severer. In addition, increasing exposure to the hazards due to rapid reclamation and development has been raising sediment disaster risks in urban and rural areas. The establishment and improvement of the early warning system and legal arrangement for land use planning and development standards are urgent issues in Sri Lanka.

Weeriyapura is a major landslide susceptible GN in Badulla district. It is essential to identify landslide susceptible locations and predict the probability of occurrence of each. Disaster risk assessments, early warning systems, and land use planning which considers disaster risk are required to mitigate future sediment disaster risk in the country. The Project of “Capacity Strengthening on Development of Non-structural Measures for Landslide Risk Reduction in Sri Lanka” was set up between National Building Research Organization (NBRO) and Japan International Cooperation Agency (JICA). The project aims at strengthening the capacity of NBRO on non-structural measures such as sediment disaster risk assessments, improving early warning systems using existing observation networks, and land use and development standards.

Local Sediment Disaster Risk Reduction Plan (LSDRRP) is a comprehensive plan to promote sediment disaster risk reduction measures at the local level, including non-structural measures developed based on site-specific sediment disaster risk assessment. The LSDRRP also clarifies the role and responsibility of the local organizations.

1.2. Objectives

The objectives of LSDRRP are as follows;

- Reduce landslide vulnerability old landslide valley of Weeriyapura
- Introduce non-structural landslide DRR measures
- Optimum utilization of lands prone to landslide hazard
- Zero the life damages and minimize the casualties due to landslides
- Minimize the economic damage

1.3. Vision

The vision of LSDRRP is;

“Creating A Disaster Resilient-Neighborhood in Weeriyapura”

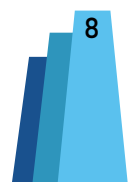
1.4. Target Users for the LSDRRP

This LSDRRP belongs to Badulla MC. MC takes actions with cooperation of relevant agencies such as Badulla Divisional Secretariat, District Disaster Management Coordinating Unit (DDMCU), National Building Research Organization (NBRO) in Kegalle District to mitigate sediment disaster risk according to the action plan written in Section 6. In addition, as this plan includes a land use plan considering sediment disaster risk, the primary target users of the LSDRRP are the practitioners of land use planning and development control

of both the national government and local government, including the officials of Badulla PS, Urban Development Authority (UDA), National Physical Planning Department (NPPD), Land Use Policy Planning Department (LUPPD), and NBRO.



Current Setting



2. Current Setting of Weeriyapura

2.1. General Information of Badulla MC

Weeriyapura is a part of Hingurugamuwa Grama Niladari (GN), located southeastern boundary of the Badulla Municipal Council (MC). Badulla MC is located in the middle of Badulla District and it belongs to UDA declare area. The administrative territory of Badulla MC is about 1,065.6 ha. The population of Badulla MC is 54,000 and the population density of the Badulla MC is 746 person/ha. (Source: Badulla MC). According to the Census and statistics data (2012), majority of female population is recorded in all age groups in Badulla MC Limits, where as 46.9% are male and 53.1% are female from total population. Population who can be considered as the labour force is potentially high in the area.

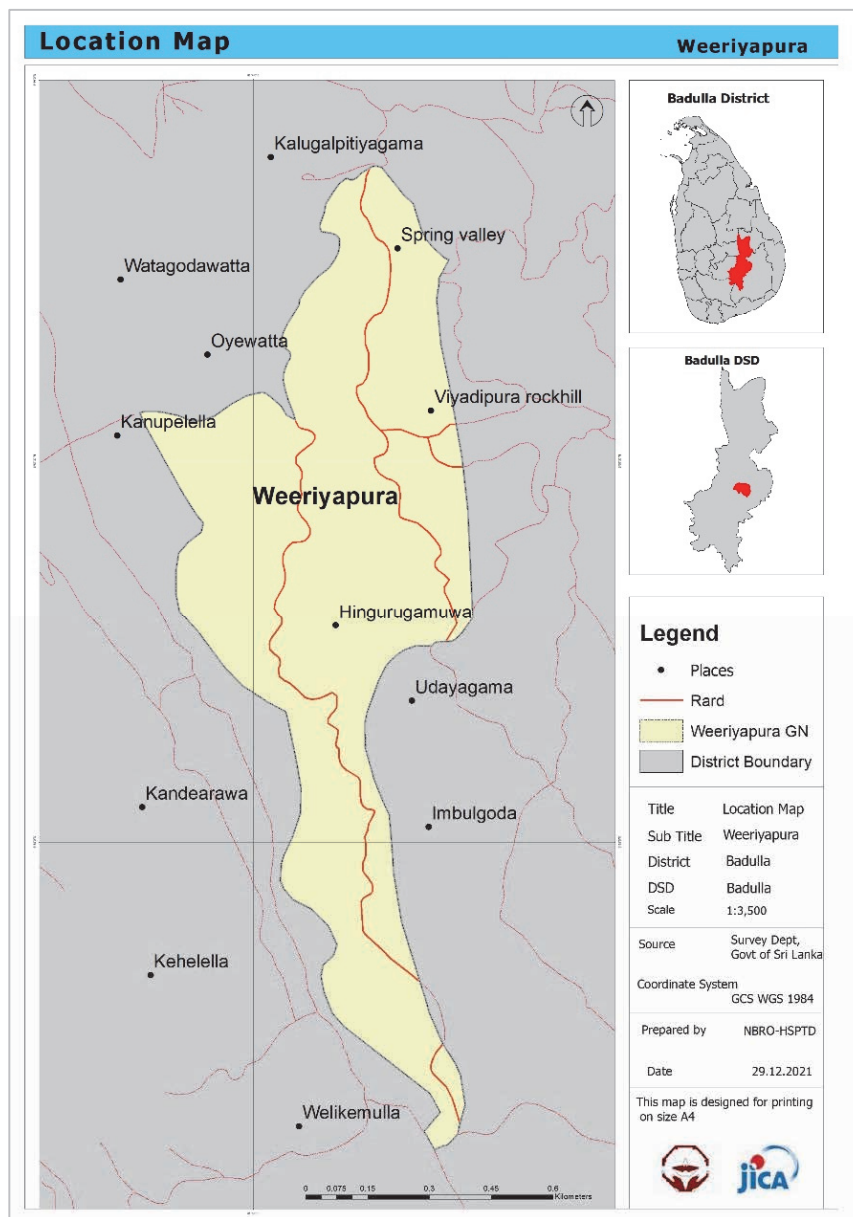


Figure 1: Location map

2.2. General Information of Weeriyapura GND

2.2.1. Geographic information

Weeriyapura is located in the hill area of the Badulla MC with 666 meters/ 2185.04 feet.

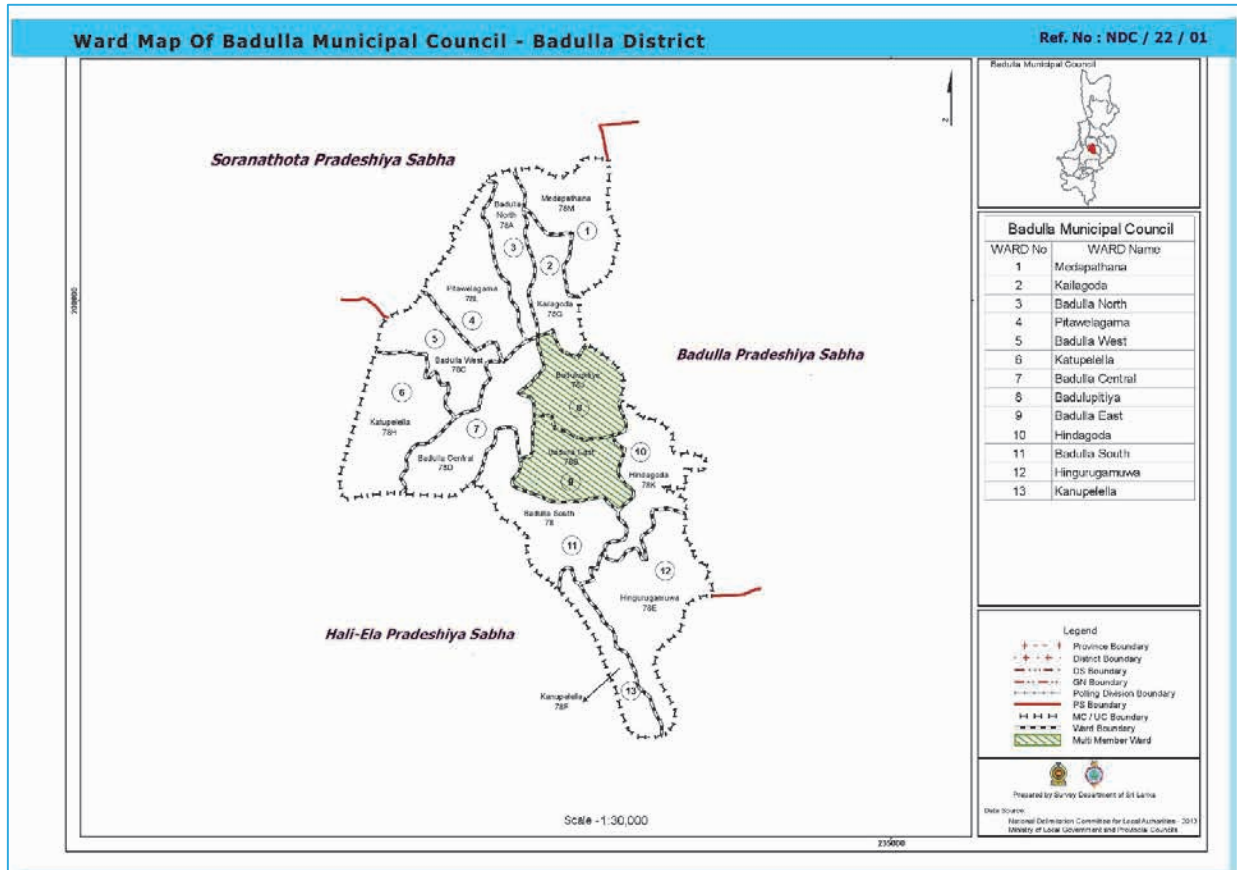


Figure 2: Ward map of Badulla MC

2.2.2. Demographic Background

The population of Weeriyapura GN was 2,851 in 2012. The Male population and female population are 1,366, 1,485 respectively. Population Density is sixteen persons per square Kilometer, and building density is sixteen per square Kilometer.

There are 371 population living in the project area. Among them, 186 are Male, and 185 are Female.

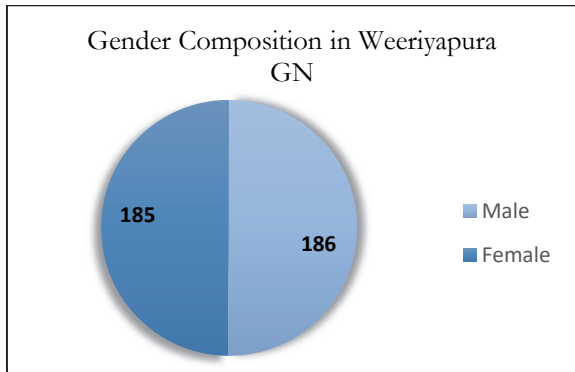


Figure 3: Gender composition in Weeriyapura

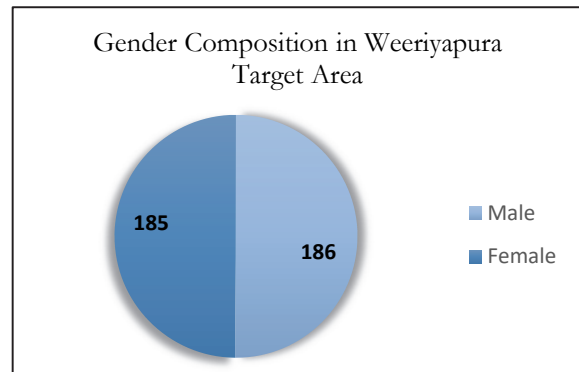


Figure 4: Gender composition in Weeriyapura target area

The age category of the Weeriyapura area is distributed as figure 5. 253 (68%) people are fallen under the labour force age (15-64) group, and the dependency (<15 and >64) population are 118 (32%). The working people need to tolerate the damage cost along with the cost of dependent people.

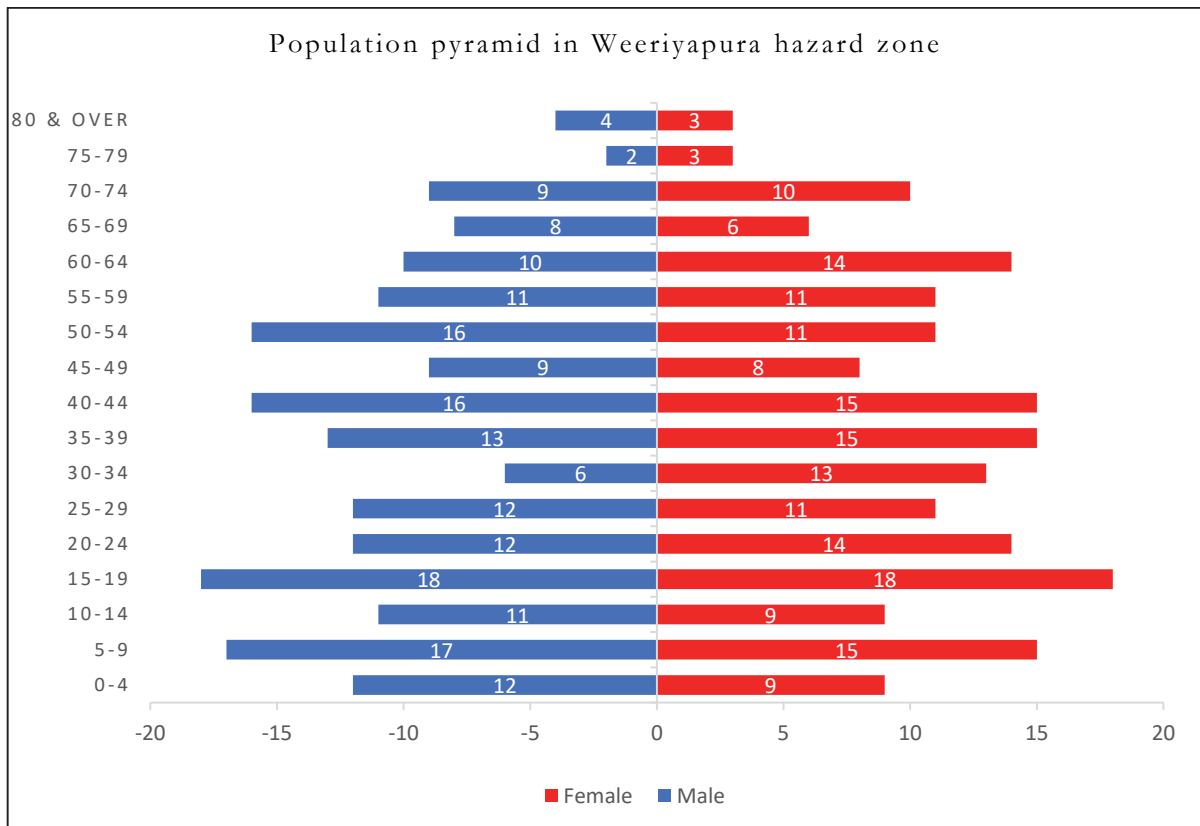


Figure 5: Population pyramid in Weeriyapura hazard zone

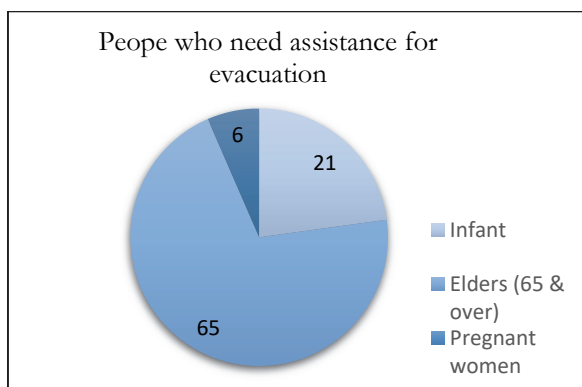


Figure 6: People who need assistance for evacuation

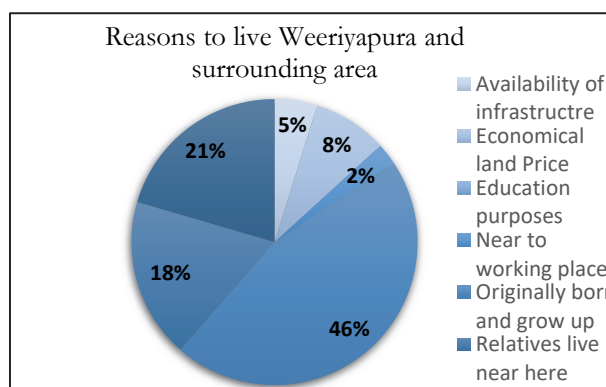


Figure 7: Reasons to live Weeriyapura and surrounding

Specifically, the people who are need assistance to evacuate in terms of existing population in Weeriyapura and surrounding area (65 people) are elders (The persons who are age 65 and above) and 21 people are infants (The person who are age 5 and under). Only 6 people are Handicap.

The majority of the family, 38 (46%), were born and grown up in the project area. The reason behind remaining the communities in the landslide high-risk area may be the adjoining town centers providing adequate services and facilities to the community. 21% of responses to availability of infrastructure in the area provide evidence for that.

2.2.3. Housing Conditions

Weeriyapura GN consisted of 753 housing units (2012 Census & Statistic Survey), and out of these, 643 are permanent dwellings, 103 are semi-permanents and 7 housing units are improvised. There are thirty-eight housing units in the yellow zone and two houses are in red zone area. All these housing units are constructed by using permanent materials.

2.2.4. Essential Public Facilities

The following table shows the public facilities exist in Weeriyapura area. Location of those facilities are shown in Figure 8.

| | |
|------------------|--|
| School | Sirisumana Maha Vidhyalaya |
| Institutions | District secretariat Badulla |
| Health center | Provincial general hospital |
| Police station | Badulla police station |
| Higher education | Uva wellassa university/ District vocational training center |
| Transportation | Railway station Badulla |
| Playground | Hingurugamuwa playground |

Public Facilities

Weeriyapura Area

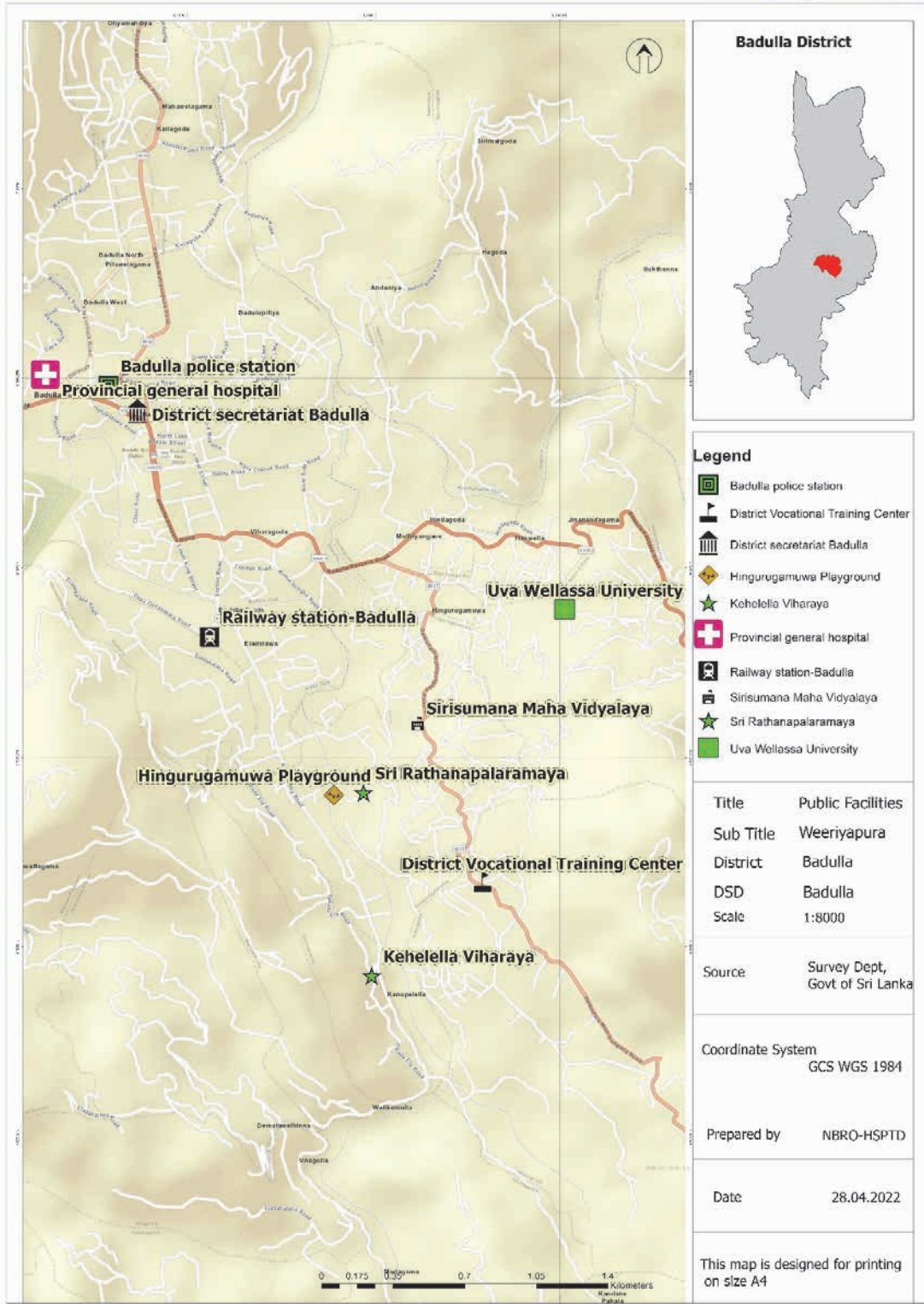


Figure 8: Public facilities

2.2.5. Climate Condition

Rainfall pattern

Weeriyapura is located at an intermediate climate zone of the country. There is significant rainfall in most months of the year and annual average rainfall is around 1723mm.

The below table shows the monthly rainfall variation in the Weeriyapura surrounding area.

Table 1: Monthly rainfall distribution

| Month | Rainfall (mm) |
|-----------|---------------|
| January | 139 |
| February | 94 |
| March | 88 |
| April | 169 |
| May | 141 |
| June | 54 |
| July | 52 |
| August | 74 |
| September | 130 |
| October | 280 |
| November | 279 |
| December | 223 |

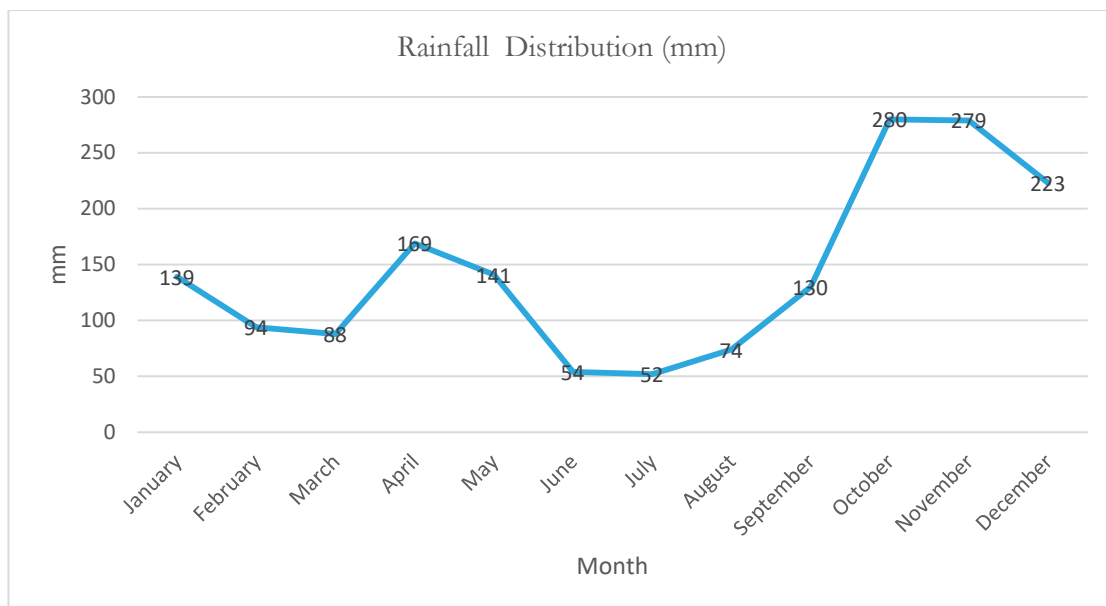


Figure 9: Rainfall distribution

The above figure shows the rainfall distribution in the Weeriyapura. The results show the highest average rainfall received to the area is in October and November, during the southwest monsoon period, and the lowest rainfall received in June and July.

Temperature

The average annual temperature of the area is 24.1°C. The highest average monthly temperature is usually recorded during July, which is around 29°C. The lowest average monthly temperature of the year is encountered during January and December, which is around 23.5°C -23.6°C. Below table 2 shows the average, minimum and maximum monthly temperatures for each month in Badulla.

Table 2: Annual temperature

| Month | Temperature (Celsius) | | |
|-----------|-----------------------|---------|---------|
| | Minimum | Average | Maximum |
| January | 17.3 | 20.1 | 23.5 |
| February | 17.4 | 20.7 | 24.5 |
| March | 17.9 | 21.9 | 26.3 |
| April | 19.1 | 22.7 | 26.9 |
| May | 20.2 | 23.7 | 28.2 |
| June | 20.2 | 24 | 28.7 |
| July | 20.2 | 24.1 | 29 |
| August | 19.9 | 23.8 | 28.7 |
| September | 19.8 | 23.4 | 28.3 |
| October | 19.1 | 22.1 | 26.3 |
| November | 18.6 | 21.1 | 24.4 |
| December | 18.1 | 20.5 | 23.6 |

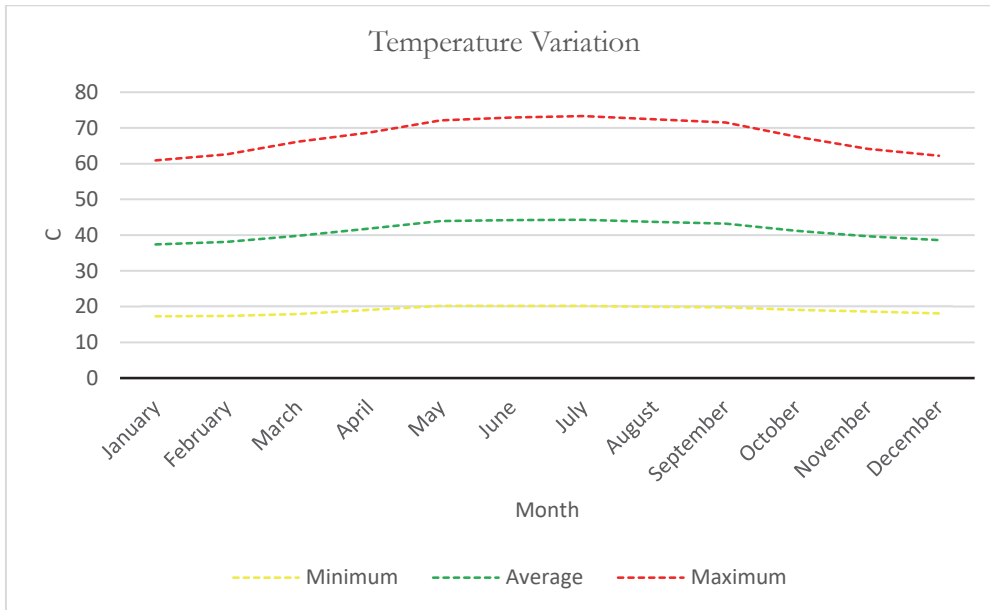


Figure 10: Temperature variation of the area

2.2.6. Disaster Record

There is no previously occurred disaster in project area.

2.2.7. Current Land Use

The area statistics are shown in Table 3. The major Land use types in Weeriyapura area are Tea, Homestead, and Scrub.

Table 3: Land use types

| Land use Type | Area (m2) |
|---------------|-----------|
| Homestead | 11611 |
| Paddy | 2618 |
| Playground | 38 |
| Rock | 921 |
| Scrub | 4013 |
| Steam | 410 |
| Tea | 19721 |

The above chart shows the amount of distribution of land uses in the Weeriyapura GN division. The mountain area is covered with forest lands, and downstream areas are covered with home gardens 29%. Major agriculture types are tea 49.3% and paddy 7.3%.

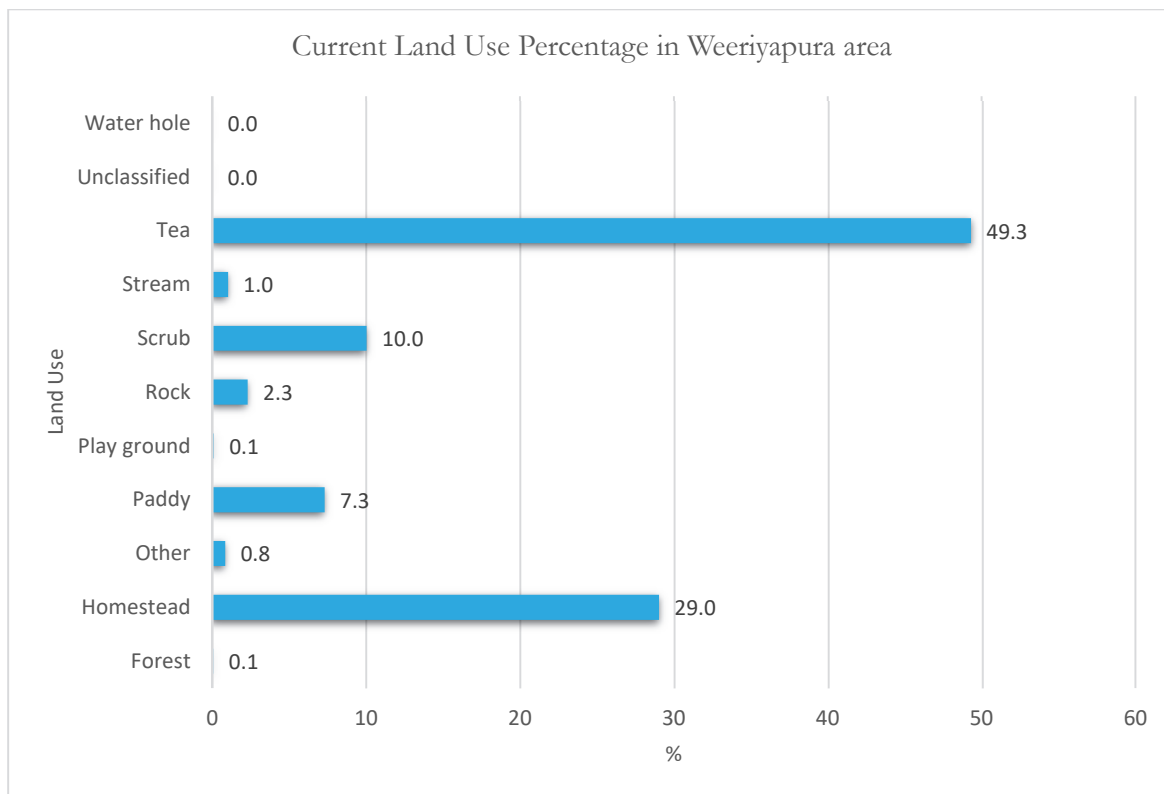


Figure 11: Current land use percentage in Weeriyapura area

2.2.8. Current Land Use with Yellow and Red Zone in the target area

An updated land-use map was prepared using aerial image interpretation captured through drone technology in 2020 by NBRO. The aerial image was classified according to the existing land use classification system used for landslide risk mapping and generated a 1:1000 land use map for the project area. These high-resolution images help to identify the detail various of the ground, and it helps identify the exact building shapes and sizes. The black squares represent the existing building layer, and small buildings were located adjoining to the forest area. Larger-size buildings are located near the main roads, and building density is also higher near the road. The map highlighted the existing landslide flow path and marked the possible landslide debris flow paths generated through the yellow-red zone method described in the next section.

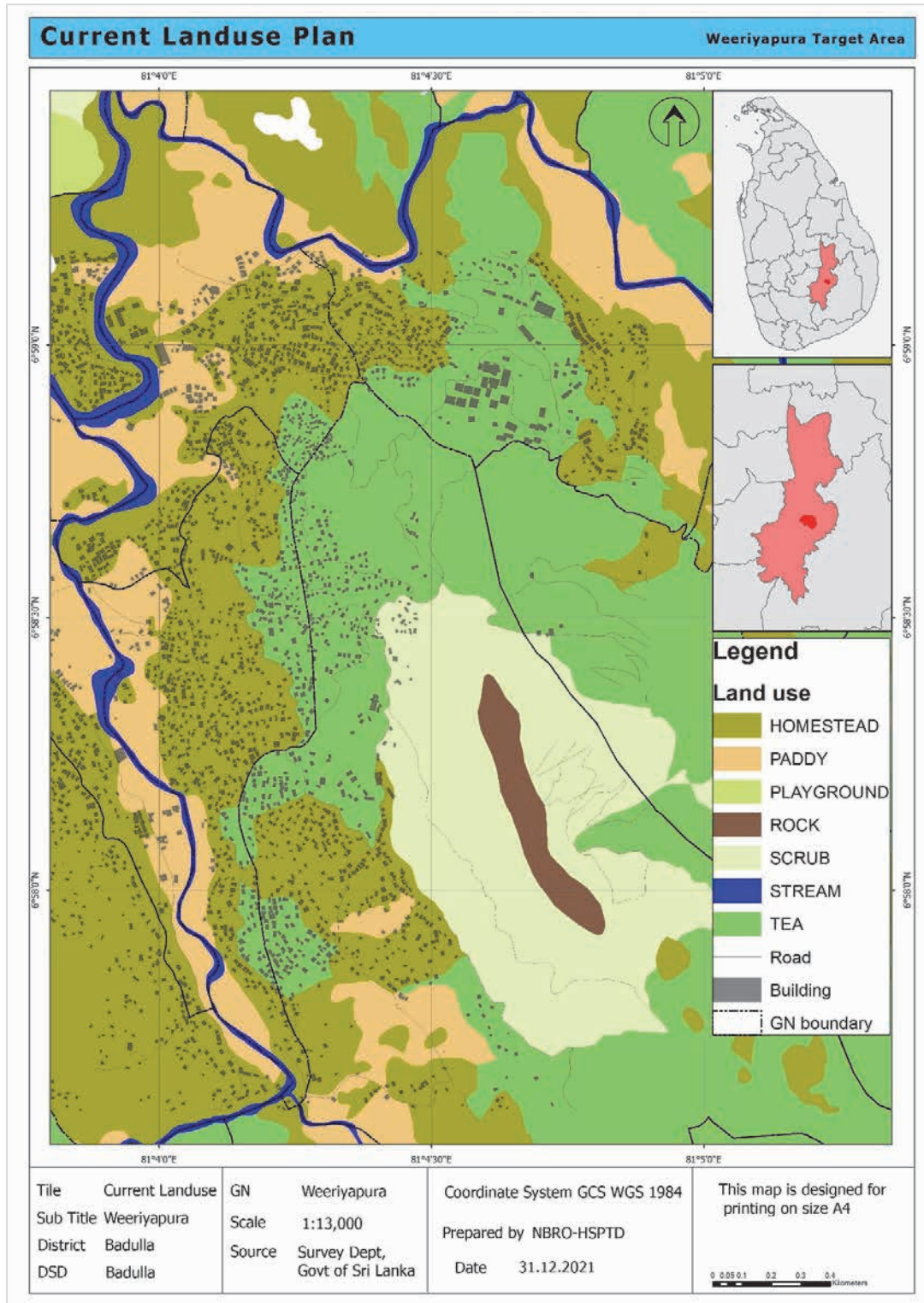


Figure 12: Current land use plan

2.3. Concept of Yellow/Red Zone

Sediment Disaster Hazard Area (Yellow Zone) is defined as an area prone to sediment disaster. If an area is designated as a Yellow Zone: 1) early warning systems should be established, and 2) steps to raise the awareness of local people about sediment disasters should be taken. Special Sediment Disaster Hazard Area (Red Zone) is designated where there is a severe risk of damage to buildings and threat to residents; thus, structural and non-structural measures, including development regulation, should be applied based on the appropriate land use planning.

2.3.1. Yellow/Red Zone for Slide

Slide blocks are classified into three ranks, A, B and C, in terms of the clarity of slide topography and its activity based on the topographical interpretation. These ranks are defined and shown in the following table

Table 4: Classification of ranks

| Classification of Ranks | Definition |
|-------------------------|--|
| Rank A | The slide is confirmed to be completely active at the field survey; and Its shape, including its foot, is identifiable. |
| Rank B | The shape of the slide, including its foot, is identifiable, but the slide is not confirmed to be active at the field survey; or The slide is confirmed to be locally active, and its shape is not identifiable. |
| Rank C | The slide is not confirmed to be active at the field survey, and also its shape, including its foot, is not identifiable. |

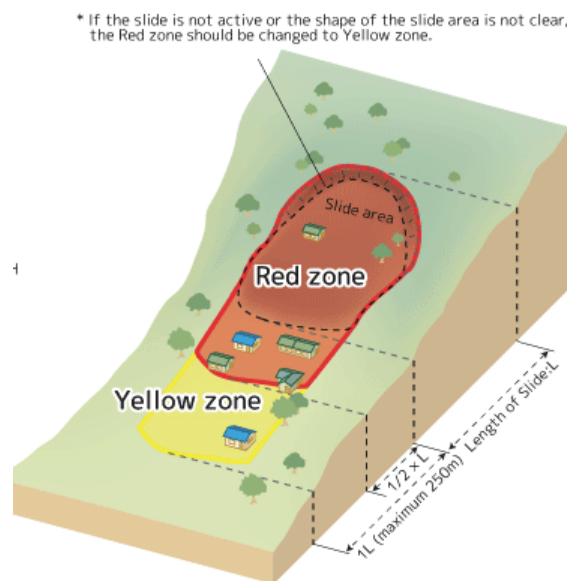


Figure 13: Yellow/red zone for slide

2.3.2. Yellow Zone and Red Zone for Slope Failure

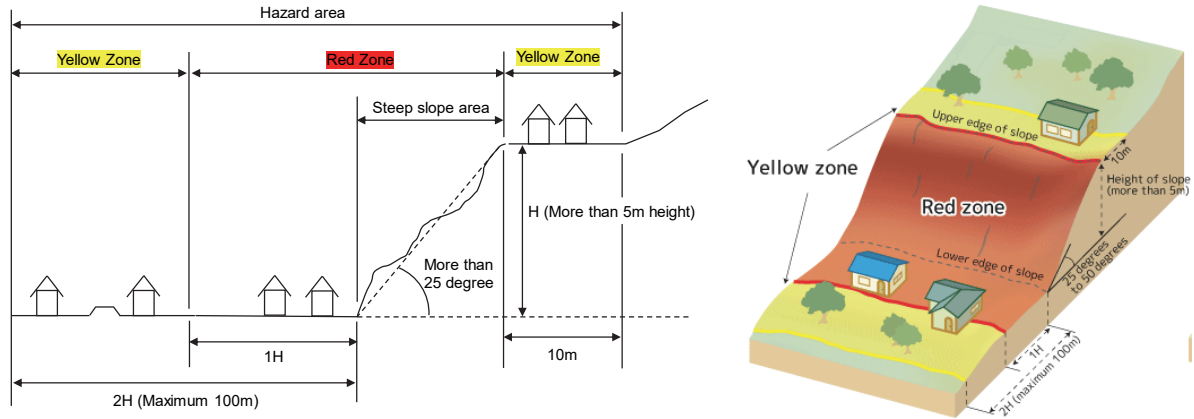


Figure 14: Yellow/red zone for slope failure

2.3.3. Yellow Zone and Red Zone for Debris Flow

The lower ends of the Yellow Zone and Red Zone for debris flow shall be determined based on the ground gradient or inclination from the profile of the target area. In addition, the width of the zone shall be determined based on spreading angles such as 30 degrees for Yellow Zone or 15 degrees for Red Zone. The concept of setting the Yellow Zone or Red Zone for debris flow is shown in the following figure.

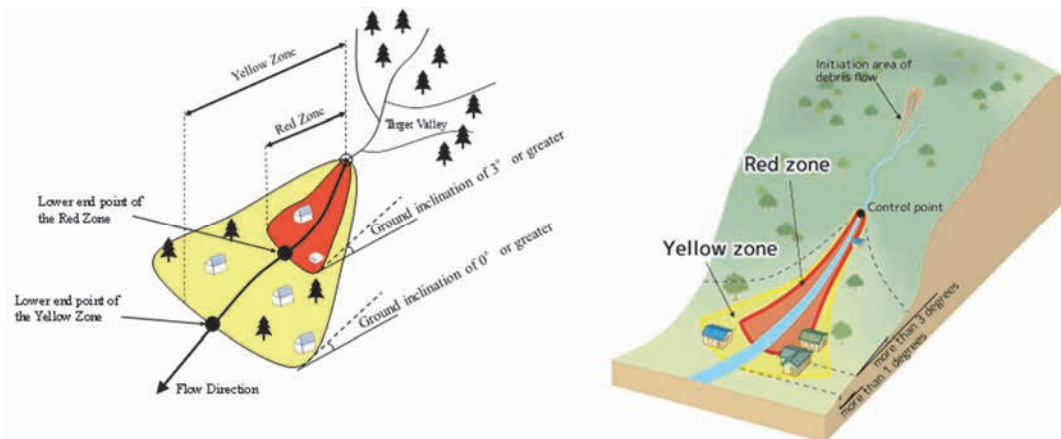


Figure 15: Yellow/red zone for debris flow

2.4. Categorized Zone based on Yellow/Red zoning and LHM

NBRO has developed and distributed Landslide Hazard Map (LHM), in which the area is divided into main four categories; “Landslide not likely to be occurred”, “Modest level landslide risk exists”, “Landslide risk might be existing” and “Landslide can be occurred”. There are fewer restrictions on “Landslide not likely to be occurred” areas, but in other zones, specific construction and structural guidelines need to be followed. However, due to the haphazard planning activities of the country, most of the landslide-prone categories consists of settlements.

The current hazard mapping activities do not consider the debris flow simulations. Therefore, possible debris flow areas are required to identify to incorporate the existing development guidelines. Accordingly, NBRO introduced a new Yellow/Red zone mapping concept for the area to simulate the landslide flow paths. In the concept, more detailed and site-specific hazard risk levels can be indicated to promote appropriate land use. The Yellow/Red zone concept has four zones, “Restricted Zone”, “Prohibited Zone”, “Warning Zone” and “Development Zone”, which is similar classification with the flood-resilient guideline published by NBRO in 2003. The concept is only applied for the debris flow area, and the rest of the area is followed by the Landslide Hazard Map-based land-use guidelines. The following table shows the yellow/red zone and present LHM categories correlated with development zone categories.

Table 5: Categorized zones based on yellow/red and LHM

| Development Zone Category | Yellow/Red Zoning (applied for the Y/R zoning prepared area) | Landslide Hazard Map (applied for the remaining area) |
|---------------------------|--|---|
| Restricted Zone | Red Zone (Sediment Disaster Hazard Area) | Landslides most likely to occur |
| Controlled Zone | | Landslides are to be expected |
| Warning Zone | Yellow Zone (Special Sediment Disaster Hazard Area) | Modest level of landslide hazard exists |
| Development Zone | Else | Landslide not likely occur |

1. Restricted Zone

The “Restricted Zone” is assigned for the lands identified as “Red Zone” and ranked in “Landslides most likely to occur (HR)” in LHM. Any construction or any development shall be prohibited in the zone and the zone is high probability for future landslide events. If any constructions are available in this zone should be relocated, with proper investigations. This land area should be kept as natural areas and required to monitor the environmental condition, water flow and hazard situation in detail manner. In future, this area shall be demarcated as sensitive area and control all kind of human impacts for the area. Landslide flow path area also considered into this zone and considering the feasibility studies, the land should be converted as green area for the settlement. It is required to have detail investigations and proper early warning systems for upper catchments before converting the area as green area.

Currently, the land use types in the Restrict zone are Scrub, tea and rock. The future land use plan should be aimed to convert the existing land uses in the Restricted zone into forestry type land use categories.

2. Controlled Zone

The “Controlled Zone” is assigned for the lands identified as “Red Zone” and ranked in “Landslides are to be expected (HR)” in LHM. This zone is considered as high-risk zone due to landslide events. The area could be used for the low dense controlled development activities. In addition, this area should have proper early warning system. Detail building codes and designed should be followed by the developers in the area and if any construction didn’t follow the proper guideline, the authority shall be reported to the proper planning agencies to remove such construction by considering its’ impact to the area.

Currently, the land use types in the control zone are Tea and homestead. The future land use plan should be aimed to convert the existing land uses in the control zone to promote agricultural activities which are manage water.

3. Warning Zone

The “Warning Zone” is assigned for the lands identified as “Yellow Zone”. Development activities are allowed in this zone, but need to follow the resilient construction guideline which was published by the NBRO. This zone can have different building densities depending on the risk levels. However, entire zone should have proper early warning system and continuous awareness programs for the commuters and residents. Controlled land uses are allowed in the zone and management plan of each land uses should be monitored by the respective institutes.

Currently, the land use types in the warning zone are Tea, paddy and homestead. In the future, It is suitable for any agriculture activities as well as to establish new residential also.

4. Development Zone

The “Development Zone” is assigned for the lands which are not identified as either Yellow zone or Red zone. This zone is demarcated by considering the importance of development and hazard levels. This zone can be used to develop any kind of constructions, but it should be adhered to the guidelines which are provided by the planning agencies like UDA, NPPD, etc. No resilient construction techniques are mandated for the zone, unless, if disaster management professionals were identified as disaster impacted area. If so, the retrofitting guidelines should be adhered for the constructions.

Based on this, the land area could be divided into main four sections and each section should be clearly monitored by the institute. Furthermore, these main zones could be divided into sub categories by considering the hazard zones and development zone.

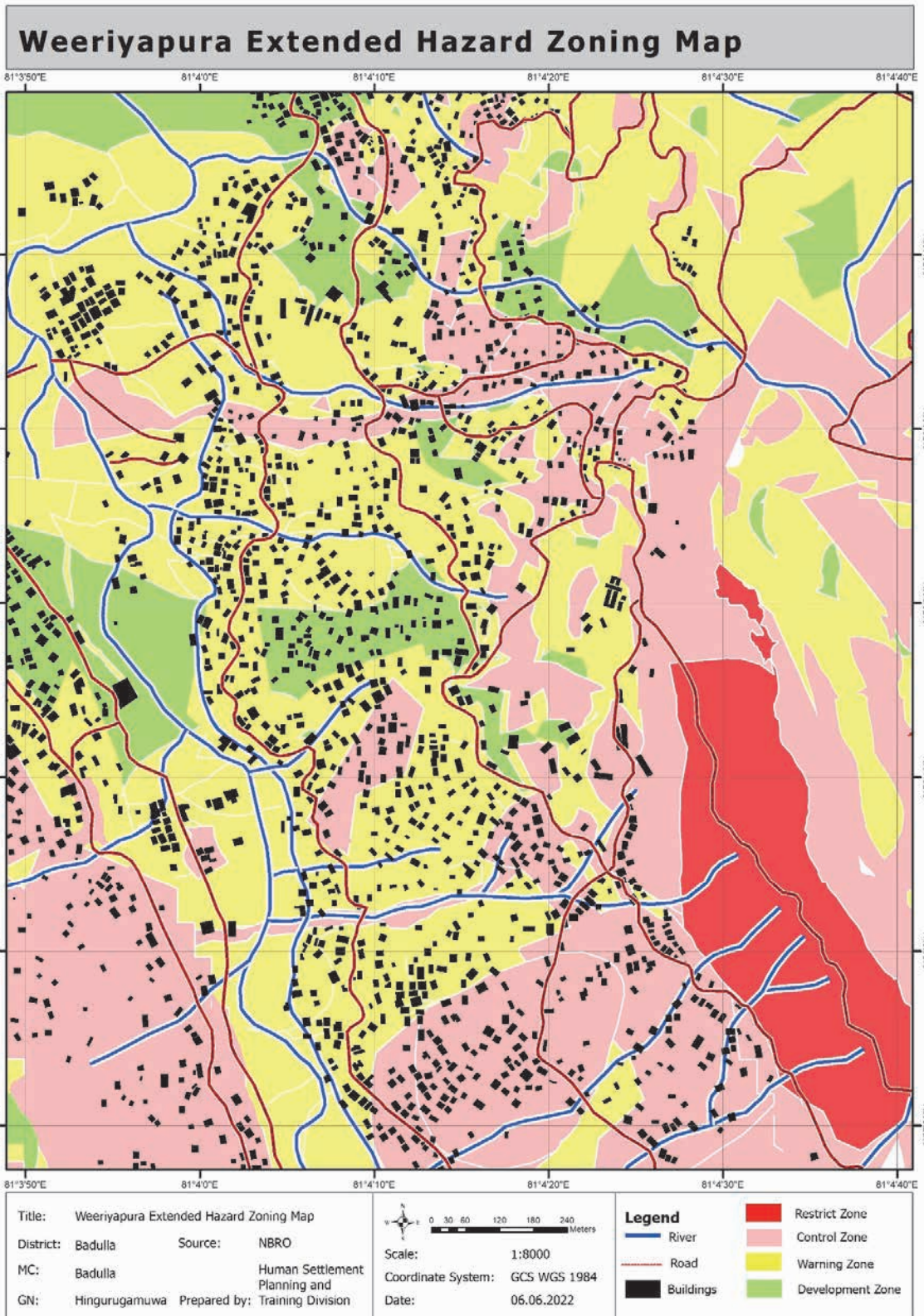


Figure 16: Zoning plan

The following table indicated the allowed and not-allowed land use activities in each zone.

Table 6: Allowed and not allowed land uses to the area

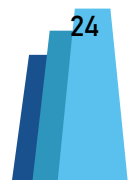
| | Proposed Land use category | | | |
|---------------------|----------------------------|------------------------|------------------------|------------------------|
| | Development Zone | Warning Zone | Controlled Zone | Restricted Zone |
| Residential | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Retail & Commercial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Office | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Industrial | Suitable for Use | Detailed Investigation | Not Suitable | Not Suitable |
| Parks/ Playgrounds | Suitable for Use | Suitable for Use | Detailed Investigation | Not Suitable |
| Agricultural | Suitable for Use | Suitable for Use | Suitable for Use | Detailed Investigation |

2.5. Approval and Enforcement of the Land Use Plan

2.5.1. General conditions

Before doing any development activity need to get the approval from the local authority: Construction activities, Land use changes (Change of use), Land subdivision and amalgamation, and Infrastructure development.

- 1) Local authority should demarcate the boundaries of yellow zone and red zone physically
- 2) An emergency response plan should be in place for every community in yellow zone
- 3) NBRO and DMC should establish early detection instruments within the Red Zone





Risk Assessment

3. Risk Assessment for Weeriyapura

The general concept of risk assessment for a landslide is to examine both the likelihood and adverse consequence of a landslide hazard, then thereby address risk in totality and finally compares the level of the resulting risk against predetermined standards, or other criteria to determine risk treatment and management prioritization. To simplify matters, this manual is not intended to cover the overall processes of hazard analysis (frequency and magnitude) to risk evaluation.

3.1. Database for Designated Yellow/Red Zones

The following table shows the criteria that used to assess the existing risk situation within red and yellow zone areas of Weeriyapura.

Table 7: Items for Database for Designated Yellow/Red Zone

| Category | Item | |
|----------------------------------|---|---|
| Basic information | District | |
| | DS Division | |
| | GN Division | |
| | ID No. (District code - GN P code- Landslide type - serial No.) | |
| | Name of PS | |
| | Landslide Type (Slope failure/Slide/Debris flow) | |
| | Area of Yellow/Red Zone (m2) | |
| Elements at risk | Number of facilities for vulnerable people | Facilities for the aged |
| | | Facilities for physically handicapped persons |
| | | Facilities for mentally retarded and disordered persons |
| | | Kindergartens |
| | | Maternity facilities |
| | | Other similar facilities |
| | Number of evacuation places | |
| | Number of hospitals | |
| | Number of schools | |
| | Number of other important facilities | |
| | Traffic network | |
| Number of residential houses | | |
| Impact of past sediment disaster | Land devastation situation (nothing/slight/significant) | |
| | Impacts of past sediment discharge on nearby facilities | |
| Local request | Request from residents and/or local authorities for risk reduction measures | |
| Countermeasures | Existing structural countermeasures | |
| | Existing non-structural countermeasures | |
| Land development plan | Presence of land development plan / land use plan | |

3.2. Preparation of Data for Risk Evaluation

The relevant data for further risk evaluation is collected and assessed for each of the designated Yellow/Red Zones in accordance with the actual site-specific and local conditions, as sorted and listed below:

- a) Basic information
 - Yellow/Red Zone hazard maps (1:2,500 or 1:5,000 scale)
 - Location information (ID No., District, GN division, Landslide type)
- b) Information on important and vulnerable elements at risk
 - Number of facilities for vulnerable people
 - Number of evacuation places for a disaster
 - Number of public facilities except for road networks
 - Class of road networks
 - Number of residential houses, within red and yellow zones, respectively
- c) Information on impact of past landslide disasters
 - Land devastation situation
 - Impact of past landslide disasters on nearby facilities
- d) other information
 - Request of implementation of measures from residents and/or local authorities

3.3. Items for Risk Evaluation

The risk evaluation for each of the designated Yellow/Red Zones will be conducted in accordance with such items as given in Table 8, and then the level of risk for each of the designated Yellow/Red Zone will be evaluated as very high, high, moderate or low according to the total scores using the risk evaluation sheet shown in Table 9 below. Figure 17 shows a concept of risk evaluation for the target zone

Table 8: Items and Scores for Risk Evaluation for Yellow/Red Zone

| Item | Maximum Score (Total: 100) |
|---|-------------------------------|
| 1) Number of facilities for vulnerable people | 10 |
| 2) Evacuation places | 10 |
| 3) Public facilities | 10 |
| 4) Number of facilities of the above items 1) to 3) within the Red Zone | 10 |
| 5) Traffic network | 10 |
| 6) Number of residential houses within the Yellow/Red Zone | 10 |
| 7) Number of residential houses within the Red Zones | 10 |
| 8) Land devastation situation | 10 |
| 9) Impacts of past sediment discharge on nearby facilities | 10 |
| 10) Request from residents | 10 |

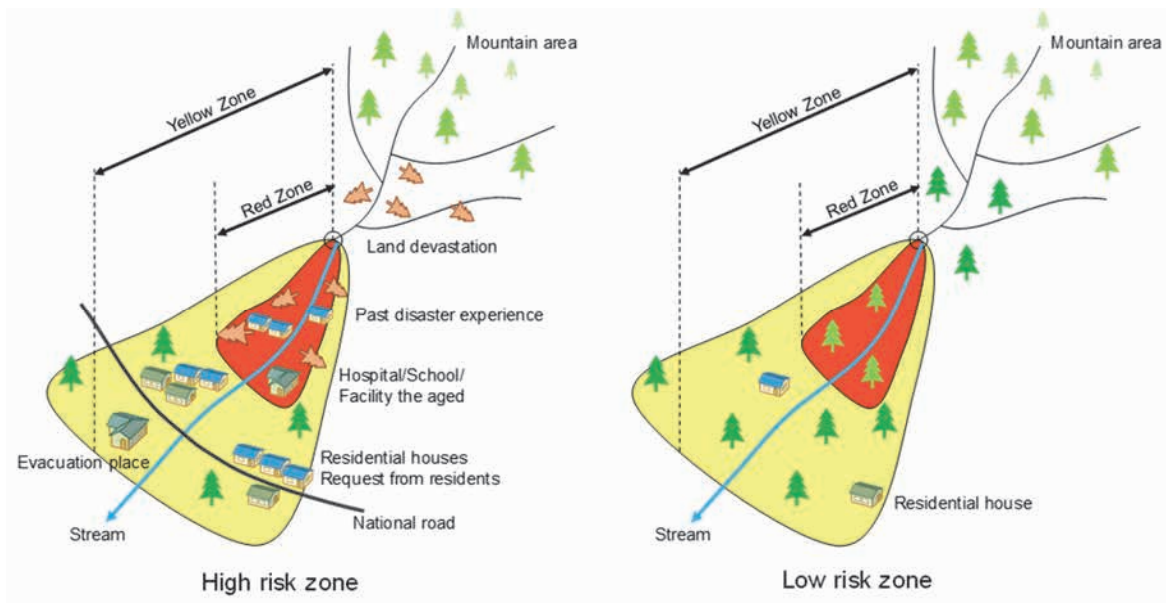


Figure 17 Concept of Risk Evaluation for the Target Yellow/Red Zone (for Debris Flow)

3.4. Risk Evaluation Sheet for Yellow/Red Zone

| | | | |
|---------------------------|---|--------------|---------|
| District | Badulla | Prepared by | |
| GN Division | Imbulgoda, Hingurugamuwa | Organization | NBRO |
| Landslide Type | <input type="checkbox"/> Slope failure <input type="checkbox"/> Slide <input checked="" type="checkbox"/> Debris flow | Date | 2020.11 |
| Designation No. | Red Zone - Debris Flow (2) | | |
| Result of Risk Evaluation | High Risk | | |

| No. | Item | Max Score | Allotment Score | | | Evaluation Score | Remarks |
|---------------|--|------------|-----------------|---|----|------------------|--|
| | | | 0 | 5 | 10 | | |
| 1) | Number of facilities for vulnerable people | 10 | 0 | 0 | 0 | 0 | |
| 2) | Evacuation places | 10 | 0 | 0 | 10 | 10 | Weeriyapura Temple |
| 3) | Public facilities | 10 | 0 | 0 | 0 | 0 | 2 Boutiques and Medical Center |
| 4) | Number of facilities of the above items 1) to 3) within the Red Zone | 10 | 0 | 0 | 10 | 10 | Bor tree and Provincial Education Quarters |
| 5) | Traffic network | 10 | 0 | 5 | 0 | 5 | SDRDL, 2 TRCKL, MNRDL |
| 6) | Number of residential houses within the Yellow and Red Zone | 10 | 0 | 5 | 0 | 5 | 10 residential houses |
| 7) | Number of residential houses within the Red Zones | 10 | 0 | 0 | 10 | 10 | 41 residential houses |
| 8) | Land devastation situation | 10 | 0 | 5 | 0 | 5 | Fractured Land |
| 9) | Impacts of past sediment discharge on nearby facilities | 10 | 0 | 0 | 10 | 10 | |
| 10) | Request from residents | 10 | 0 | 0 | 10 | 10 | Yes |
| Total: | | 100 | | | | 65 | |

Figure 18 Filled Risk assessment sheet for debris flow path in Weeriyapura

Explanation and Description:

- 1) Facilities for vulnerable people mean facilities for people who require assistance during a disaster, mainly including a) facilities for the aged, b) facilities for physically handicapped persons, c) facilities for mentally retarded and disordered persons, d) kindergartens, f) maternity facilities, and g) Other similar facilities.
- 2) Evacuation places mean whether evacuation shelters are present or not around or within the Yellow/Red Zone.
- 3) Public facilities include a) Important facilities such as hospitals and schools, and b) others rather than important facilities.
- 8) Land devastation situation means the relevant lands are significantly devastated due to sediment disasters and almost cannot be used, or are slightly devastated and can be used as farm lands or forest land.
- 9) Impacts of past sediment discharge on nearby facilities mean a) presence or absence of past sediment discharge and its impacts on nearby facilities if present.

The risk evaluation for each of the designated Yellow/Red Zones is carried out and rated on the basis of the selected ten (10) items, as explained above. The risk of each of the designated Yellow/Red Zones is scored using the risk evaluation sheet for yellow/red zone shown in Figure 17 and is further classified into four levels, namely, very high, high, moderate or low according to the total scores.

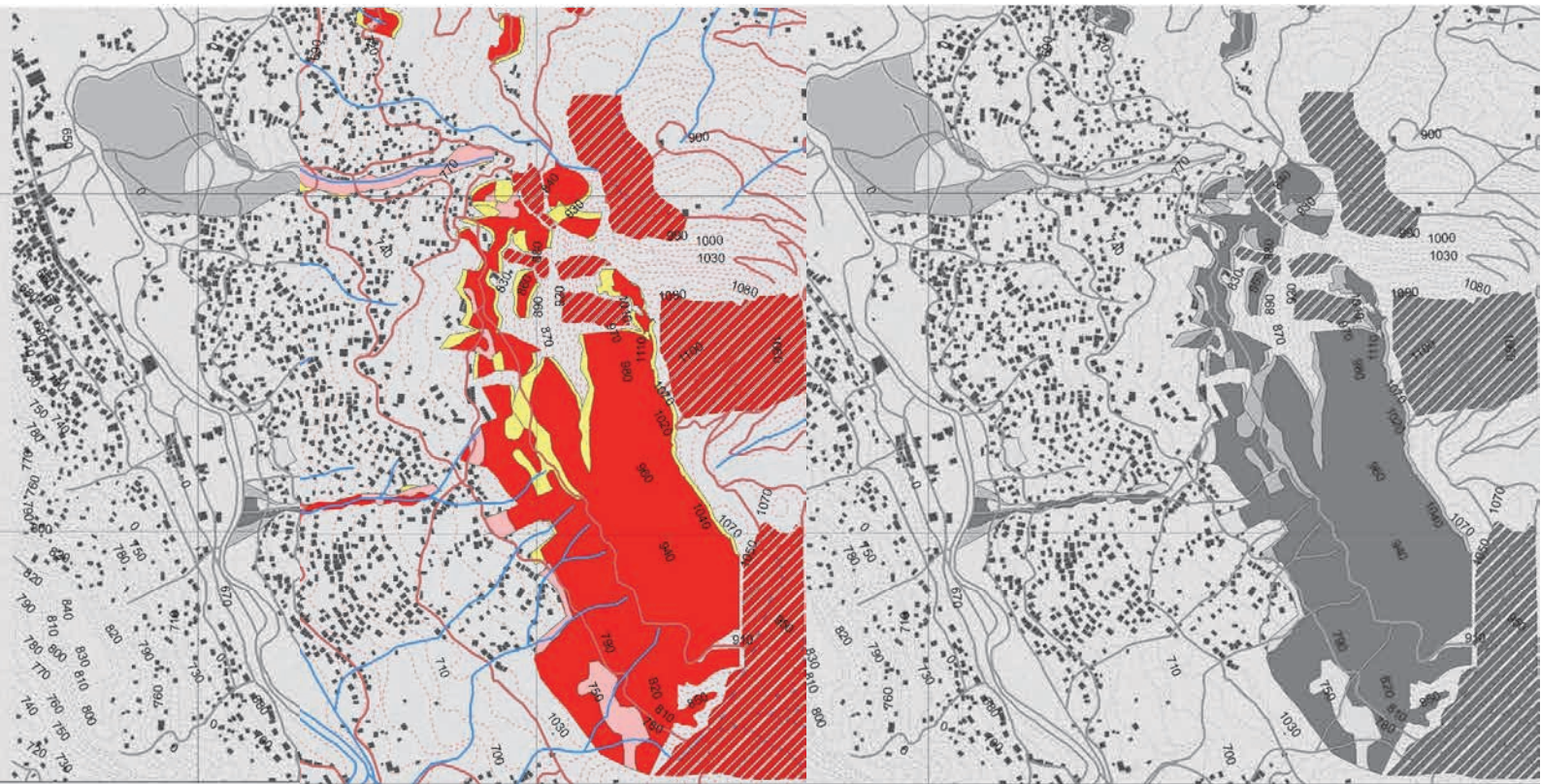
Table 9: Classification of Risk Level

| Risk Level | Total Evaluation Score |
|------------|------------------------|
| Very High | 75 and more |
| High | 50 to 74 |
| Moderate | 25 to 49 |
| Low | 0 to 24 |

The designated Yellow/Red Zones is prioritized by considering these selected items, and this enables risk management, for example, further risk reduction measures, land use planning, to be considered according to priority or risk level. This will facilitate a rational and effective approach to risk treatment and management given the resources available.

4

Land use zoning



4. Land Use Zoning Plan in Weeriyapura

As mentioned above concepts, the yellow zone and Red zone of the target area were created by NBRO in 1:12,500 (Figure 11) and 1:14,000 scales (Figure 15). There are several potential debris flow-prone areas around the Weeriyapura. In this LSDRRP, only a selected area is considered.

Current Land Use Map overlaying red and yellow zone in Weeriyapura is displayed Figure 20. In addition to the current land use displayed in Figure 21, those area covered as Red and Yellow Zone are required to follow the development restriction determined in this LSDRR.

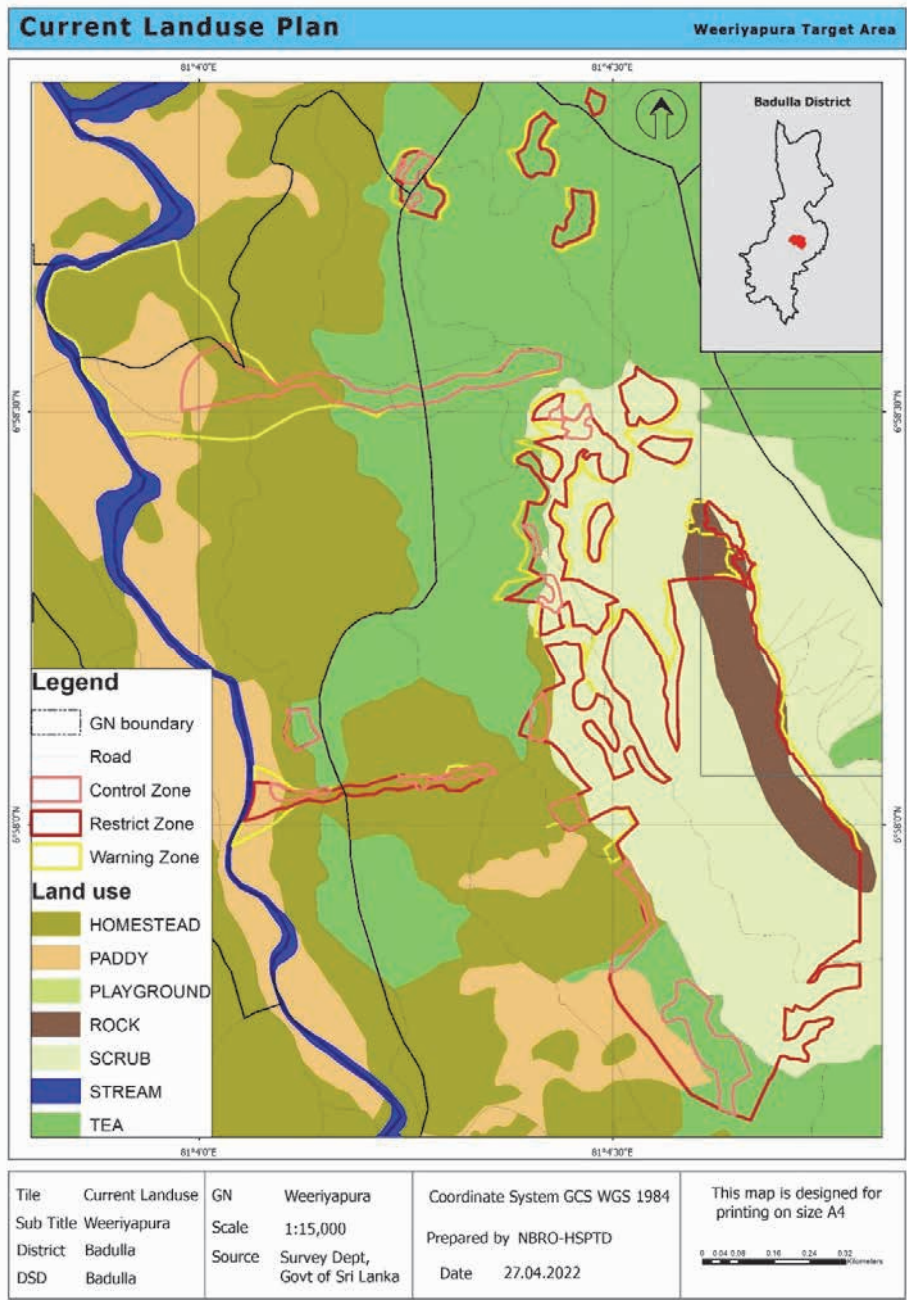


Figure 20: Current land use plan

Land Use Zoning Plan for Weeriyapura is shown in Figure 21. The four zone “Restricted Zone”, “Controlled Zone”, “Warning Zone” and “Development Zone” are illustrated on the map of the figure.

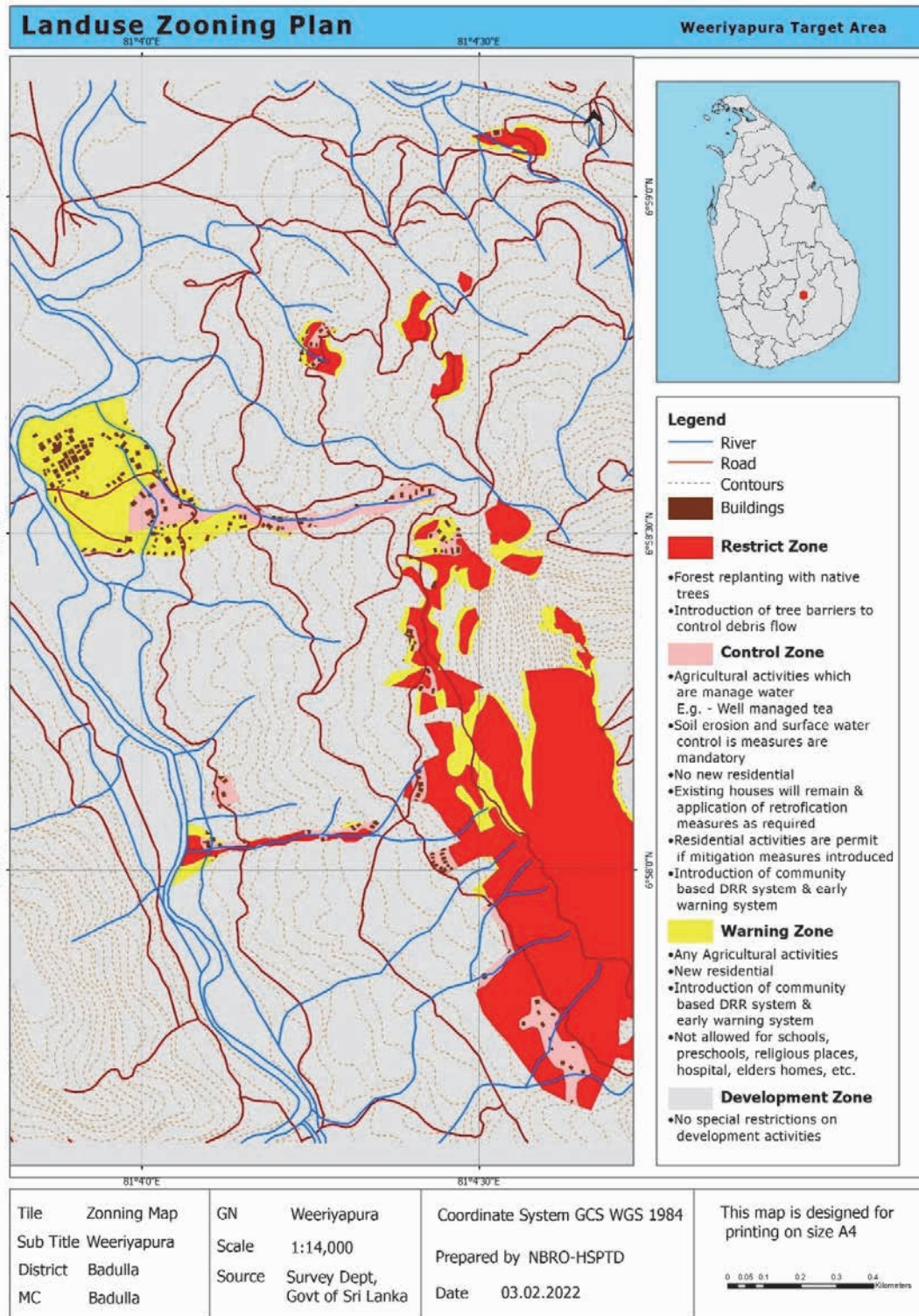


Figure 21: Land use zoning plan

4.1. Basic DRR Strategies for Weeriyapura

Restricted Zone

- Forest re-planting with native trees.
Use native plants to replant the degraded land. Nature based landslide risk mitigation project, a technical collaboration project of NBRO with Asian Disaster Preparedness Center (ADPC) have developed a plant manual to use for such kind of situation.
- Introduce tree barriers to control debris flow
Introduce tree line as a debris along the border of restricted zone and control zone. it may help to control debris to flow in to residential area to certain extent.
- Sabo structural facilities
- In consultation with the central government such as NBRO and Road Development Authority, debris flow prevention facilities such as Sabo dam, training dyke, channel works.

Controlled Zone

- Promote agricultural activities which are manage water (e.g. well manage tea)
- Soil erosion and surface water control is measures are mandatory.
- Not allow to new residential
- Existing housing will remain and application of retrofication measures as required. There are 34 houses in controlled zone in Weeriyapura.
- Residential activities are permit if mitigation measures introduced.
- Introduction of community based DRR system and early warning system.

Warning Zone

- It is suitable for any agriculture activities as well as to establish new residential also.
- Introduction of community based DRR system and early warning system
- Not Allowed for Schools, preschools, religious places, hospital, elder homes and so on.

Development Zone

- No special restrictions on development activities
- Regular development approval process will be taken in to consideration

4.2. Statistics in Yellow and Red Zone

The statistics are based on the filed survey in Weeriyapura target area which is conducted on 2021.11.30-2021.12.02 by the NBRO, and the following information is utilized to plan relocation of housing, an evacuation drill, and a communication channel to disseminate early warning.

Table 10: Statistics in Yellow and Red zone

| | Number of Housing | Number of Family (people) | Number of people who needs assistance to evacuate (infants, elderly, pregnant woman, people with handicap) |
|-----------------|-------------------|---------------------------|--|
| Restricted Zone | 3 | 3 family (17 people) | No |
| Controlled Zone | 52 | 34 family (106 people) | 18 |
| Warning Zone | 34 | 52 family (248 people) | 9 |

| | Total Number of Housing | Permanent | Semi-permanent |
|-----------------|-------------------------|-----------|----------------|
| Restricted Zone | 3 | 3 | 0 |
| Controlled Zone | 52 | 52 | 0 |
| Warning Zone | 34 | 32 | 2 |

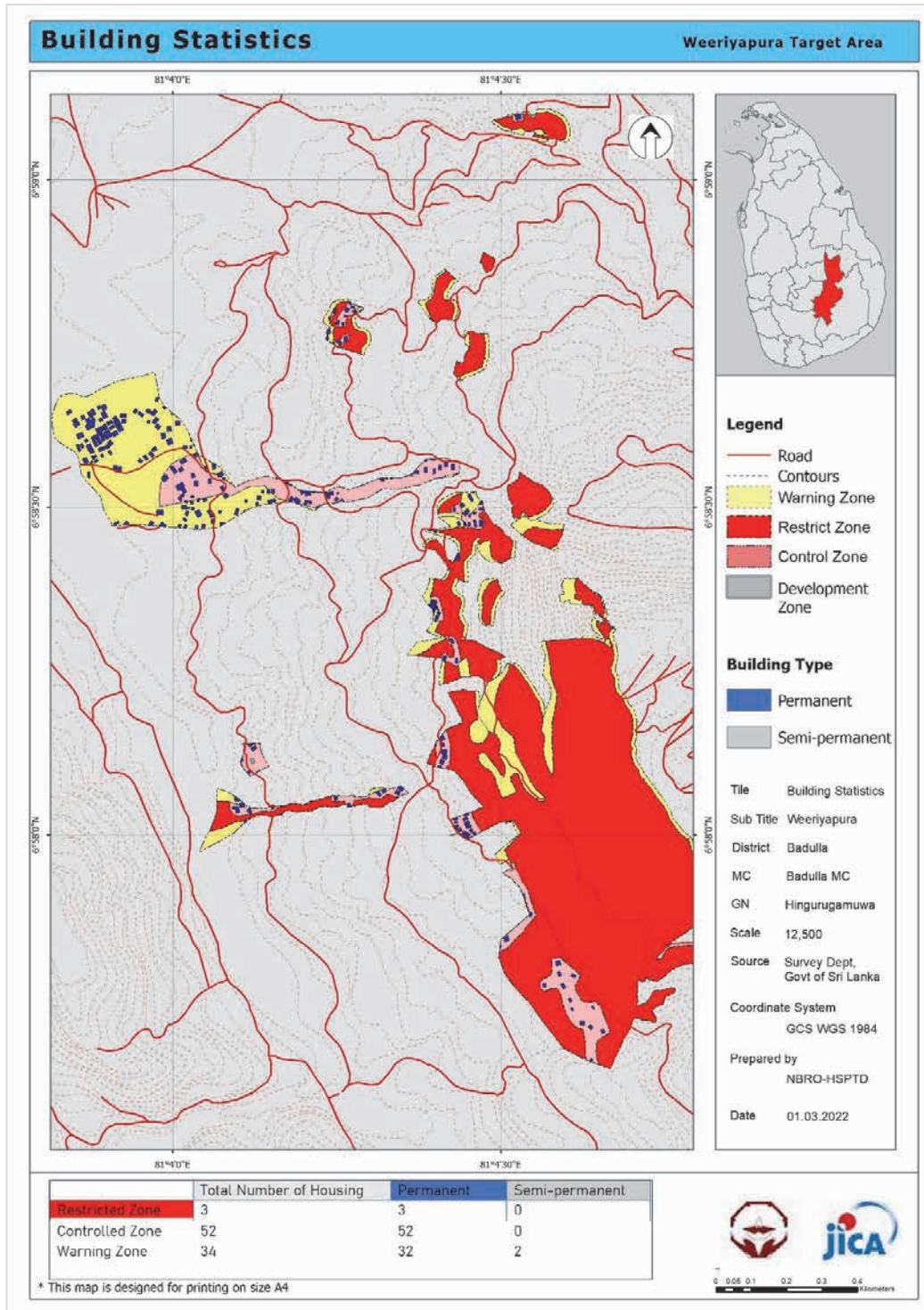


Figure 22: Building statistics

5

Structural Measures



5. Structural Measures

Structural measures are planned to be implemented at four sites: Site 1, Site 2, Site 3, and Site 4 in Weeriyapura. Hazard and impacts and suggested structural measures for the four sites are delineated below. The location map of the sites is shown in Figure 23.

5.1. Site 1 – A Debris Flow Red Zone

1. Hazard and Impacts

Site 1, located in the northern part of the Weeriyapura Pilot Site (see Figure 23), is a Red Zone corresponding to debris flow with a source area of slope failure.

A potential slope failure above the zero valley together with an observable debris fan at the base of the slope indicates that the debris flow is highly expected to occur during or after a heavy rainfall.

Many residential houses are located on the source area – the upper potential slope failure, along the flow path, and on the depositional area – debris fan. A debris flow, once it occurs, originating from either slope failure, or sediments of stream erosion, or their combination, would cause a considerable damage to these residential houses, especially along the flow path and in the depositional area, thus posing a high risk to human lives (Figure 2).

2. Suggested Structural Measures

The impact or consequence of a debris flow on humans and infrastructures depends mainly upon its velocity and magnitude. It is an effective solution to mitigate debris flow risk basically by controlling the magnitude of a debris flow or by reducing the sediment discharge – by stabilizing unstable sediments from the upper potential slope failure and/or the streambed and stream bank slopes. It is an alternative solution to guide the debris flow up to a safe place by installing a training wall or dyke behind or within the populated area of the debris fan for the purpose of avoiding the direct hit of debris flow to the residential houses and infrastructures, if the space is enough for installation of such structural measures.

As shown in Figures 24 and 25, because many residential houses to be protected from the expected debris flow lie on the source area, along flow path and within the depositional area, the structural measures conceivable for Site 1 are as follows:

- Sabo dams to be installed at the toe part of the upper steep slope failures, to control the toe erosion of steep slopes, thereby stabilizing the steep slopes and reducing sediment yield amount.
- Sabo dams to be installed within the flow path, to control the streambed and valley slope erosions along the flow path and partially catch sediment from the upper slope, thereby reducing sediment discharge.

These Sabo dams are planned to control sediment source supply, reducing the sediment discharge of debris flow and minimizing the magnitude and frequency of debris flow, consequently mitigating the impact of debris flow into human lives and infrastructures involved.

Quantity and specification of the planned Sabo dams are summarized in Table 11.

Table 11: Summary of the Suggested Structural Measures at Site 1

| No. | Measure Type | Description/Specification |
|-----|---------------|--|
| 1 | Sabo dam No.1 | 1) Concrete, 2) Non-permeable type, 3) L=10 m, H=5 m |
| 2 | Sabo dam No.2 | 1) Concrete, 2) Non-permeable type, 3) L=15 m, H=5 m |
| 3 | Sabo dam No.3 | 1) Concrete, 2) Non-permeable type, 3) L=15 m, H=5 m |
| 4 | Sabo dam No.4 | 1) Concrete, 2) Non-permeable type, 3) L=10 m, H=5 m |

Notes: L=length of sabo dam, H=height of sabo dam

5.2. Site 2 – A Debris Flow Red Zone

1. Hazard and Impacts

Site 2, located in the southern part of the Weeriyapura Pilot Site (see Figure 23), is a Red Zone corresponding to debris flow with a source area of slope failure.

Similar to Site 1 mentioned above, a potential slope failure above the zero valley together with an observable debris fan at the base of the slope indicates that the debris flow is highly expected to occur during or after a heavy rainfall.

Many residential houses are located on the source area – the upper potential slope failure, along the flow path, and on the depositional area – debris fan. A debris flow, once it occurs, originating from either slope failure, or sediments of stream erosion, or their combination, would cause a considerable damage to these residential houses, especially along the flow path and in the depositional area, thus posing a high risk to human lives.

2. Suggested Structural Measures

As shown in Figure 24 and 25, because many residential houses to be protected from the expected debris flow lie on the source area, along flow path and within the depositional area, three sabo dams are similarly recommended to reduce the risk posed by debris flows for Site 2, as follows:

- Sabo dams to be installed at the toe part of the upper steep slope failures, to control the toe erosion of steep slopes, thereby stabilizing the steep slopes and reducing sediment yield amount.
- Sabo dams to be installed within the flow path, to control the streambed and valley slope erosions along the flow path and partially catch sediment from the upper slope, thereby reducing sediment discharge.

These sabo dams are planned to control sediment source supply, reducing the sediment discharge of debris flow and minimizing the magnitude and frequency of debris flow, consequently mitigating the impact of debris flow into human lives and infrastructures involved.

Quantity and specification of the planned sabo dams are summarized in Table 12 within the Weeriyapura Pilot Site.

Table 12: Summary of the Suggested Structural Measures at Site 2

| No. | Measure Type | Description/Specification |
|-----|---------------|--|
| 1 | Sabo dam No.1 | 1) Concrete, 2) Non-permeable type, 3) L=10 m, H=5 m |
| 2 | Sabo dam No.2 | 1) Concrete, 2) Non-permeable type, 3) L=15 m, H=5 m |
| 3 | Sabo dam No.3 | 1) Concrete, 2) Non-permeable type, 3) L=10 m, H=5 m |

Notes: L=length of sabo dam, H=height of sabo dam

5.3. Site 3 – A Slide Red Zone within the Weeriyapura Pilot Site

1. Hazard and Impacts

Site 3 is a Red Zone corresponding to slide in the northern part of the Weeriyapura Pilot Site (Figure 23).

The slide showed a clear landslide topography, including main scarp, depression, hummocky topography and so on. Some ground surface deformations were also observed in the slide slope. Accordingly, the slide is highly expected to occur during or after a heavy rainfall.

Many residential houses are located within and below the slide area. Once moving down, the slide would cause a considerable damage to these residential houses, both within the slide area and below the slide area, thus posing a high risk to human lives.

2. Suggested Structural Measures

In general, slide movement is closely related to rainfall. In addition, as stated above, because of the depression in the upper part of the slide area and some ground surface deformations, rainwater would be infiltrated into the ground during a rainfall – forming shallow groundwater, causing a rise in ground level, consequently reactivating the slide.

Accordingly, horizontal drain hole work is recommended to drain shallow groundwater effectively and promptly, to stabilize the slide. In addition, drain ditch work is used to collect surface water and then drain out of the slide area (Figures 24 and 25). Quantity and specification of the planned structural measures are summarized in Table 13.

Table 13: Summary of the Suggested Structural Measures at Site 3

| No. | Measure Type | Description/Specification |
|-----|------------------------|--|
| 1 | Horizontal drain holes | 1) 50 m x 8 holes + 50 m x 6 holes = 700 m |
| 2 | Drain ditch | 1) L= 200 m in total |

Notes: L=length of drain ditch

5.4. Site 4 – A Slide Red Zone within the Weeriyapura Pilot Site

1. Hazard and Impacts

Site 4 is also a Red Zone corresponding to slide in the northern part of the Weeriyapura Pilot Site (Figure 23).

The slide showed a clear large landslide topography, including main scarp, depression, hummocky topography and so on. Some ground surface deformations were also observed in the upper slope of the slide area. Accordingly, the slide is highly expected to occur during or after a heavy rainfall.

Many residential houses are located within and below the slide area. Once moving down, the slide would cause a considerable damage to these residential houses, both within the slide area and below the slide area, thus posing a high risk to human lives.

2. Suggested Structural Measures

Similar to the slide at Site 3 above, the slide at Site 4 may be reactivated due to groundwater, both shallow and deep. Accordingly, horizontal drain hole work is recommended to drain shallow groundwater around the upper slope and drainage well work to drain deep groundwater in the middle slope of the slide, to improve the safety factor of the slide slope.

Quantity and specification of the planned structural measures are summarized in Table 14.

Table 14: Summary of the Suggested Structural Measures at Site 4

| No. | Measure Type | Description/Specification |
|-----|------------------------|--|
| 1 | Horizontal drain holes | 1) 30 m x 6 holes = 180 m |
| 2 | Drainage well No.1 | 1) Well depth = 15m, 2) Well diameter = 2 to 3m, 3) Collecting holes = 50 m x 10 holes x 2 lines = 1000 m, 4) Drainage hole length = 100 m |
| 3 | Drainage well No.2 | 1) Well depth = 15m, 2) Well diameter = 2 to 3m, 3) Collecting holes = 50 m x 10 holes x 2 lines = 1000 m, 4) Drainage hole length = 100 m |
| 4 | Outlet | 1) Concrete, 2) 100cm (length) x 100cm (width) x 80cm (depth) x 2 locations |
| 5 | Drain ditch | 1) L= 25 m in total |

Notes: L=length of drain ditch

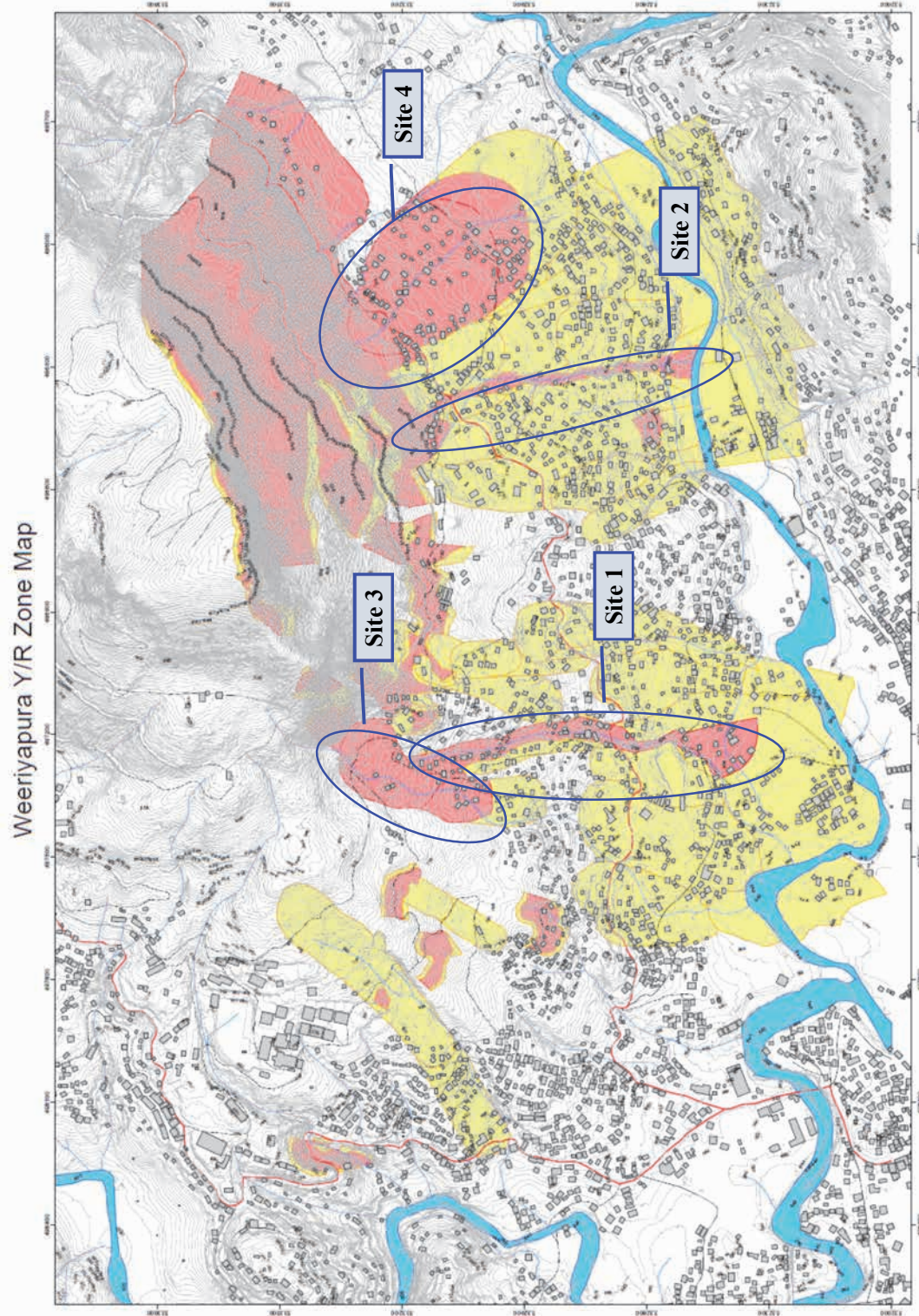


Figure 23: Location of the Selected Red Zones for Conceptually Planning Structural Measures

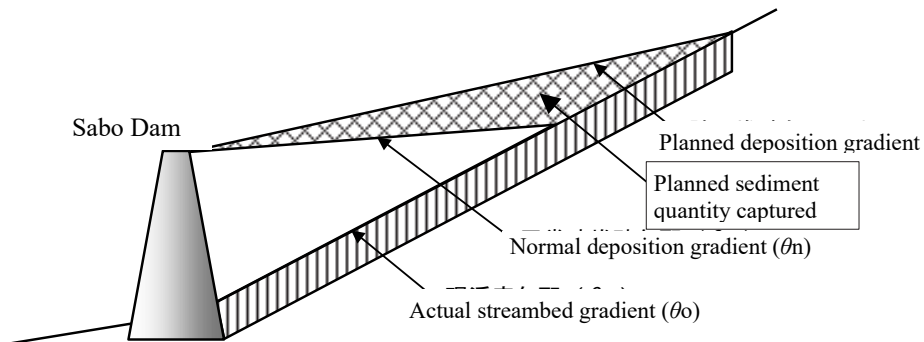


Figure 24: Conceptual Illustration of Non-permeable Sabo Dam

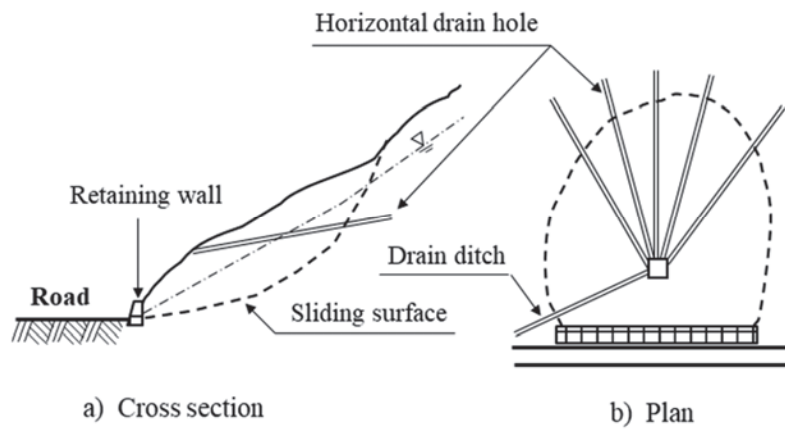


Figure 25: Typical Layout of Horizontal Drain Holes

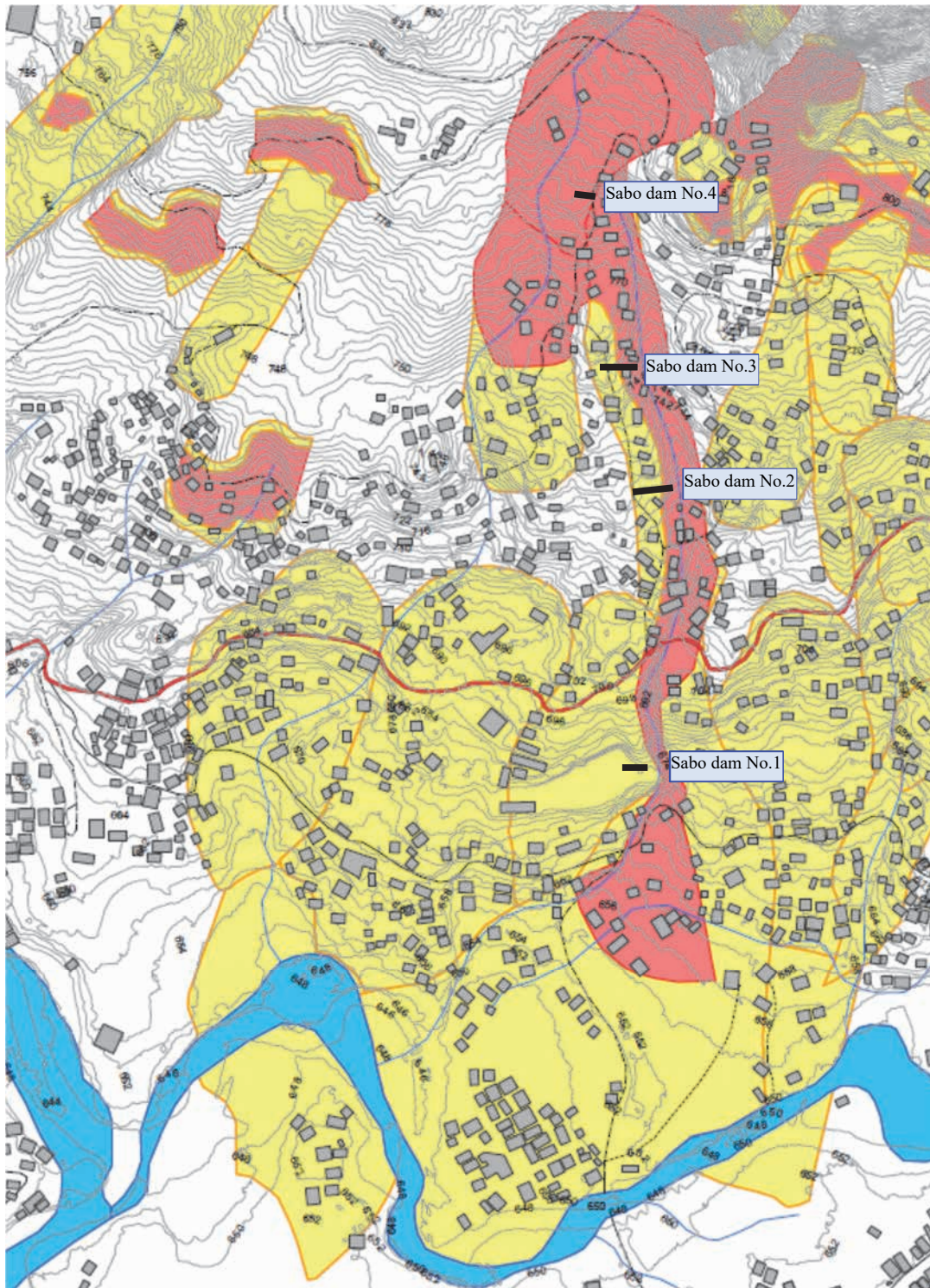


Figure 26: Layout of the Planned Structural Measures for Site 1 in the Weeriyapura Pilot Site

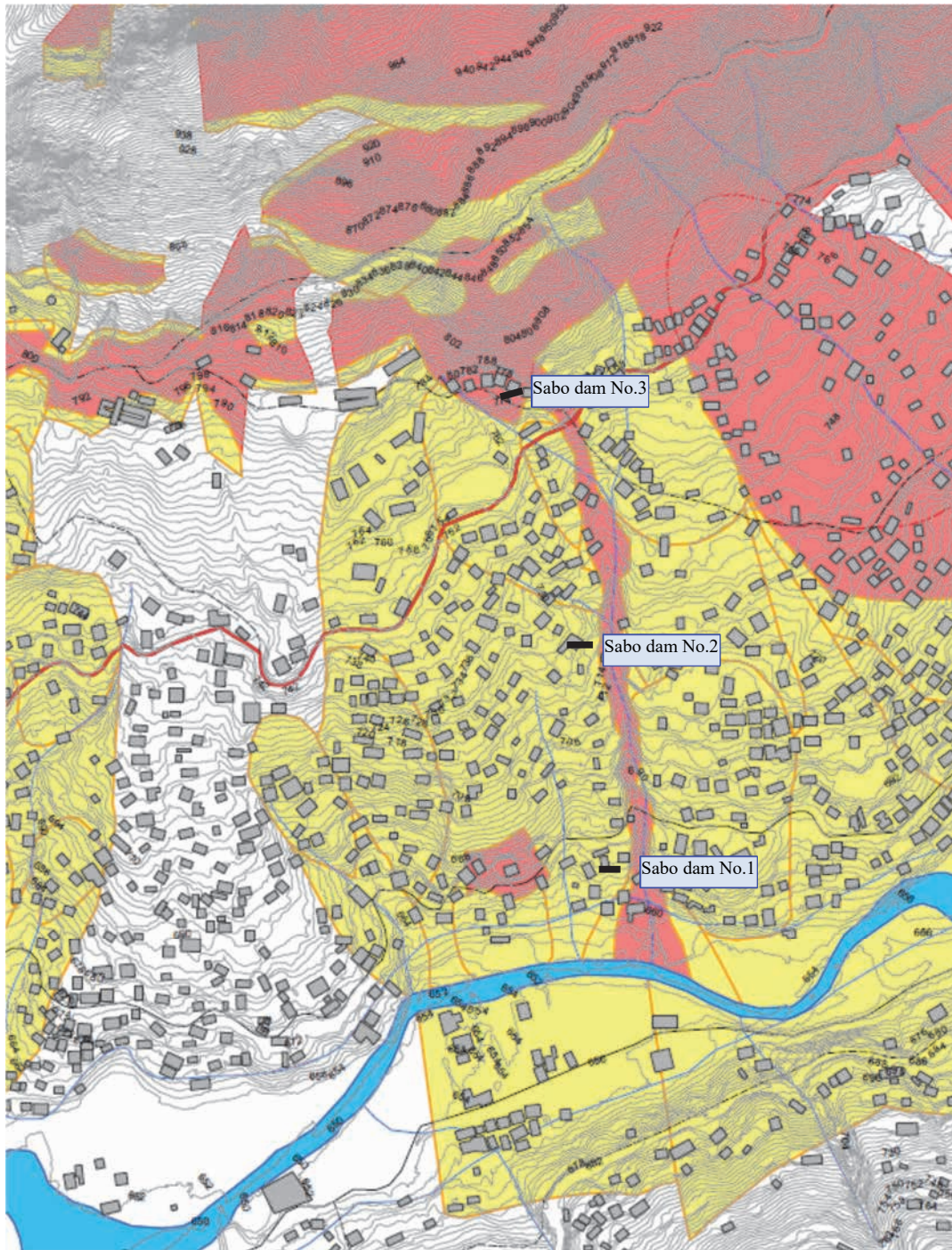


Figure 27: Layout of the Planned Structural Measures for Site 2 in the Weeriyapura Pilot Site

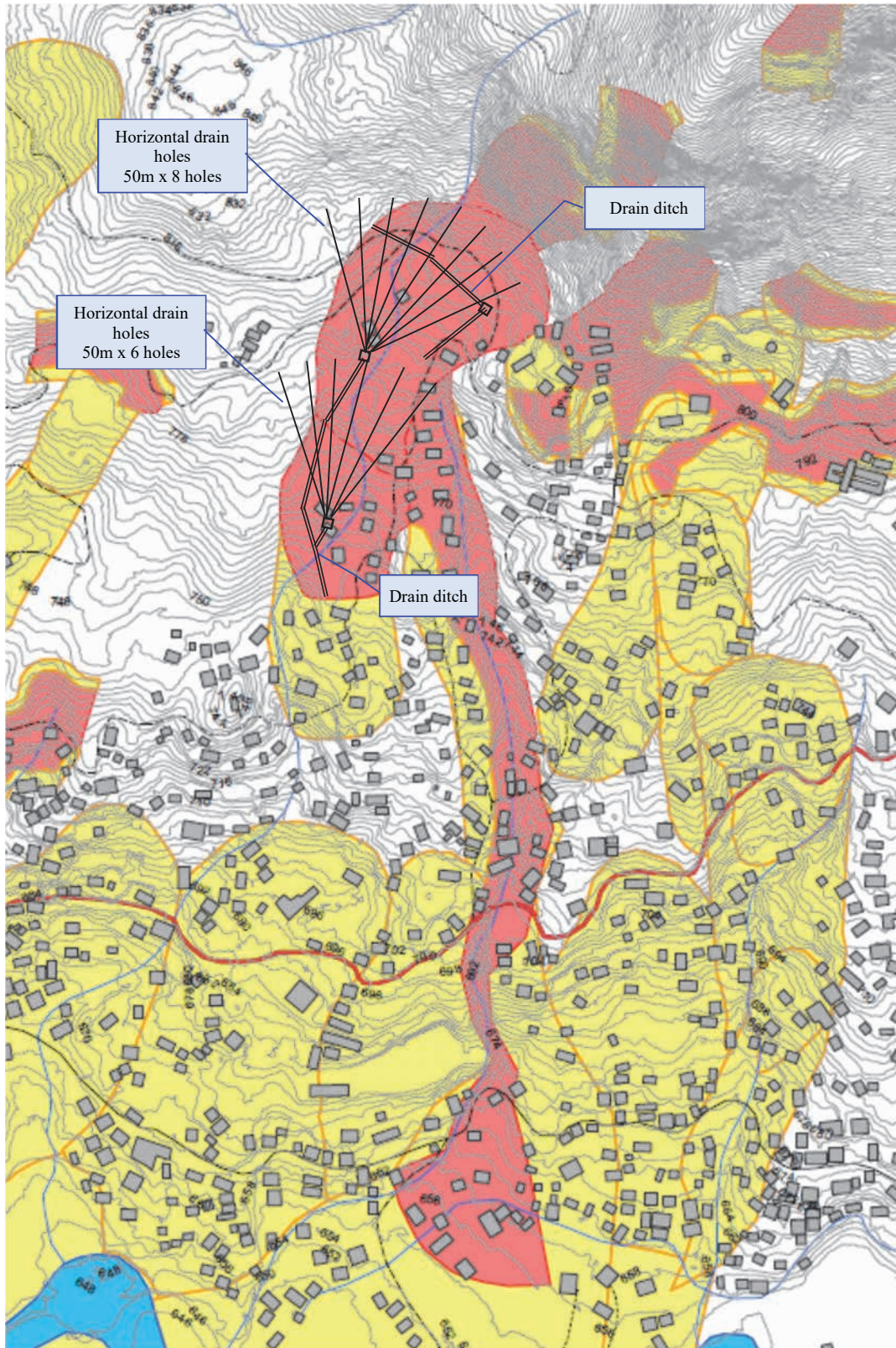


Figure 28: Layout of the Planned Structural Measures for Site 3 in the Weeriyapura Pilot Site

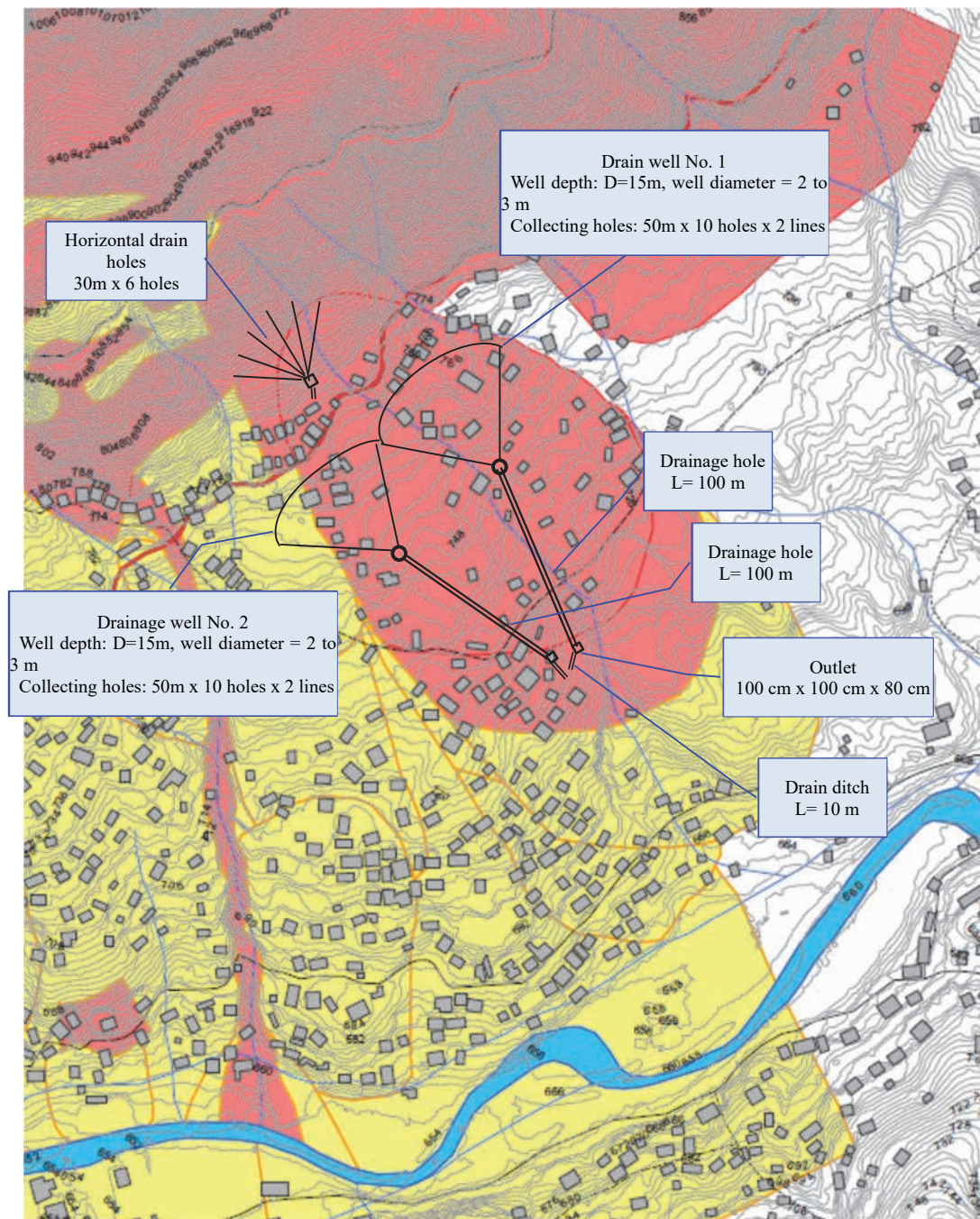


Figure 29: Layout of the Planned Structural Measures for Site 4 in the Weeriyapura Pilot Site

5.5. Current issues in hazard area and required structure and non-structure measures

The following issues regarding housing in hazard area are identified at the workshop with Weeriyapura and Imbulgoda community members on 10th March 2022.

- There are flows of water in the area that should be drained properly by constructing a drainage line with concrete.
- Many people are covering the slopes or building the walls around their houses and lands with cement and concrete, in order to protect their property. Such haphazard manners of construction in the upstream land, both within and outside the hazard zones, are affecting the downstream houses and lands. Therefore, residents need a proper drainage plan to release the rainwater in the whole area
- Early warning system is very important to save people's lives, because nobody in the area is willing to relocate to other places, due to the convenient location of the village to access to Badulla town

As a prevention measure for new housing in the risk area, Badulla MC, a responsible authority of providing a land permission, shall develop the guide for development regulation. Moreover, cooperation of neighbors is necessary to prevent new housing construction in the restricted and control area. Furthermore, as most of the residents do not want resettlement to other area, it is beneficial to install early warning in the area and that Badulla MC promotes retrofitting of the existing houses in the control zone in cooperation with NBRO in the future.



Strengthening Early Warning and Evacuation

6. NBRO Landslide Early Warning

NBRO Early Warning Centre (EWC) issues landslide warnings based on real-time observed rainfall data from NBRO automation rain gauge. Warning criteria and actions to take during the respective warning level is as shown in the following table. In addition to 24 hours rainfall, NBRO EWC considers Soil Water Index (SWI) which indicates how much water is accumulated in the soil since landslide is caused when water in the soil gets saturated by heavy rainfall. It is important to remember that there is cases that NBRO keeps the warning even if the rainfall become little since there is high risk of landslides due to high water saturation in the soil (high SWI).

Table 15: NBRO Landslide Early Warning Criteria and actions to take

| Warning Level | 24 hours rain fall | Actions to take |
|---------------|--------------------|---|
| (None) | | |
| 1 Watch | More than 75 mm | Be watchful on the possibility of landslide |
| 2 Alert | More than 100 mm | Be on alert, prepare to evacuate |
| 3 Evacuation | More than 150 mm | Evacuate to a safe location |

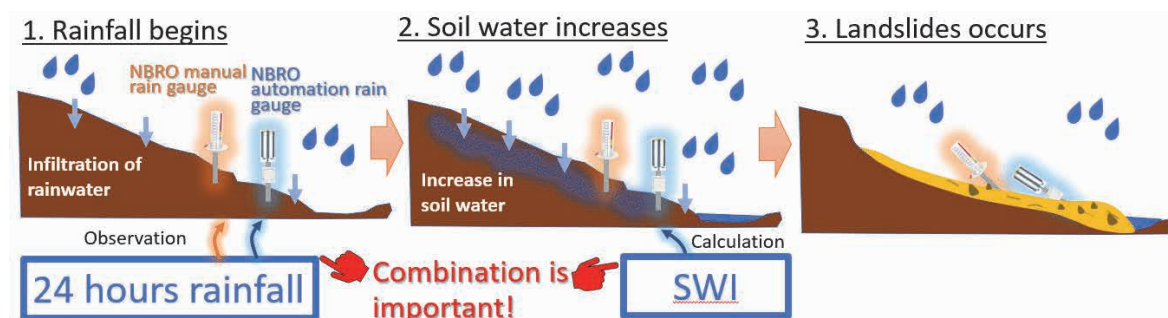


Figure 30: Cause of Landslide and Soil Water Index

After NBRO EWC transmits the warning messages to Disaster Management Center (DMC), DMC is in charge of disseminating the NBRO warning to DDMCU in Badulla District, Badulla DS division, Weeriyapura GN Division, and Emergency Community Committee in Weeriyapura as shown in the following figure. Considering the landslide warnings, DDMCU (or DS division) issues evacuation order to local people. The local people living in Yellow/Red zones shall evacuate to safe place to comply with the section 7.(2) and (3). Certain dissemination of the landslide warnings and evacuation order shall be ensured through the awareness activities. NBRO will continue routine operation and maintenance of the rain gauge.

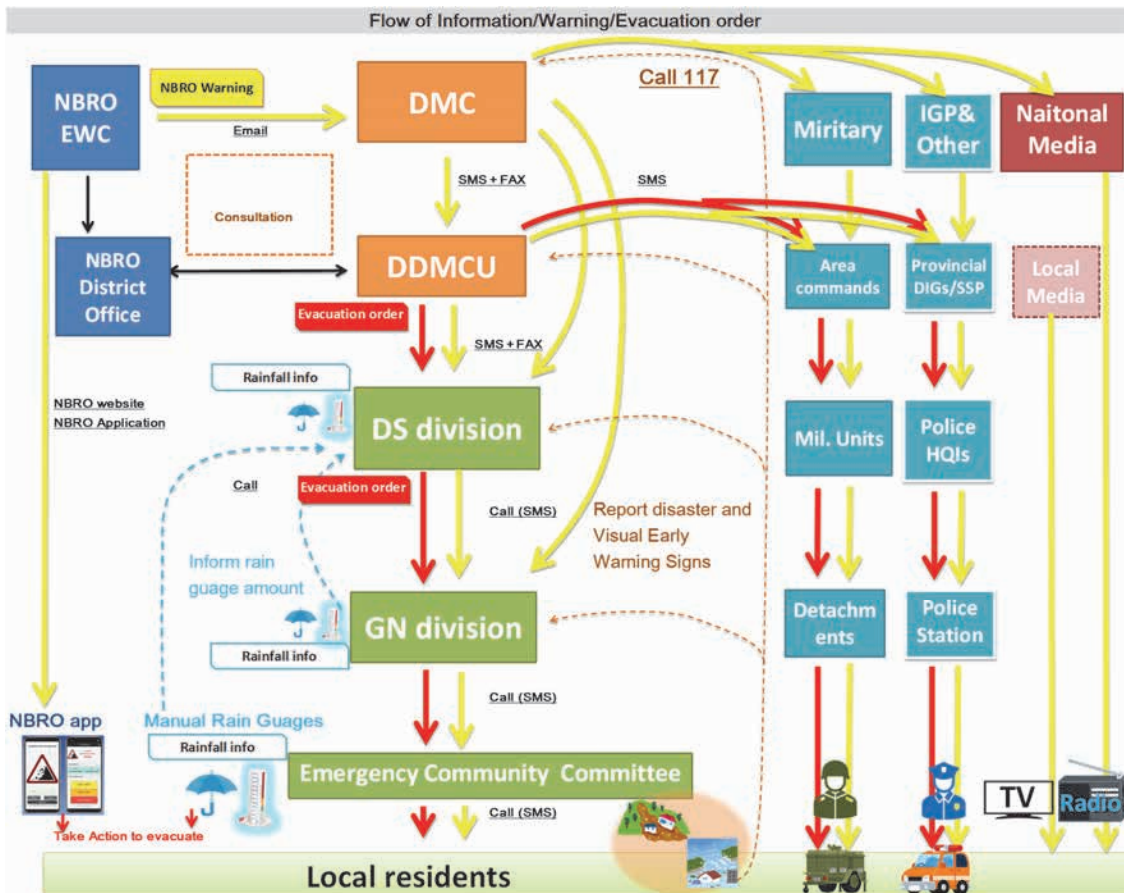


Figure 31: Dissemination flow of NBRO Landslide Early Warning and Evacuation Order

Although the direct Call/SMS comes to only focal people at respective level, the landslide warnings are also broadcasted by media and published on the NBRO websites (<https://www.nbro.gov.lk/index.php?lang=si>) and NBRO mobile application. Therefore, all residents can check the warning by themselves also. The real-time observed rainfall data by NBRO automation rain gauge (https://www.nbro.gov.lk/index.php?option=com_content&view=article&layout=edit&id=215&lang=en) is also available at NBRO website.



Community Based Early Warning

In addition to NBRO EW sent from EWC, a community-based approach on landslide early warning needs to be functioned even if the level of NBRO EW sent through DMC is not at the same level, when observed rainfall by the manual gauges at the field exceeds the threshold, Disaster relief officer or the Emergency Community Committee shall inform the situation to Divisional Secretary and make decision to evacuate if it is over 150 mm per 24 hours. The local people shall start evacuation based on the local information since NBRO EW is not for site-specific area but the entire district. Emergency Community Committee shall inform the warning to the residents by call, SMS and oral communication to encourage evacuation.

6.1. NBRO Early Warning Communication Channel in Weeriyapura

The following figure is a NBRO Early Warning dissemination method in Weeriyapura. The warning is mainly delivered by Calls and SMS. 60 households in Weeriyapura are covered through this channel at present. The residents who are not in the channel shall be informed that NBRO early warning information is available at NBRO EW application and website at awareness activities.

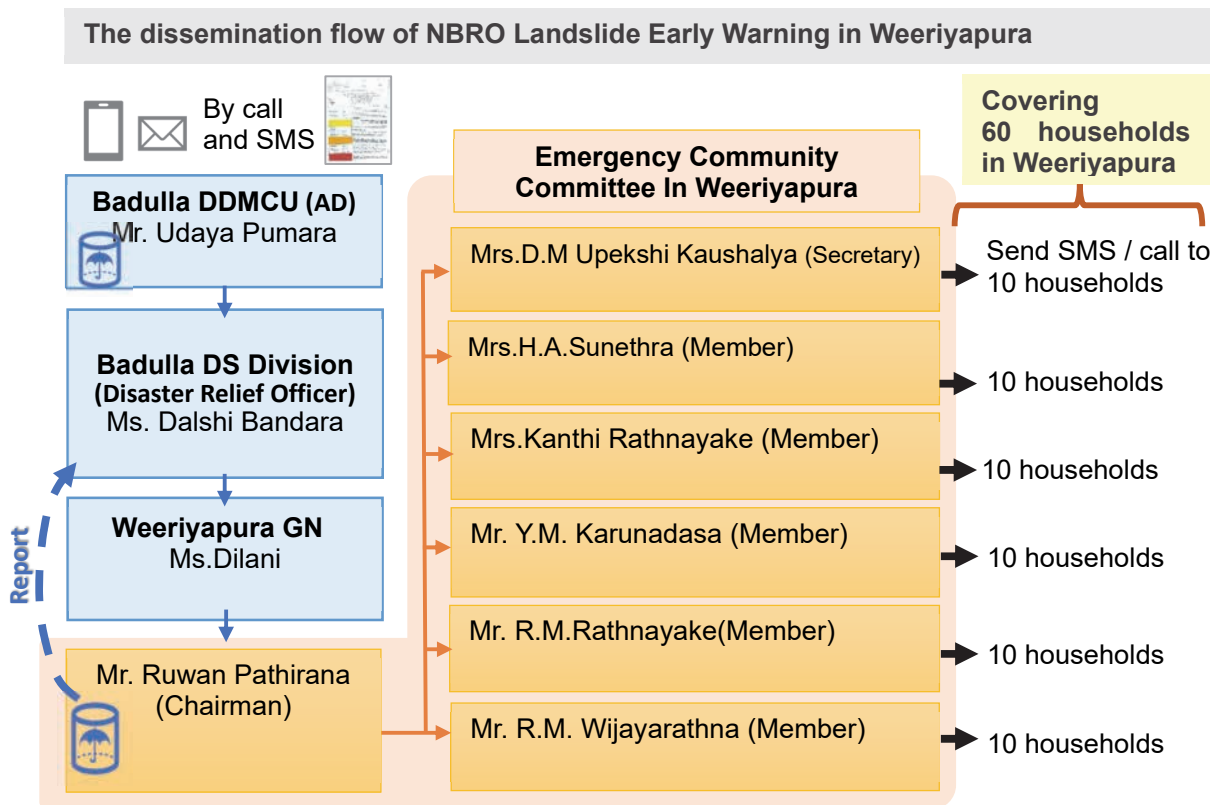


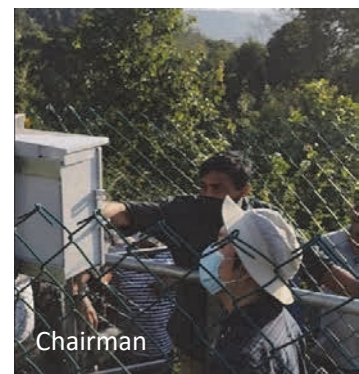
Figure 32: Contact information and the dissemination flow of NBRO Landslide Early Warning in Weeriyapura

6.2. Emergency Community Committee in Weeriyapura

Emergency Community Committee was newly established in Weeriyapura area in March 2022 with NBRO officers. The following is the committee members.

Table 16: Members of Emergency Community Committee in Weeriyapura

| Position | Name |
|-----------|-----------------------------|
| Chairman | Mr. Ruwan Pathirana |
| Secretary | Mrs. D.M. Upekshi Kaushalya |
| Member | Mrs. Kanthi Rathnayake |
| Member | Mr. Y.M. Karunadasa |
| Member | Mr. R.M. Rathnayake |
| Member | Mr. R.M. Wijayarathna |



6.3. Installed Landslide Remote Monitoring System and EW equipment

Landslide Remote Monitoring System (LRMS)

As many residents in Weeriyapura and Imbulgoda are not willing to be relocated from the area and slowly moving landslide blocks are still found in those area, two sets of Landslide Remote Monitoring System (LRMS) was installed by NBRO in 28th January, 2022. LRMS is consists of 4 equipment. At the Base station, there are 1. Alarm device and 2. Rain gauge with a main controller of installed devices and data transmission. Other equipment are 3. Extensometer, which measures the movement of soil mass and 4. Multi-point Inclinometers which measures the inclination of soil-mass.

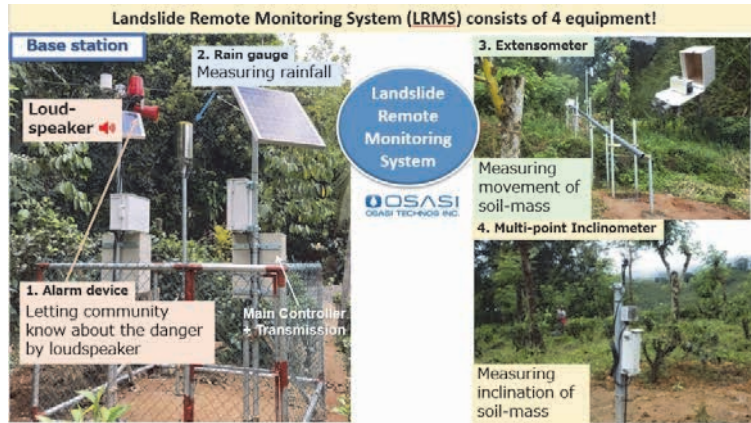


Figure 33: Main equipment of Landslide Remote Monitoring System (LRMS)

The extensometer is a device used to measure the changing distance between two points. A fixed measurement point with a main device is located at upper side of landslide block. The other measurement point at the lower area is placed inside the landslide block. A wire is set from the equipment at the top to the bottom. Therefore, when landslide occurs, the bottom measurement point moves to the lower area and make the wire extend. When the device detects the change over the threshold, the alarm rings and warning message is disseminated to the registered SMS number.

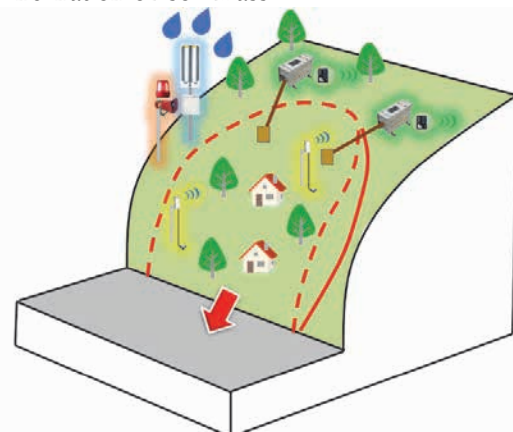


Figure 34: Locational image of extensometer and multi-point Inclinometer

The multi-point inclinometer is located inside the landslide block. It has a sensor used to measure the magnitude of the inclination angle of soil-mass. The data is depicted in degrees. When the change becomes over the threshold, the alarm rings and warning message is also sent to the registered SMS number.

All the observed data by extensometers, inclinometers and automation rain gauge is sent to NBRO EWC server. Therefore, the current condition of each equipment and the site are monitored by NBRO EWC and District office online.

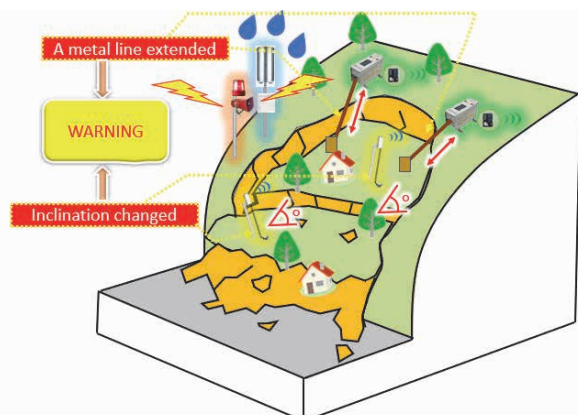


Figure 35: Location and warning image of LRMS

Possibility of a wrong warning by LRMS

It is crucial to note that as the device detects the above changes, a warning occurs not only due to landslide but also other factors, such as when tree branches are fallen onto the wire of extension meter and when residents or monkeys touches the

inclinometer. If loudspeaker starts ringing without rainfall, it may be the wrong warning. If the wrong warning occurs frequently, PS shall consult with NBRO EWC and District office about the issue. Awareness activities to residents regarding the LRMS and keep the area clear is also crucial.

Installation of LRMS

Installed LRMS are total 2 base stations, 1 rain gauge, 4 extensometers and 4 inclinometers in Weeriyapura area. The equipment was installed in Imbulgoda area also.

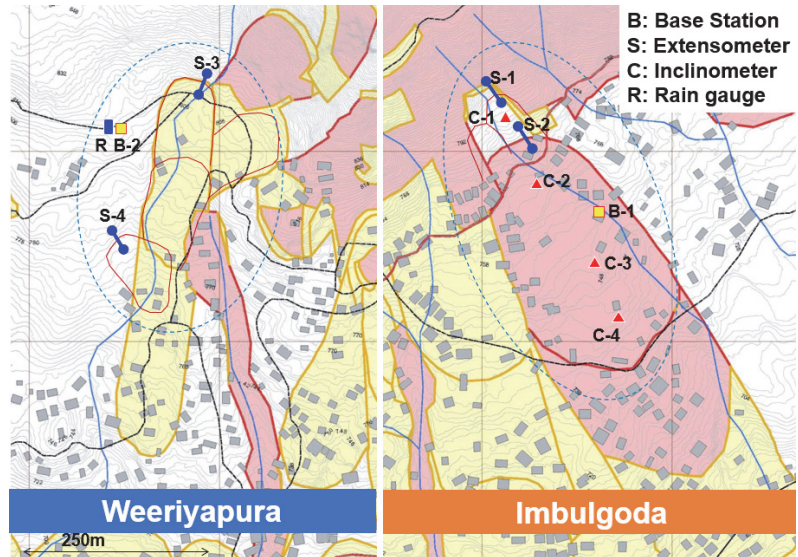


Figure 36: Location of extensometers and multi-point inclinometers in Weeriyapura area (Overview)

Location and photos of LRMS

Specific location of installed LRMS equipment in Weeriyapura and Imbulgoda is shown in the following map. Base station of Weeriyapura are located in front of Ganesha statue and Base station of Imbulgoda is at Sri Dumindaramaya temple, which is also an evacuation site.

Base station 1 – at Sri Dumindaramaya temple



Base station 2 – In front of Ganesha statue in Weeriyapura

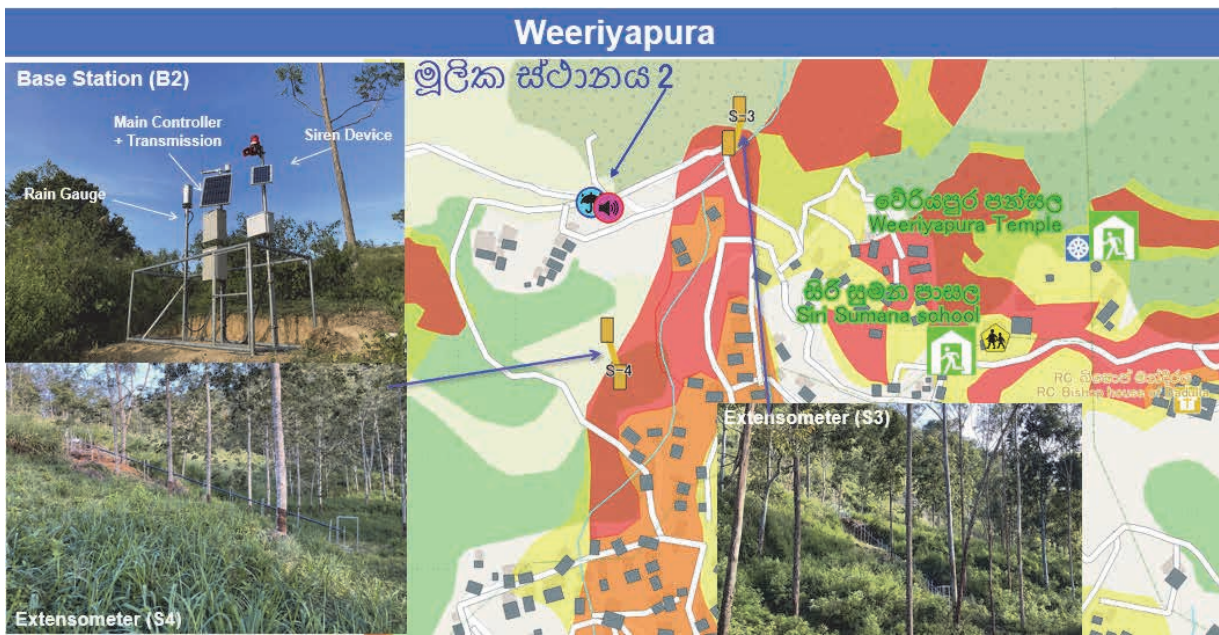


Figure 37: Location of extensometers and multi-point inclinometers in Weeriyapura (Overview)

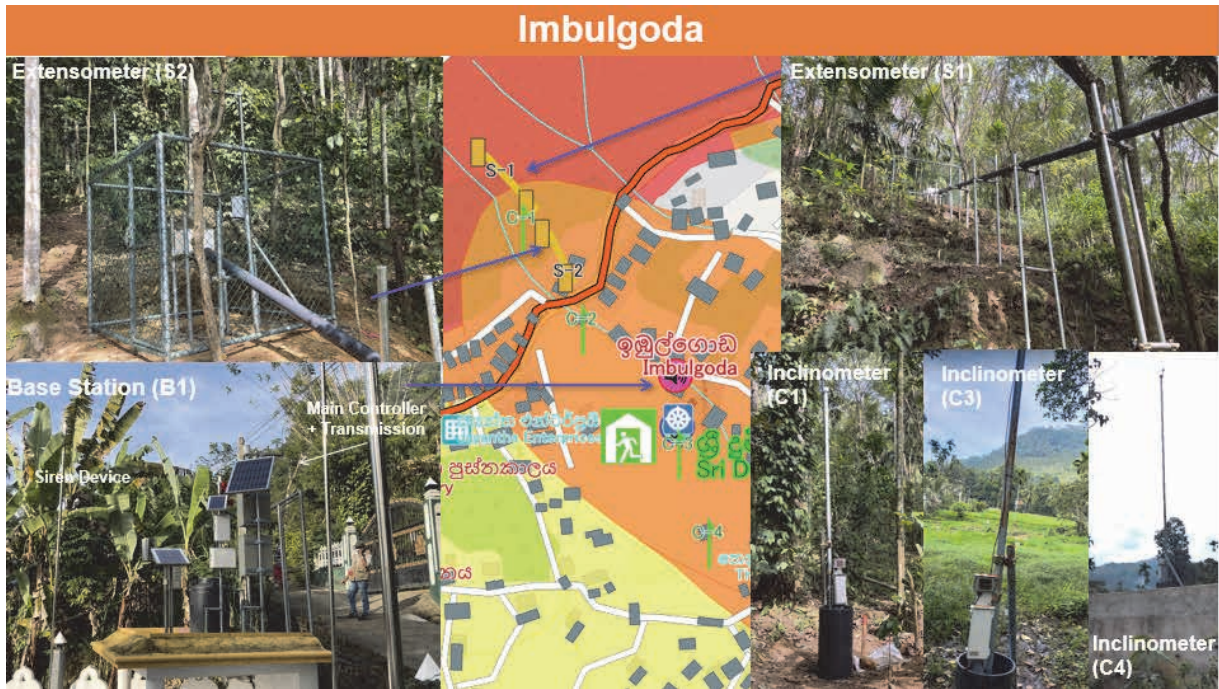


Figure 38: Location and image of installed extensometers and multi-point inclinometers in Weeriyapura (Base Station 1 & 2)

Warning siren and SMS from the LRMS equipment

When extensometers and inclinometers detect the movement over the threshold, the alarm and the loud speaker at the base station start ringing. At the same time, the warning SMS message is also sent from the base station to the registered phone numbers.

As only four numbers can be registered for each base station, the same warning SMS is sent to all other relevant personnel from the NBRO EWC server. The registered numbers for the base stations and NBRO EWC Server are the following numbers in the table. Since all the registered number should be updated whenever the responsible personnel from each organization is changed, it should be checked at a regular maintenance meeting lead by NBRO.



Figure 39: Structure of Warning SMS sent from Base Station and NBRO Server

Table 17: Registered number for Warning SMS at Base Station 1 & 2 and NBRO EWC Server

| Registered numbers at Base Station 2 in Weeriyapura | | |
|---|--|---------------------|
| No | Position | Name |
| 1 | NBRO EWC | Dr. Wasantha |
| 2 | NBRO Badulla District office | Ms. Harshani |
| 3 | Weeriyapura GN officer | Ms.Dilani |
| 4 | Emergency Community Committee (Chairman) | Mr. Ruwan Pathirana |

| Registered numbers at NBRO EWC | | |
|--------------------------------|---|---------------------------|
| No | Position | Name |
| 1 | DDMCU Badulla office | Mr. Udaya Pumara |
| 2 | DDMCU Badulla office | Mr. Sanjeewa Samarakoon |
| 3 | Badulla DS Division (Disaster Relief Officer) | Ms. Dalshi Bandara |
| 4 | Emergency Community Committee (Secretary) | Mrs.D.M Upekshi Kaushalya |
| 5 | Emergency Community Committee (Member) | Mrs.H.A.Sunethra |
| 6 | Emergency Community Committee (Member) | Mrs.Kanthi Rathnayake |
| 7 | Emergency Community Committee (Member) | Mr. Y.M. Karunadasa |
| 8 | Emergency Community Committee (Member) | Mr. R.M.Rathnayake |
| 9 | Emergency Community Committee (Member) | Mr.R.M. Wijayarathna |

| Registered numbers at Base Station 1 in Imbulgoda | | |
|---|--|--------------------------------|
| No | Position | Name |
| 1 | NBRO EWC | Dr. Wasantha |
| 2 | NBRO Badulla District office | Ms. Harshani |
| 3 | Imbulgoda GN officer | Ms.W.A.N.Niroshani Wijeshinghe |
| 4 | Emergency Community Committee (Member) | Mr. Kalunaratha |
| Registered numbers at NBRO EWC | | |
| No | Position | Name |
| 1 | DDMCU Badulla office | Mr. Udaya Pumara |
| 2 | DDMCU Badulla office | Mr. Sanjeewa Samarakoon |
| 3 | Hali-Ela DS Division (Disaster Relief Officer) | Mr. Upul Wijendra |
| 4 | Emergency Community Committee (Chairman) | Mr.Samantha Karunadasa |
| 5 | Emergency Community Committee (Member) | Mr. H. G Chaminda Pushpakumara |

The warning message appears like the next figure. When there is a warning, the warning SMS is coming from the following number from each base station.

As the warning message is not easy to understand, it is preferable that receivers save the number as “Weeriyapura Early Warning”. Awareness activities and evacuation drills utilizing the siren with cooperation of DDMCU and DS division are essential for residents to effectively utilize the siren and warning SMS for evacuation.

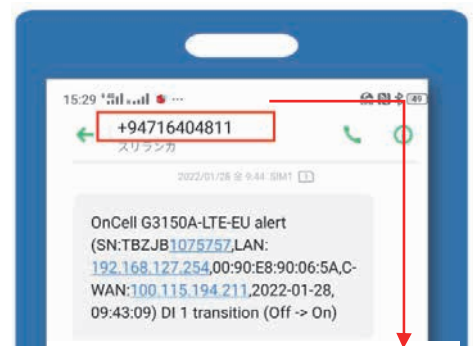


Figure 40: Example of Warning SMS

| Location | Base Station |
|-------------|----------------|
| Weeriyapura | Base Station 2 |
| Imbulgoda | Base Station 1 |

Responsible person in maintenance

LRMS needs to be maintained with cooperation efforts among NBRO EWC, NBRO District office and residents. Role of each actor is as described in the following figure. The responsible personnel of residents are listed in the next table with their respective role.

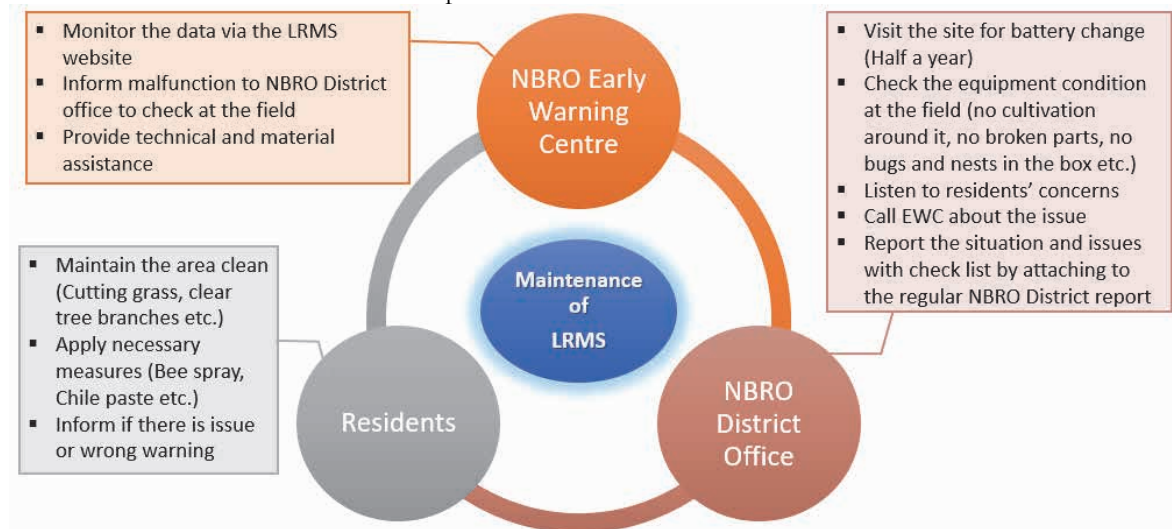


Figure 41: Role of each actor for LRMS maintenance

Table 18: Responsible personnel for LRMS maintenance from residents

| Responsible personnel for LRMS maintenance | | |
|---|---------------------|----------------|
| Emergency Community Committee (Secretary) in Imbulgoda | Mr. Karunaratha | Base Station 1 |
| Emergency Community Committee (Chairman) in Weeriyapura | Mr. Ruwan Pathirana | Base Station 2 |

6.4. Securing Evacuation Place and Route

Evacuation places are designated on ahead. The evacuation places must be located outside of the Yellow/Red areas as well as other disaster risky areas. Safeness of evacuation routes shall be also considered when the evacuation places are designated. Information of the designated evacuation place, evacuation route and appointments are archived by DS division and DDMCU. Necessary appointments, such as generators, blankets and emergency provisions, shall be stored in the evacuation places.

At the workshop with Weeriyapura and Imbulgoda community members on 11th March 2022, the school which is proposed as one of the evacuation centres is also has a risk of sediment disaster. Reconsideration of safe evacuation place and route by DDMCU and NBRO are necessary.

Evacuation Place for Weeriyapura

1. Weeriyapura temple
Note: Elderly people need assistance to reach to the place since it is a very steep area.
2. Sri Dumindaramaya temple
Note: People can evacuate to this place.
3. Siri Sumana school
Note: People can evacuate to this place.
4. Sri Rathanapalaramaya temple
Note: People can evacuate to this place.

5. Rockhill Community Hall
Note: people can evacuate to this place.
There is not enough space to evacuate to people

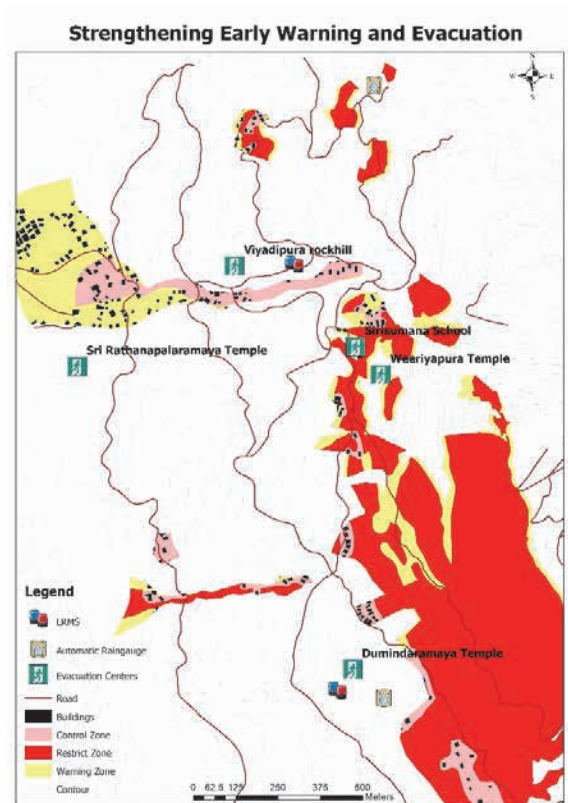


Figure 42: Map indicating evacuation places in Weeriyapura area



6.5. Awareness Activity for EW

In Weeriyapura, some evacuation drills and awareness programs are held by DDMCU after sediment disaster in 2011. However, drills have not conducted after 2011. Smooth and timely warning dissemination from NBRO and GN officers to local community through Emergency Community Committee shall be strengthened by the evacuation drill. In addition, as LRMS is installed in Weeriyapura, sounds of the alarm, receiving warning SMS and actual procedure of the evacuation shall be notified to local peoples by the drill. Simultaneously, awareness meeting is held to train for local peoples to understand meaning of landslide hazard maps, NBRO landslide early warning, LRMS equipment warning and necessary preparedness.

Necessary actions to strengthen early warning and evacuation are;

- Designation of safe evacuation places and routes considering landslide hazard maps with DDMCU and NBRO
- Procurement of necessary appointments in the evacuation places
- Awareness meeting and evacuation drill once a year to ensure the warning dissemination and evacuation



Management plan



7. Long-term management plan

7.1. Land use management plan

The Restricted zone and Control zone should be free from the settlements, and it has high risk due to sediment disaster. The future land use plan should be aimed to convert the existing land uses such as scrub, tea, homestead and rock in the Restricted and Control zone into forestry type land use categories.

7.2. The land value management plan

The council should be posed to implement a land value management plan for the Weeriyapura area by producing legal by-laws. These by-laws should be including the following key Articles.

Article 1: Principles.

- Public interests in land are superior to private interests
- Land-uses shall be in accordance with uses appropriate to an area's natural, social, economic, and cultural conditions
- Speculative investments in land shall be restrained
- "Appropriate burdens" shall be placed on parties profiteering from increases in land prices

Article 2: Land price

- Limited and vital resource for citizens and forms a fundamental basis for citizen activities.
- Price of land affects trends in population, industry, land-use, social capital, and facilities, and can change social and economic conditions.
- Land prices affect the public interests.

Article 3: Land use plan should be area specific.

- Land-use must be in accordance with uses appropriate to an area's natural, social, economic, and cultural conditions.

Article 4: Speculative investments shall be restrained.

- Some authorities have interpreted "speculative investment" as buying for the sake of selling at a later date.
- purpose of controlling the land market for a purported public good.

Implementation



8. Implementation

8.1. Action Plan

The implementation plan specifies the projects and the project budgets for implementation of land use plan, countermeasure facilities and strengthening early warning and evacuation system in the target area. The target years are also indicated with consideration of terms of Municipal councils. The main body of implementation is Badulla MC with supports of DS Divisional Secretariat, NBRO, DMC, UDA and other central agencies.

Action Plan for LSDRRP in Weeriyapura

| No. | Item | Contents of the Measures | Responsible Agencies | Budget | Short Plan (to 2023) | Mid Plan (to 2025) | Long Plan (to 2030) |
|---|--|---|----------------------|----------------|----------------------|--------------------|---------------------|
| 1. Implementation of land use plan | | | | | | | |
| 1-1 | Implementation of land use plan and regulation | Badulla PS organizes stakeholder meeting to introduce land use regulation in Weeriyapura area in collaboration with DS Divisions | LA (DS Division) | to be assessed | | | |
| 1-2 | | Badulla PS organizes workshops in Weeriyapura in order to raise awareness of the local residents | LA (DS / GN) | XXXXXX | | | |
| 1-3 | | Badulla PS develops By-law to implement the plan and the guide for development regulation | LA | to be assessed | | | |
| 1-4 | | Badulla PS promotes retrofitting of the existing houses in the control zone in cooperation with NBRO | LA/NBRO | to be assessed | | | |
| 1-5 | Up-scaling LSDRRP into the other area in PS | Badulla PS expands LSDRRP into the sounding area especially Ihalagama based on Yellow/Red zoning provided by NBRO | LA (NBRO) | to be assessed | | | |
| 1-6 | | Badulla PS develops local disaster risk reduction plan in cooperation with DDMCU and incorporate LSDRRP into the plan. | LA (DDMCU/NBRO) | to be assessed | | | |
| 2. Risk reduction measures | | | | | | | |
| 2-1 | Construction of Sabo facilities as the measure to reduce debris flow risks | Badulla PS officially requests NBRO or other concerned agencies to conduct technical study for Sabo facilities in Weeriyapura. | LA (NBRO) | to be assessed | | | |
| 2-2 | | NBRO and other concerned agencies conduct technical study for Sabo facilities in Weeriyapura | NBRO | to be assessed | | | |
| 2-3 | | Central government secure implement construction of Sabo facilities in Weeriyapura | Central Government | to be assessed | | | |
| 2-4 | Promotion of nature-based landslide risk mitigation project | NRBO implements nature-based landslide risk mitigation project in collaboration with ADPC. | NRBO (L.A) | to be assessed | | | |
| 2-5 | | Badulla PS and GN introduce tree barriers along the border of restricted zone in order to prevent migration in the zone and to control the flow. | LA / GN | to be assessed | | | |
| 3. Early warning and evacuation system | | | | | | | |
| 3-1 | Strengthening landslide early warning and evacuation system | Badulla PS monitors maintenance activity for LRMS by responsible personnel in Weeriyapura with NBRO. | LA/ NBRO/ECC | to be assessed | | | |
| 3-2 | | Badulla PS identifies the safe evacuation center and routes in Weeriyapura and equips necessary facilities with consultation of DDMCU and NBRO | LA/ DS/ DDMCU/NBRO | to be assessed | | | |
| 3-3 | | Badulla PS and DS Divisional Secretariat conducts community workshops and evacuation drills by utilizing LRMS equipment in cooperation with DDMCU | LA/ DS/ DDMCU/NBRO | to be assessed | | | |
| 3-4 | | Badulla PS, DS Divisional Secretariat, Emergency Community Committee and DDMCU attend a maintenance meeting for LRMS equipment lead by NBRO EWC and District office before rain season starts | LA/ DS/ DDMCU/NBRO | to be assessed | | | |

8.2. Role and Responsibilities of Concerned Agencies

The following figure shows interactions among LA, DS Divisional Secretariat, GN Division and NBRO in non-designated area by UDA. LA will revise the existing land use plan where land use plan was already developed or develop new land use plan where land use plan is not yet developed. Inputs such as disaster risk related information from NBRO and inputs such as community information from GN are provided to LA.

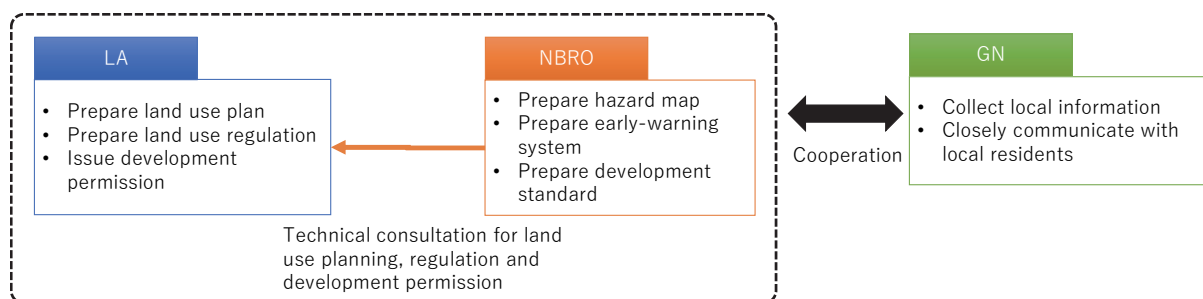


Figure 43: Interaction among LA, DSD, GND and NBRO

Roles & Responsibilities

Table 19: Roles & responsibilities

| Organization | Role and Responsibilities |
|-----------------------|--|
| NBRO | <ul style="list-style-type: none"> ▪ NBRO prepare the sediment disaster hazard map based on the Guideline for Disaster Resilient Land Use Regulation/Development Standards. The map shows red/yellow zone (or 4 zones). ▪ Regarding to land use in high-risk area, NBRO prepares development standard, which is explained in the Chapter 4. ▪ NBRO helps early warning and evacuation system in high-risk area. The early warning system includes installment of rain gauge, alarm, evacuation plan and disaster drill and education together with DDMCU ▪ NBRO provides consultation to LA for land use plan and land use regulation based on the hazard assessment in the planning area. ▪ NBRO provides consultation to the local authority for development permission in red and yellow zone. |
| LAs | <ul style="list-style-type: none"> ▪ LA prepares development plan including land use plan as designated in the Town and Country Planning Ordinance. It is recommended to take into account the hazard map and development regulation prepared by NBRO in this process. ▪ The local authority issues development permission based on the development plan prepared by LA. It is recommended to take into account the hazard map and development regulation prepared by NBRO. If the development plan does not incorporate enough consideration about disaster risk management, it is recommended to add further land use regulation based on the hazard map by bylaw. |
| Grama Niladari | <ul style="list-style-type: none"> ▪ Provision of data |

NBRO consultation menu

- Prepare hazard map
- Prepare early warning system
- Prepare development standard
- Inspect land use plan in the aspect of hazard and risk management
- Prepare draft land use plan
- Prepare land use plan and regulation in special projected area
- Hold workshop, seminar, etc. for local residences' understanding of hazard map and regulation

- Prepare evacuation plan
- Hold disaster drill and disaster education program for local people

LA

LA prepares development plan including land use plan as designated in the Town and Country Planning Ordinance. It is recommended to take into account the hazard map and development regulation prepared by NBRO in this process.

The local authority issues development permission based on the development plan prepared by LA. It is recommended to take into account the hazard map and development regulation prepared by NBRO. If the development plan does not incorporate enough consideration about disaster risk management, it is recommended to add further land use regulation based on the hazard map by bylaw.

GN

GN takes important role to collect information and facilitate understanding and communication with local people. As the hazard mapping is sensitive and influential to local people's life, it is important to have appropriate communication including workshop, seminar and inspection of hazard map between the relevant parties and public.

8.3. Monitoring and Verification

The monitoring and verification of the action plan is fully responsible of Badulla MC. Municipal council members will closely monitor the implementation of each item in the action plan, and necessary countermeasures will be taken by Badulla MC.