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# North-East Monsoon Rainfall Induced Landslide Hazard and Nonstructural Preparedness

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**Abstract:** This study reveals the scenario of landslide hazards and non-structural preparedness among the community. During the NE monsoon rainfall in 2012, the study area experienced a high level of risk from landslide occurrences. Due to the lack of preparedness, people were not alert enough in the pre-disaster stage. Since the study area has been identified as a high risk area, potential landslides could be expected in the future as well. Therefore, it is necessary to be prepared for landslide hazards, in order to reduce the impacts to minimum level.

**Keywords:** NE Monsoon Rainfall, Landslide, Impacts, Risk, Preparedness

## Introduction

Sri Lanka, as a small highland, is facing serious threats from various types of natural hazards such as floods, droughts, landslides and extreme weather conditions due to its different types of physical features. Among them, the landslide is one of the very common natural hazards in the country. Sri Lanka has been experiencing a spate of landslides over extensive areas of the central hill country and south western region since the early eighties (*Amaratunga, 1994*). World Atlas of Natural Hazards also states that, landslides are the most frequent and widespread natural hazard on Earth (*Jelinek. R, et, al, 2007*). The term 'Landslide' is restricted to movement of rock and soil in the broad range of velocities even slow movements which are rarely a direct hazard to life can destroy buildings or break buried utility lines (*Kularathna, 1998*). Some landslides move slowly and cause damage gradually; whereas others move so rapidly that they can destroy properties and take lives

unexpectedly. The threats which caused by landslide events in Sri Lanka are considered to have significant negative consequences on various sectors which are highly depending on environmental conditions.

In general, landslides are associated with the periods of heavy rainfall. History of Landslide events in Sri Lanka clearly indicates that continuous and intensive rainfall has triggered a number of catastrophic landslide events in the hill country region. This tendency has attested by most of the Sri Lankan researchers with apposite verification. North-East monsoon, which is one of the predominant climatic seasons in Sri Lanka, having variability in rainfall, brings extreme weather conditions to Sri Lanka in the recent past. Accordingly, during the recent North-East monsoon rainy season in Sri Lanka which started in the month of December 2012 aggravate the situation of the country by causing a significant number of natural hazards such as landslides and flood events. Those negative situations were caused not only profound harm to the lives and properties but also severe decrease in economy and social development of the country.

This status clearly indicates that the impacts of landslide hazards drive the people into high risk and socioeconomic structure of the people is becoming worse. Thus, it is necessary to take appropriate remedial actions to avoid the impacts of landslide hazards. The people who are living in landslide prone areas should be guarded from the losses of lives and properties. In general, lack of mitigation and preparedness measures cause high level of impacts, besides mitigate or prevent the landslides will not be possible always. However, by implementing proper

preparedness measures, the impacts of landslide hazards can be reduced. Though, the landslide events usually occur with a short notice, it can be predicted. Because of that, preparedness phase is becoming as a most important part in the disaster management.

Preparedness is shortly defines as planning how to respond to a hazard. This phase involves two main parts which are structural preparedness measures and non structural preparedness measures. Preparedness measures include preparedness plans; training; warning systems; communication system; evacuation plans and training; resource inventories; and public information /education (International Strategy for Disaster Reduction (ISDR), 2012). Part of this preparedness depends on how the community has the knowledge and how they respond to landslide hazards (Iyengar, 1998). Accordingly, this research addresses an important problem in the pre-disaster stage and particularly discusses the non-structural preparedness towards landslide hazards.

## Background of the Problem

The Matale District situated above 2147 feet from Mean Sea Level (MSL) experiences a number of landslides and subsequent floods due to the intensive rainfall in this period. Several areas in the Matale district were affected by landslide occurrences caused a number of deaths, displacement and damages to the properties. Among them Rattota is a key area which faced severe negative circumstances due to landslide hazards. Eight deaths were reported and 3,242 persons belonging to 1,029 families were displaced. They have been accommodated in 14 temporary shelters. The Ministry of Disaster Management has allocated over Rs.2.5 million additional funds for disaster relief in the Matale district. These records showed that, the people living in landslide prone areas of Rattota had a vulnerable situation from landslide hazards which were triggered by last North-East monsoon rainfall. On the other hand, these catastrophic events have caused huge impacts on the economy and social structure of the people in this district.

Through the investigation carried out in landslide prone areas especially in Ukuwela, Rattota and Naula,

it has been ascertained that 127 areas in 29 GN Divisions have a high risk of landslide events in Matale District (NBRO, 2012). Most of them are belonging to the Rattota DS Division. Bodhikotuwa, Alakolamada, Punchiselvakande, Kandenuwra West, Kandenuwara East, Madakumbura, Dhambagolla, Hungrankandha, Velangahawatta, Bambarakiriyella are some areas that have been identified as high and moderate risk area for landslide hazards. Out of them, Punchiselvakande and Kandenuwara East have been selected for this particular study to analyze the scenario of landslide hazards and non-structural preparedness level towards the landslide hazards.

Accordingly, the research question of this study is, how the people were affected by NE monsoon rainfall induced landslide hazards in December 2012 and how much they are ready to face the landslide hazards to be occurred in future. The objectives of this research are to understand the scenario of North-East monsoon rainfall induced landslide hazard, identify the impacts and to assess the level of non-structural safety and preparedness measures towards the landslide hazards.

## Materials and Methods

Since the study primarily focusing on the scenario of landslide hazards and the preparedness level, disaster management theories were applied to this study. Out of the major phases of the disaster management cycle, considerable priority has been given to the phase of risk reduction to analyze the preparedness level. While identifying the scenario, these study mainly emphasizes on non-structural measures like awareness, knowledge and practices among the community. Though, the study deals with both primary and secondary data, primary data were the fundamental data source of this study. These data were collected through key informant interview, focus group discussions and questionnaire survey. Among them, a questionnaire survey was occupied as key primary data collection method for acquiring information on the experience of affected people and the preparedness level towards the landslide hazards. Apart from this, group discussions were carried out with the community to identify the general picture of

the preparedness. Key informant interviews were conducted with a social development officer and rural development officer of the Rattota DS division. In addition, secondary data were also accommodated to understand the nature of problem, impacts, affected families and provided reliefs to those families. 30 families were selected from the affected families through purposive sampling techniques for the survey. Collected data were analyzed through quantitative and qualitative analysis methods. Ranking and descriptive methods specifically used to analyze the qualitative data. This qualitative analysis part identifies why these communities are having problems and how they are going to face forthcoming landslides.

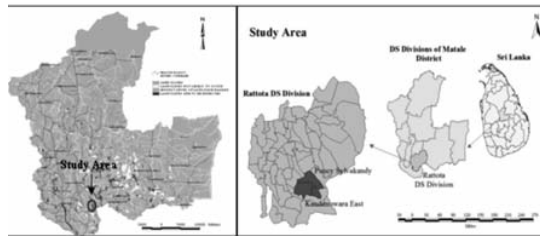
### Study Area

The study area is situated in the southern part of the Matale district in Central Province of Sri Lanka. The total land extent of the study area is about 478ha. The study area experiences frequent rainfall almost throughout the year. Since the study area belongs to Upcountry Intermediate Zone, it receives annual rainfall of about 110 inches during both southwest and Northeast Monsoons. The average temperature is about 18°C. Both Punchiselvakande and Kandenuwara East are tea estates; majority of the people who lives in these estates are working as estate labors with low income. Each of these areas has specific and different economic and socio cultural characteristics. The workforce comprises of 266 workers, who are on daily paid. Location map of the study area is shown in figure 01. The study area is also shown in landslide hazard map of Matale district prepared by the National Building Research Organization.

### Results and Discussion

The study revealed that the study area has been experiencing a significant number of small and large scale landslide hazards and identified as a high risk area for landslide hazard by the National Building Research Organization. Figure 02 shows the 3D map of the study area and it indicates that, the eastern part consists of the higher elevation of more than 1000m. Northern and western parts consist of valleys and low-lying areas. Occurrence of the slope failures in the

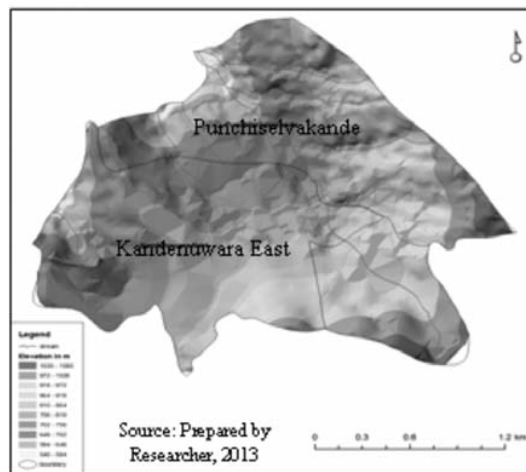
**Figure 1: Map of Landslide Hazard Zones and Location map of the Study Area**



Source: National Building Research Organization (NBRO)  
Source: Prepared by Researcher, 2013

rainy season is a common phenomenon in this area. It differs from smaller scale earth slide to larger scale rock falls. It is important to note the history of landslide hazards where there was a huge landslide occurred in the study area in 1983 causing 13 casualties and severe damages to lives and properties.

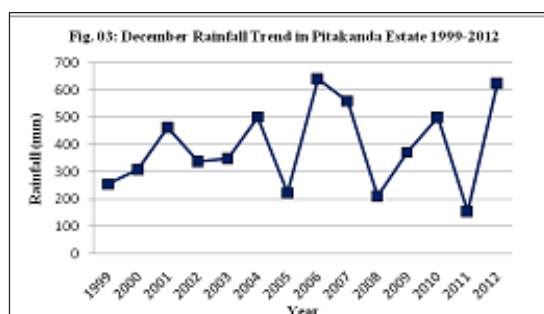
**Figure 2: 3D Map the Study Area**



Although, smaller scale slope failures typically occur along the roads and the slopes in this area, during December 2012 North-East rainfall aggravate the disastrous situation. The natural factors of study area such as topography, geology, slope types, soil structure and tributaries are mechanically leading to high potential landslide hazards. However, intensive and continues rainfall is the major triggering factor for several landslide occurrences which were experienced during last northeast monsoon season.

Figure 03 shows the average annual rainfall statistics of the study area from 1999 to 2012. During this period, the month of December has received more than 600 mm rainfall in both 2006 and 2012. This short term high intense rainfall in 2012 has direct relationship with occurrence of landslide hazards in the several parts of the study area. As per the global trend, there is going to be a particular increase in rainfall intensity in Sri Lanka. Recently antecedent rainfalls and short term high intense rainfalls have become a general weather condition in the country (Rathnaweera, et, al, 2012). During the last ten years it has become evident that most devastating landslide events tend to occur as a result of comparatively short duration, high intense rainfall compared to the previously had lower intense prolonged rainfalls in Sri Lanka (Ibid). This will lead to the potential landslide hazards as increasing trend.

**Figure 3:**  
**December Rainfall Trend in Study Area**



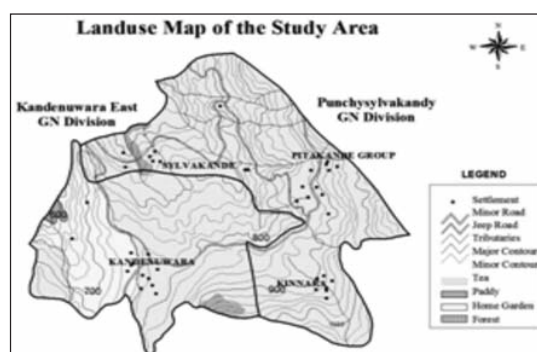
Source: Reports of Pitakande Estate and Meteorological Department Data

Apart from natural factors, anthropogenic factors also contribute to the landslide occurrences in this area. More than 85% of the land area is utilized for cultivation, particularly tea. The slope areas of the mountain region have been entirely changed by human interventions. Figure 04 illustrates the land use pattern of this area. In addition to agricultural activities, clearance of land and construction of the houses on the slope areas are foremost factors which are influencing on the slope failures. Due to this hazardous situation, a significant number of houses have been identified as high and moderate risk for

landslide hazards. Among them 33 houses have been identified in high risk areas in Kandenuwara East and Punchiselvakande GN divisions and it have been pointed out in table 01. These statistics are clearly notified that, the landslide hazards will become a serious issue and the severity of the problem will be leading to high vulnerability in the future.

This Disastrous situation caused significant impacts to the community. During the phase of landslide hazard, the community was helpless. Intense rainfall blocked the transportation by causing rock slides along the roads of the study area, and it caused complicated situation to the officers of local authorities to guard the people from hazardous situations. However, next to the clearance of the blocked roads, they could manage to reach the affected areas and direct the people for the safeguard. Subsequently, people were asked to move to the nearby school by local authorities and they were accommodated in

**Figure 4:**  
**Land use map of the Study Area**



Source: Prepared by Researcher, 2013

Pitakande Maha Vidyalayam. Those affected people faced lots of challenges when they were asked to displace. Even as rank the impacts of landslide hazards based on the priorities, loss of lives (two children) comes first. Next to that, loss of houses, displacement, fractures and cracks in the houses, loss of livestock, are some important impacts aroused due to this hazard.

**Table 1:**  
**Number of Houses identified in Landslide Risk Areas**

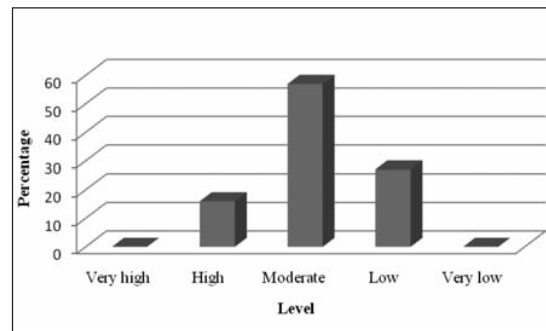
Division	Land Extent (ha)	High Risk	Moderate Risk
Kandenuwara East	195.77	23	09
Punchiselvakande	283.52	04	05
<b>Total</b>		<b>33</b>	<b>30</b>

Apart from the primary impacts, secondary impacts also significantly affected the community. Among them the impacts which were arising from the camp (school) enduring still. Secondary impacts such as loss of income, employment, shortage of food and drinking water, impacts on education of the school children, difficulties arise from camps such as conflicts, disturbance, privacy related issues, psychological problems, and dependency are vital. Next to the incident three weeks later, most of the families were relocated in their own houses again; still, twenty one families were accommodated in the school with the expectation of alternative houses. Qualitative analysis of the satisfaction level of reliefs provided indicates that 27% of the community were satisfied with the relief while 67% with moderate satisfaction. The people who were not satisfied with the relief were very low (6%). This percentage shows that, the majority of the community people were with moderate satisfaction and considerable assistance has been provided to the community. Even though the local authorities and other institutions endowed with reliefs to resolve the existing needs of the people, their problems are still lasting as unsolved. The role of non-structural preparedness level of this community is the most important factor which determining the impacts.

The study reveals that the community's awareness, knowledge and practices towards landslide are not in a satisfactory level due to their socioeconomic conditions. This level is identified by means of knowledge on past landslide, symptoms and causes of landslide hazards and mitigation measures. Results revealed that the knowledge on the past

landslides is relatively better among the community. However, some people in the study area are unaware of the past landslides and landslide processes prevalent in this area. Meanwhile the community's awareness of the signs of the landslide was relatively low in pre-disaster stage.

**Figure 5:**  
**Knowledge on Past Landslide in the Study Area**



Source: Field study, 2012/13

Though, study area undergone landslide problems in the past, people were unaware of the symptoms of the landslide. After the occurrence of landslide in December 2012, the community could be able to identify the warning signs. The main signs identified by the community were, formation of fractures, sliding of soil and rock, increase in water level, the formation of water source, turbidity of water, and formation of mud water through fractures. Discussion with the community clearly indicates that they are aware of signs after the landslide event via virtual experience. Table 02 shows the difference between the awareness of the symptoms of landslide hazards in pre and post disaster phases.

**Table 2:**  
**Signs of the Landslide Hazards identified by the community**

Category	Pre-disaster stage	Post-disaster stage
Below than two ( $\leq 2$ )	72.6%	36.3%
Between three to four (3-4)	26.4%	39.6%
More than five ( $\geq 5$ )	-	23.1%

Source: Field study, 2012/13

Similarly, the community was not conscious with the factors responsible for landslide hazards in this particular area. The majority of the community, pointed out that, rainfall is the main triggering factor of slope failures, but they were unaware of human factors which are responsible for that. This implies that, they completely deem that human intervention on the slopes will not trigger the landslides. This can be demonstrated through the several improper human interventions which already incorporated on the slopes. For an example, houses have been constructed on the steep slope area which already undergone landslide problem without the approval from the relevant authorities. Even though, relevant authorities instructed the people to avoid the constructions, activities were taken place due to several necessities of the community.

Due to the low level of awareness of the community on the precise causes and the warning signs of landslide hazards, the steps to be taken during the periods of heavy rainfall were not taking place. Even after the identification of the signs, they didn't take immediate action to move to safer places due to the ignorance and dispassion. While continuing the intense rainfall and NBRO's landslide warning; the people were staying at their house; even after they accommodated in camps, some of the people in particular, males having the practice to go their houses to sleep at night and they back to the camps next day. This kind of dispassion happened due to the improper guidance and awareness. Being a community with a very poor educational background, they face lot of challenges to understand the instructions given by the authorities, such as understanding and language problems etc. However, it could be noticed that, younger generation, in particular school children; have considerable knowledge of the signs and causes, mitigation measures than the elder people to a certain extent.

This community believes that; the landslide is an unavoidable hazard and it cannot be mitigated; moving to the landslide free zones is the best solution to get protection; but, they have no choice of alternative lands, houses and livelihood. Also majority of the people were not interested to move to a different place

due to their traditional occupation. As mentioned earlier, though, the reliefs have been provided soon after the incident, awareness programs were not conducted in this community. Apart from above mentioned non-structural preparedness measures, structural measures also inadequately practiced in this area. With the proper slope management measures most of the slope failures which occur in this area can be mitigated. However, none of such practices were implemented yet, besides, such structural practices require advanced technical approach and also it is very expensive.

## Conclusion and Recommendations

December 2012 rainfall induced landslide event which caused a number of negative impacts to the community and there are potential landslides can be expected in the future as well. Though the government has taken several steps to improve the existing mitigation and preparedness level; impacts of the landslide hazards have not reduced yet in the study area. Particularly, the National Building Research Organization has undertaken a number of programs to reduce the risk. However the devastation of the last event occurred in December 2012 reminds that landslide problem has not resolved yet. Therefore the community has to be prepared to reduce the high level of vulnerability. If proper attention is given by the relevant authorities considering the economic condition, educational level and language of the community, impacts of landslide hazards could have been minimized. Therefore, the study clearly enlightens that vulnerable community has less awareness and hence need more attention towards more focused preparedness programs. The following recommendations will support to reduce the impacts and improve the preparedness level of the community.

- o Develop the sustainable slope management practices in the high slope area and implement different types of landslide hazard risk reduction measures for different parts of the slopes

- o Minimize the human intervention on the hill slope region through stringent legislation or by appropriate awareness programs, particularly, construction of houses in the steep slope area should be avoided
- o Provide proper trainings to build the knowledge and undertake necessary actions to avoid improper human interventions on slopes.
- o Provide alternative lands and livelihood facilities in secure places according to their preference
- o Strengthen the skills of the community through appropriate and sufficient awareness program towards risk reduction
- o The community should aware of their vicinity, landslide processes prevalent in the area and potential sites for landslide hazards
- o Educate the public on the causes, symptoms and the mitigation measure of the landslides and people should be trained to recognize immediate actions to be taken soon after the identification of the symptoms of landslide hazards, particularly, during the rainy season
- o More focused awareness programs should be implemented based on the socio-cultural characteristics of the community

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