Assessment of Governance Gaps in Landslide Risk Reduction—A Case Study from Kattippara Panchayath, Kozhikode District

K. Sreerekha and S. Jawahar Saud

Abstract Landslides are hazards which frequently occur and affect the life of human, animals and damage properties. Kattippara Panchayath is a highly landslide prone area in which landslides had occurred in different locations and public have been asked to stay away from this area. Currently there are no effective strategies to reduce the risks of landslides. A Geographic Information System has proved to be a useful tool for analysing and managing landslide related data. Landslide susceptibility map of the study area is prepared using Arc GIS software by combining some of the critical factors like land use pattern, geology, geomorphology etc. It can be used for assessing the risks of landslides, for developing early warning systems and mitigation plans. This paper seeks to identify the existing governance gaps in the study area, to ascertain the status of existing risk reduction measures available, the constraints associated with such measures, and thereby to suggest suitable measures to fill the identified gaps. This paper concludes with a synthesis of governance gaps and opportunities to reduce the risk of such disasters.

Keywords Landslide · Risk · Risk reduction · Landslide susceptibility map

1 Introduction

Landslides are major natural hazards which frequently occur and affect the life of human and animals, damage properties. Different phenomena cause landslides, including intense or prolonged rainfall, earthquakes, and a variety of human activities [1]. Landslides constitute a major natural hazard in India which accounts for considerable loss of life and damage to communication routes, human settlements, agricultural fields and forest lands [2]. The Western Ghats of Kerala are highly fragile

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and are under repeated threats of landslides. Kozhikode is the worst affected district with respect to the number of landslide incidences, casualties and property loss [3]. Landslide can happen unexpectedly and in most cases it become worse due to lack of proper governance. Governance is cited as the most recommended landslide disaster risk reduction component [4]. As governance, in general, refers to the processes of decision-making and implementation, risk governance applies the principles of good or sound identification, assessment, management and communication of risks. Governance is a crucial point for proper planning and implementation; it would require bringing together engineering, environmental and communities in a joint effort [5]. The analysis and management of landslide related data can be made easier with the help of Geographic Information System (GIS). Landslide susceptibility map of the study area can be prepared using Arc GIS software by combining some of the critical factors like land use pattern, geology, geomorphology etc. It can be used for assessing the risks of landslides, for developing early warning systems and mitigation plans [6]. The main objectives of this works are established (1) to identify the governance gaps in landslide risk reduction activities in the study area (a) to generate landslide vulnerability zonation map using remote sensing and GIS techniques (2) to understand the status of existing risk reduction measures in the study area (3) to identify the governance gaps related to landslide risk reduction in the study area.

Many areas of Kerala are prone to frequent landslides in the past because of intense rainfall. These landslides, year after year bring about untold misery to human settlements apart from causing devastating damages to transportation and communication network [7]. This work gives the detailed analysis of accessible data from the study area which helps in creating awareness among people about the current visible risks, and to identify the existing gaps in landslide risk reduction.

2 Selection of Study Area

Kattippara is a panchayth (Latitude 11° 47′ 08″ and Longitude 75° 92′ 13″) in Kozhikode district, Kerala. It is a village with a lot of hilly areas. As the name indicates, it is famous for hard rocks which we can find everywhere in this village. Kattippara Panchayath is a highly landslide prone and unstable area. The major source of income in this village is agriculture. Majority of the population depend on the agriculture crops such as rubber, coconut, ginger, pepper etc. A very minority only depend on business and govt. jobs. Kattippara has a generally cool humid climate with a very hot season extending from March to May. The average annual rainfall is more than 3500 mm and it is the highest rain fall in this region. According to 2011 Census report, the population in the study area was 30,123 and the population density was 1400/km^2. On 14 June 2018 a major landslide in the form of debris flow along with mudslips erupted in 8 different locations of Kattippara Panchayth. 14 persons were killed and many others injured, 14 houses were totally washed out, 20 houses were partially damaged and transportation systems as well as communication systems were badly affected by the landslide. The triggering factor for this landslide

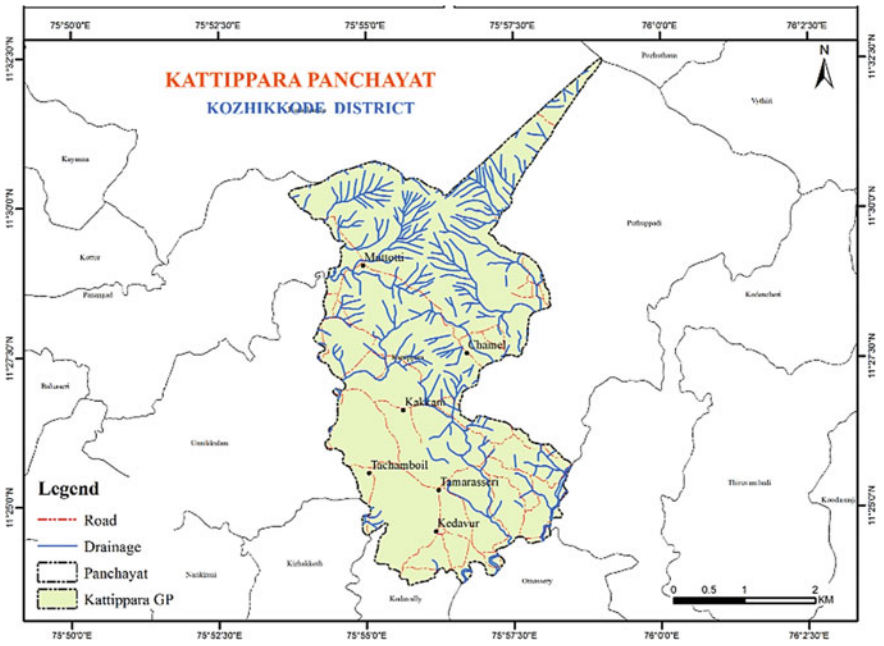

Fig. 1 Base map of the study area. *Source* GSI

was the action of quarrying and intense rainfall. Still people are residing in this area and currently there are no effective strategies to reduce the risks of landslide. The base map of the study area is shown in Fig. 1.

2.1 Data Collection

The data collections were carried out in two stages, one through developing the landside hazard zonation map and another one was the administration of questionnaire survey. Based on the past and landslide in the study area different survey techniques were used for data collection directly from the affected victims, local bodies, respective authorities of disaster prone areas etc.

2.1.1 Questionnaire Preparation

Two types of questionnaires are prepared, one for authorities and other for residents of Kattippara Panchayth. While preparing the questionnaire both open ended as well as closed ended questions were used. Three point likert scale questions were used in the survey. Questions were generated in such a way to collect the maximum data

considering people knowledge, experiences, thoughts, and their role during disaster, to identify the governance gaps and to generate the hazard zonation map etc. Total 600 responses were collected from the community survey. The responses of questionnaire survey were then analysed using SPSS software.

2.1.2 Collection of Different Maps for Generating Landslide Susceptibility Map

Landslide zonation is commonly shown on maps, which display the spatial distribution of classes (Landslide Zonation). Landslide zonation refers to "The division of the land in homogeneous areas or domains and their ranking according to degrees of actual/potential hazard caused by mass movement" [8]. For the preparation of landslide hazard zonation map different maps are collected they are Slope map, Soil map, Land use and land cover map, Geomorphology map, Geology map, Drainage density map, Relief map. After collecting all these maps then it is overlaid in Arc GIS software to get the final landside hazard zonation map.

3 Results

3.1 Analysis of Questionnaire Survey

The statistical method of analysis was carried out using Statistical Package for Social Science (SPSS) [9]. Since for developing an effective Disaster management plan for an area, a proper study regarding the risk factors, capacity of the exposed community etc. should be determined. Total 600 responses were collected from the study area. The following figures show the personal details of the respondents (Figs. 2, 3 and 4).

From these figures it is clear that most of the respondents are male (51%). Most of the respondents fall in the age category 30–55 (39%) and more than 55 (39%). Figure 4 compares the educational qualification of the people. From this figure it is clear that majority of the people have school level education, nearly 12% of the

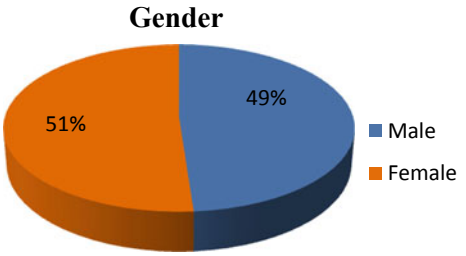

Fig. 2 Gender of respondents

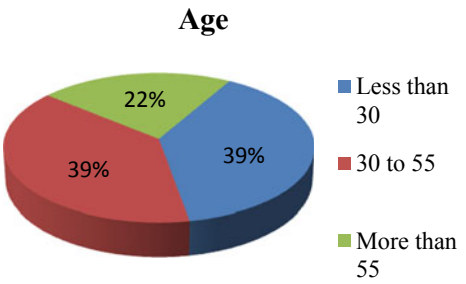

Fig. 3 Age of respondents

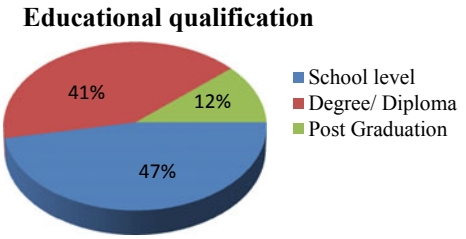

Fig. 4 Educational qualifications of respondents

respondents have post-graduation. So it says that lack of education plays a role in their poor awareness level about the risks of land slides.

3.2 Analysis of Questionnaire Using Chi Square Test

The chi-square test for independence, also called Pearson's chi-square test or the chi-square test of association, is used to discover if there is a relationship between two categorical variables [10]. In this study different question was taken as parameters and the relation between these parameters are found. The following figures show the relation between different parameters.

3.2.1 Age and Preparedness of People

Age and preparedness of people was tested to examine the influence of age on preparedness [11]. The results of Fig. 5, shows that people with age more than 55 are least prepared to face a disaster comparing with other two groups. This is may be due to lack of proper awareness programs from the authorities.

The evidences from the graph show that training programs and awareness sessions should be strengthened. It's very essential that young people have to be well trained to face a disaster because they can do a range of roles including response, recovery effort, and protection of others. So these training programs should be conducted by the role players for improving the preparedness and overall reliance of the people.

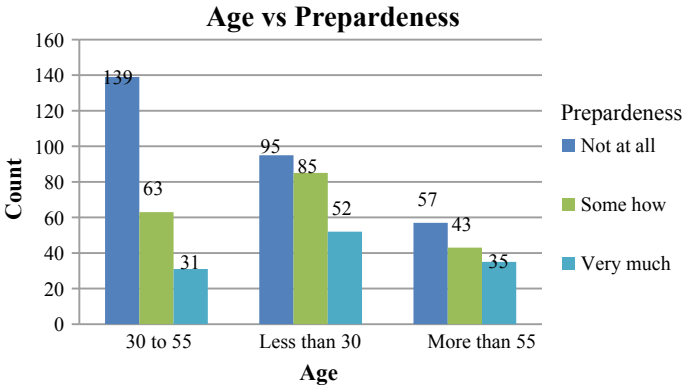

Fig. 5 Age versus preparedness of people

3.2.2 Frequency and Warning System

Both the frequency and the impact of landslide have been increasing for the past decades in the study area. When the frequency of landslides in the study area was tested against the status of warning systems it clearly depicts the warning system is not enough to tackle the slides. Landslides occur in the area 0–5 slides per year, but the early warning systems are not in place to provide warnings which leads to more risk to the community. From Fig. 6, a largest portion of respondents address the need for an early warning system. The successful implementation of early warning system can save lives to a greater extend [12]. In this study area landslide monitoring and dissemination of warning information remains a complex process where technical and communications skill should work closely together to overcome this constrain.

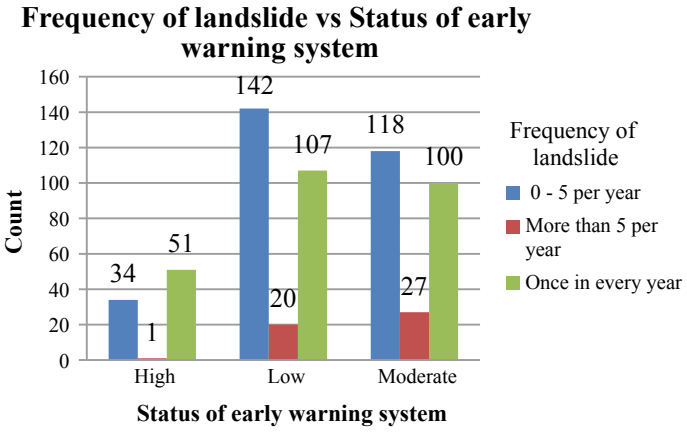

Fig. 6 Frequency versus warning system

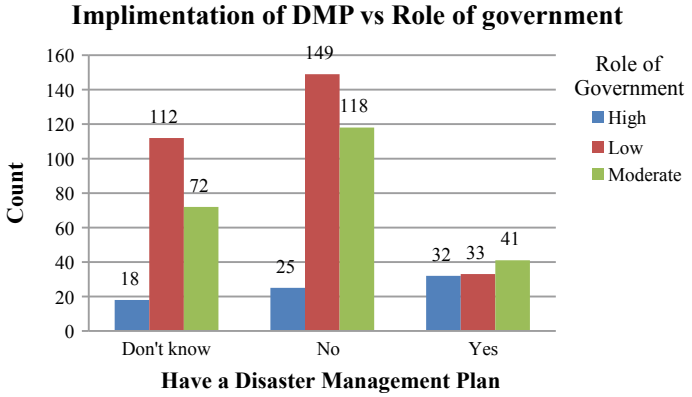

Fig. 7 Implementation of DMP versus role of government

3.2.3 Implementation of Disaster Management Plan and Role of Government

This test examines the implementation of disaster management plan (DMP) against role of government. Result of Fig. 7, shows that there is no effective disaster management plan in place to tackle the landslide and most of the people don't even know about DMP it clearly indicates the lack of awareness among people. This reminds that there is huge governance gap in generating enough awareness in people.

This shows the need of experts in the field of disaster management for proper planning and implementation of a DMP. It was found that a considerable portion of people in this area was neither accustomed nor comfortable with the regular conduct of mock drill exercises which are a prerequisite for the implementation of preparedness activities. This is a challenging thing that needs to be overcome to have a robust preparedness structure in this area.

3.2.4 Role of Government in Landslide Risk Reduction Activities and Relocation Programs in Risk Zones

When the role of government in landslide risk reduction (LRR) activities and relocation programs in risk zones tested the result of this examined parameters shows that (Fig. 8) there is no relocation programs in the place to protect the element at risk. People still resides in the vulnerable zones. They should be relocated to a safer place before a future landslide. Proper relocation programs should be taken in high risk zones.

From the survey it was clear that planned relocation programs in this area for the benefit of people at risk was not undertaken by the authorities. Lack of sufficient fund was the major reason behind this. Planned relocation programs should be carried out

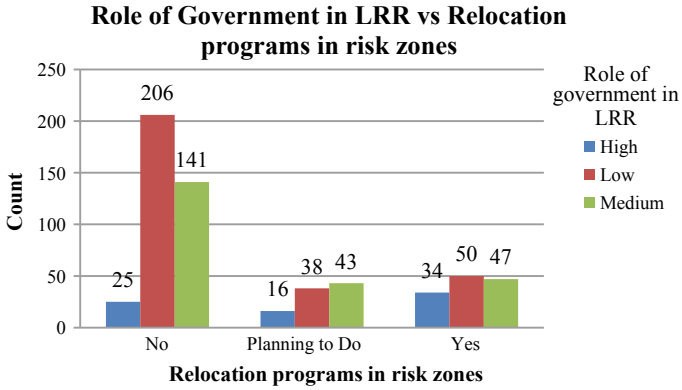

Fig. 8 Role of government in (LRR) versus relocation programs in risk zones

at individual, household or community level with in a right based frame work to ensure the safety of the people at risk.

3.3 Generation of Landslide Hazard Zonation Map

Better understanding of landslide prone areas will help people to live in harmony with the nature [13]. Since this study area is highly susceptible to landslides, preparation of landslide hazard zonation map (LHZM) is very important. This map will give the areas that are prone to landslides and the safe areas, which in-turn will help the administrators for planning and future development activities [14]. Generation of the LHZM with the help of Geographic Information System (GIS) environment could give better results and yield actual ground like scenarios for landslide hazard mapping [15]. The landslide hazard zonation map of the study area created using Arc GIS software is shown in Fig. 9. This map is generated by overlaying different maps one over other in Arc GIS software. The different maps used are Slope map, Soil map, Land use and land cover map, Geomorphology map, Geology map, Drainage density map, Relief map.

The incident landslides in Kattippara Panchayth are deep-seated landslides, which can be explained by the higher quantities of monsoon rainfall and illegal action of quarries in this area. The intensity of landslides is observed to have increased in the last 10 years. The occurrence of landslide was accelerated by anthropogenic disturbances such as deforestation, terracing and cultivation of crops lacking capability to add root cohesion in steep slopes. Invariably, in most of the failed slopes, natural drainage was blocked or modified without adequate provision for surface drainage. Unplanned developmental activities like conversion of agricultural land for the construction of buildings, road cuttings, cut and fill structures and withdrawal of toe support have also seen to increase the risk to the community from landslides.

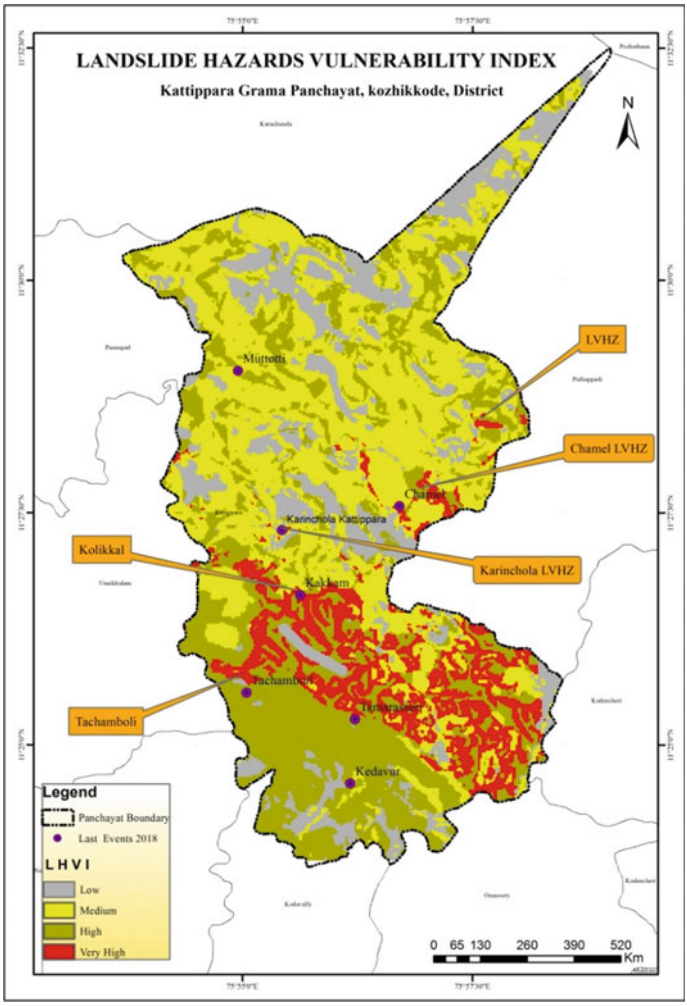

Fig. 9 Landslide hazard zonation map of the study area

The mapping of different parameters was done which influence in the occurrence of landslide. The resulting map shows High risk landslide prone areas of the study area. The landslide susceptibility map was validated by using landslide incidence points of the study area, and most of the incident points fall on the very high risk zone in the landslide susceptibility map.

Area in square Kilo meter and percentage of land involved in each risk zone is given in Table 1.

Most of the areas in Kattippara Panchayth fall in very high risk zone, high risk zone, and moderately risk zone shown in red, green and yellow colour respectively.

Table 1 Area and percentage of land included in risk zones

LHZ class	Area (km^2)	Percentage
Low	12.0	16.5
Medium	29.4	40.3
High	22.9	32.0
Very high	7.9	11.0

4 Discussions

Landslide is a natural disaster which causes severe damage to the life and the properties [16]. From the analysis of the questionnaire survey with the help of statistical methods and using different maps such as Slope map, Soil map, Land use and land cover map, Geomorphology map, Geology map, Drainage density map, Relief map etc. [17], LHZM was generated. Generation of LHZM using GIS techniques helped to find out the governance gaps in the study area. From the LHZM, it was estimated that the study area has highly unstable zones and are vulnerable to landslide activities [18]. The risk zones identified through the interaction with respondents during the survey correspond to the same risk zones of the landslide risk zone map. From this study it was observed that Remote Sensing and GIS technique can be effectively used in the preparation of hazardous zonation maps. The results confirm that the proposed LHZM will help planners and engineers to reduce losses of life and properties through prevention and mitigation measurements.

The results from the analysis show the existence of governance gaps. Most of the people were not sufficiently aware of the risks of landslides. The results of the questionnaire survey show the lack of awareness among the community. Public Awareness and Education Program for Landslide risk management were not periodically conducted by the local authorities of the study area. Similarly before any community action can be taken, residents needed some knowledge of the landslide. So this is the responsibility of the local government, no such activities or initiatives are taken from the side of local government in the study area. Residents were not taught about what is a slope, types of landslides, factor of landslides, triggers of landslides and key concepts on retaining walls and geological aspects and through seminars and public talks, the public will get a briefing of landslide.

As urban development invades the hilly areas, slope security is important to watch for signs of landslide [19]. Man-made structures after converting the natural slopes are becoming more and more prevalent in this area and they are not monitored which need to be routinely checked. Another major finding was maintenance or regular control over the physical condition of the house; it is simple to do, yet often neglected. Proper maintenance can make the difference between safety and disaster [20, 21]. In some cases the slope land was owned by private parties and the local authority will contact the landlord. In some cases, they may not respond and may be notified of the action. Lack of coordination among different authorities was identified as a major governance gap. The various authorities should coordinate and work hand in hand

with addressing the risk of landslides. It was found that, there are no prerequisites at the house hold level, such as Family Emergency Plan, to determine what everyone will do in the event of a home emergency. Through this study it is understood that people have never participated in a mock drill or community based disaster risk education programs. There are no mock drills or activities in this area run by the Authorities. Role of disaster management focal persons and disaster management committee members to prioritize, plan and implement measures to reduce human and material losses from potential landslides are trivial in this area. Based on the analysis of the data it is found that the conditions of drainage systems are very poor in this area, drainage systems have clogged and damaged. This should be corrected by the respective authorities along with the active participation of the community. Similarly there are areas in this Panchayath which have been identified for the provision of retaining wall but they have not been implemented by the authorities. It is evident that there is a need for greater fund allocation by the government for implementing preparedness activities at the grassroots level which is most important and missing factor in this area.

5 Conclusions

Landslides are one of the major disasters which affect 15% of landmass [22]. It leads to destruction of life and property [23]. Kattippara Panchayath is the most affected region in Kozhikode district during the past landslides. The triggering factors for landslide in this area are the illegal action of quarrying, the improper land use pattern and intense rainfall. The results of this work can be used to evaluate the consequences of land use change on landslide vulnerability and risk. The risk of landslide in this area can be reduced to a great extend with help of proper planning and the implementation of different landslide mitigation strategies such as provision of retaining wall, provision of efficient drainage system, implementation of early warning system, and development of awareness among community through mock drills, training programs etc. with the help of respective authorities. Lack of proper governance is identified as one of the major issue in the study area which should be bridged with possible mitigation strategies. The Landslide hazard zonation map of the study area was generated with the help of GIS techniques and this map identified the risk zones in the study area. The landslide hazard zonation map was validated by using landslide incidence points of the study area which were identified through the administration of the community survey. The generated LHZM shows that change in land-use pattern was a major triggering factor in the occurrence of landslide. The lands which were used for agricultural purposes have turned into construction work, and road work. From the analysis of data it was very clear that there are no enough measures or plans to deal with a future landslide. Lack of coordination among the authorities and that with the community in planning, prioritizing and implementing the risk reduction plans as well as illegal action off quarries were found to be a major issue in the study area. Involvement of communities in all the

phases of landslide disaster plays a crucial role in sustainable risk reduction. Lack of proper disaster management plan and training at different levels of people are one of the main gaps identified from this study, so all these indicates the need of such training activities, remedial measures, and the implementation of a proper disaster management plan. The need for coordination at the local level, inadequate early warning systems and a slow response time are also very important constraints for implementing preparedness plan in this area. The goal of the study was to identify the governance gaps and from the analysis of collected data such gaps are identified and explained. If sufficient data are available, the methodology used in this work can be used for evaluating landslide risk reduction activities in another vulnerable zone. The LHZM of such areas can be generated for developing and implementing suitable risk reduction strategies.

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