

Communication

A Brief Report of Pingdi Landslide (23 July 2019) in Guizhou Province, China

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Abstract: This short communication reports on a large landslide with a movement of 2 million m³ of soil and rock that occurred on 23 July, 2019 in the village of Pingdi, located in the county of Shuicheng, Guizhou Province, China. This landslide resulted in 42 deaths and 9 missing people. This report describes the preliminary investigation, rescue effort, and possible cause. The total rainfall in the 6 days prior to the landslide was 189.1 mm, which may be held responsible as the major cause. Some recommendations are proposed to reduce human casualties and property losses.

Keywords: landslide; pingdi; rainfall; recommendations

1. Introduction

As a result of global climate change and alteration of the natural environment by human engineering activities, the frequent occurrence of geological disasters has posed an enormous threat to both property and safety of humans [1–3]. According to a report, 130 million people were affected by natural disasters in 2008. Natural disasters also resulted in 589 deaths and 46 missing people and totalled 264.46 billion Ren Min Bi (RMB) of direct economic losses [4]. Landslides, which are major geological disaster, have frequently occurred in recent years, posing a significant risk to property and safety of people [5–7]. According to the National Bureau of Statistics (NBS), 5524 landslides occurred nationwide in 2017 [8]. Therefore, the early warning and prevention of landslides are of tremendous importance and are urgently required.

In recent years, with the development of Remote Sensing (RS) and the Geographic Information System (GIS), spatial information processing technology has been widely used in the evaluation of landslide vulnerability [9–15]. The combination of spatial information processing software and statistical analysis tools significantly improves the efficiency of data acquisition, processing, and analysis, and promotes the application of the state-of-the-art methods and models in evaluating landslide risks. In addition, a satellite image receiving system has been used to cover the entire country to obtain the information about geological disasters and a weather radar can be used to predict the possible rainfall in advance to warn humans against geological disasters [16]. Despite the efforts made by governments and researchers, it is still an enormous challenge to predict and/or prevent landslides. Recently, a large landslide (23 July, 2019) occurred in the village of Pingdi, Shuicheng County, Guizhou Province. This article presents a preliminary investigation of the Pingdi landslide. In this article, the landslide and rescue measures are presented, the main causes of the landslide are discussed, and recommendations are provided to reduce human casualties and property losses.

2. Methodology

2.1. Preliminary Investigation

A large landslide occurred in Pingdi village at approximately 9:20 p.m. on 23 July (see Figure 1). Pingdi village, with a population of approximately 6000, is located in the west of Guiyang, the capital of Guizhou Province. In this landslide, approximately 2 million m³ of soil and rock moved down the mountain foot from a height of 500 m (the vertical distance between the highest point and toe of the landslide). The landslide destroyed 27 houses, of which 21 were buried and some were dislodged a distance of approximately 100 m. Figure 2a,b show the houses in a three-dimensional (3D) view from Google Earth before the landslide and a photograph captured after the landslide, respectively. The altitude of the landslide was located at a longitude of 104°40' E and latitude of 26°15' N, and its duration was estimated to be approximately 60 s.

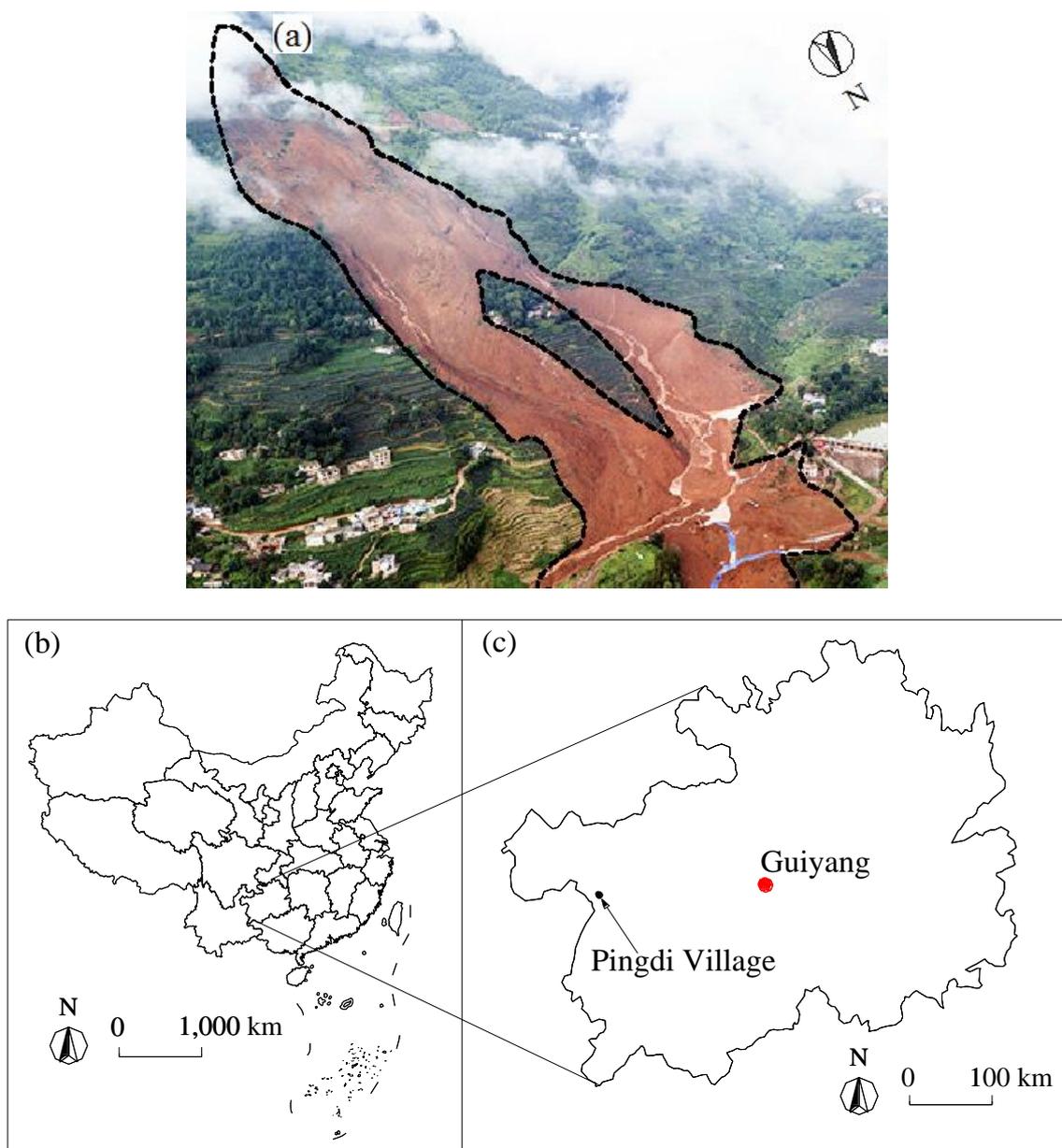


Figure 1. (a) Pingdi village after the landslide (Source: <http://baijiahao.baidu.com/s?id=1639927165371855884>) (b) location of Guizhou, and (c) Location of Pingdi village.

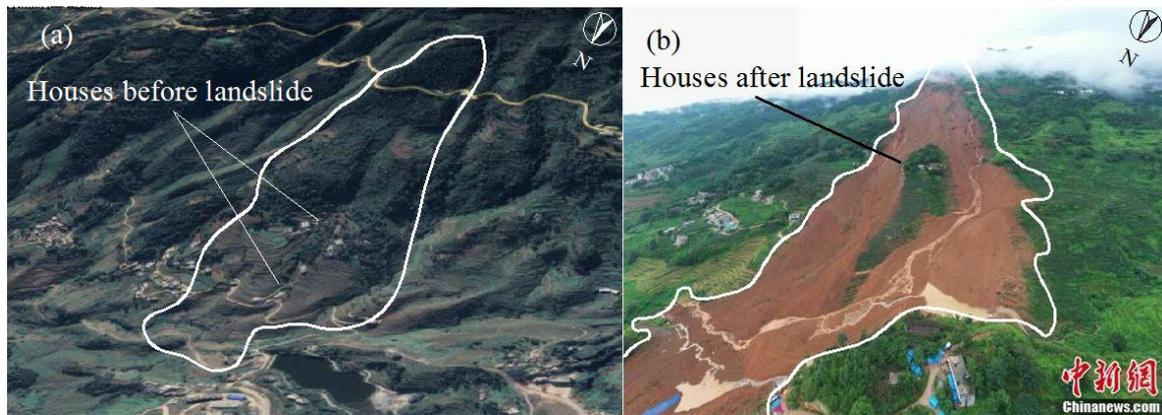


Figure 2. (a) Three-dimensional (3D) View from Google Earth before the landslide (b) Photo captured after the landslide (Source: <http://gz.people.com.cn/n2/2019/0724/c194849-33174976-7.html>).

Figure 3 presents an overview of the site after the landslide. The vertical distance and sliding trajectory along the sliding surface of the landslide were approximately 500 m and 1400 m, respectively. The average slope of the landslide was 18° , and its average thickness was 5 m. In addition, barrier lakes were formed by the landslide, which could cause some secondary hazards and exacerbate the consequences of the landslide (see Figure 4). As of 23:00 on July 28, the landslide had resulted in 42 deaths and 9 missing persons.



Figure 3. Overview of the landslide (Source: <http://baijiahao.baidu.com/s?id=1639927165371855884>).



Figure 4. Barrier lakes formed after the landslide (Source: <http://www.chinanews.com/tp/hd2011/2019/07-24/893609.shtml>).

Figure 5 presents three points in the landslide where 21 houses were buried. Continuous rainfall caused another landslide occurrence in point B on July 25, whereas point C received the soil and rock sliding from points A and B. It was estimated that point C had a high risk of debris flow. Therefore, the rescue at point C was suspended on July 25.



Figure 5. Three points A, B, and C of the rescue areas (Source: <http://gz.people.com.cn/n2/2019/0724/c194849-33174976-2.html>).

2.2. Data Source

To report and analyze this landslide, the photos captured from the site of the landslide were collected from websites, and the weather data records were collected from the National Meteorological Information Center of China (NMC, <https://data.cma.cn/>). The latter includes the annual average monthly rainfall, highest temperature (H-temperature), and lowest temperature (L-temperature) in Pingdi village. In addition, the recent rainfall data records of Pingdi village were collected from the Meteorological Bureau of Guizhou province.

3. Rescue Effort

More than 1500 people were on the site to rescue victims immediately after the landslide, and more rescue teams arrived in the following days including firefighters, police, mine rescue professionals, the Guiyang Tunnel Rescue Team, the Blue Sky Rescue Team, and other civilian rescue teams. On the day of the landslide, the Department of Emergency Management of Guizhou Province immediately dispatched 400 tents, 400 quilts, and 1000 raincoats, as well as lighting equipment, drinking water and food. Other rescue supplies began arriving in the following days. In addition, numerous vehicles and helicopters were involved in the rescue activities. Rescue teams used helicopters to transport the injured (including two children) to the Guizhou provincial hospital for treatment. As shown in Figure 6a, firefighters cleared the barrier at the site of the landslide and drained the barrier lake (see Figure 4) to prevent secondary disasters. However, another landslide occurred at point B (see Figure 5) on July 25, and a debris flow occurred at point C. Rescue operators had evacuated the people at these two points prior to the second landslide, resulting in no further casualties. The rescue efforts are currently continuing, with 11 people rescued. Figure 6b,c depict the rescue professionals saving people from buried houses. In addition, the government urgently allocated 30 million RMB for disaster relief, and a further 12 million RMB for investing in the rescue activities from the Guizhou Province.



Figure 6. Rescue activities (a) Firefighters clearing a barrier (Source: <http://www.chinanews.com>) (b) Firefighters rescuing people from buried houses, and (c) Rescue team rescuing people from buried houses (Source: <http://www.360kuai.com/> (b,c))

4. Analysis and Discussions

4.1. Rainfall

Shuicheng, located in the west of Guizhou Province, is a mountainous area bordering the Yunnan Province. The average annual rainfall in Shuicheng is 1347.9 mm, particularly in June and July, when it is 305.3 and 265.5 mm, respectively (see Figure 7a). Therefore, a landslide probably occurs in June and July. The cumulative rainfall has reached 288.9 mm since this July, and heavy rainfall was concentrated in the first 6 days before the landslide. The rainfall was 49 mm on July 19, 37.1 mm on July 20, and 98 mm on July 23. The total rainfall in the 6 days before the landslide was 189.1 mm (see Figure 7b), which may be blamed as the major cause for this landslide. By authors’ opinion, the landslide may be attributed to continuous heavy rainfall. Empirical evidence [17] strengthen this hypothesis as the rainfall peak of 23 July (98 mm in 24 h) is higher than almost all the rainfall thresholds for landslide initiation reported in a recent review at the global scale. The surface drainage was obstructed at some points where a large amount of stormwater was collected locally, resulting in sever water infiltrations [3,18]. The unit weight of soil increased significantly when it was saturated with water, resulting in an increase in the sliding force. Concurrently, the pore water pressure increased, significantly reducing the soil shear strength resulting in a reduction in the sliding resistance [19,20]. Finally, a catastrophic landslide occurred when the sliding force exceeded the sliding resistance.

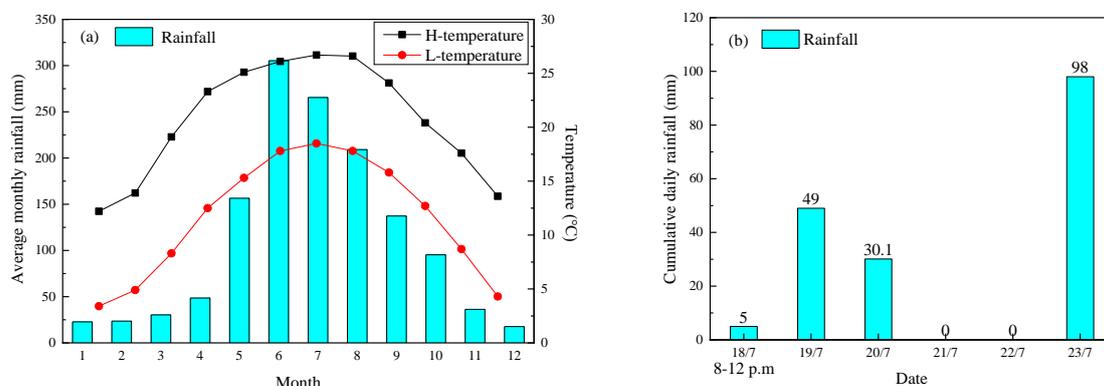


Figure 7. (a) Average monthly rainfall, highest temperature (H-temperature), and lowest temperature (L-temperature) in Pingdi village and (b) the rainfall prior to the landslide.

4.2. Recommendations

A landslide is considered as a most serious natural disaster, which leads to human casualties and enormous property losses. Numerous measures are used to monitor the occurrence of geological disasters. Instrument monitoring, manual monitoring, station observation and automatic remote sensing methods are commonly used in landslide monitoring [21]. According to the Ministry of Emergency Management of China (MEM), numerous locations remain that may be blind spots for the early warning of geological disasters [22]. Moreover, in the Emergency Response Law of the People’s Republic of China, an early warning of a geological disaster can only be sent to the county level [23]. However, there are numerous villages (particularly some in the mountainous area in the west of China) with poor communication. Therefore, the hazard management department of the county may be unable to inform every village in it [22]. In addition, in the disaster prevention of China, in geological disaster emergency treatment, villagers are not involved in the early warning and evacuation of geological disasters (see Figure 8).

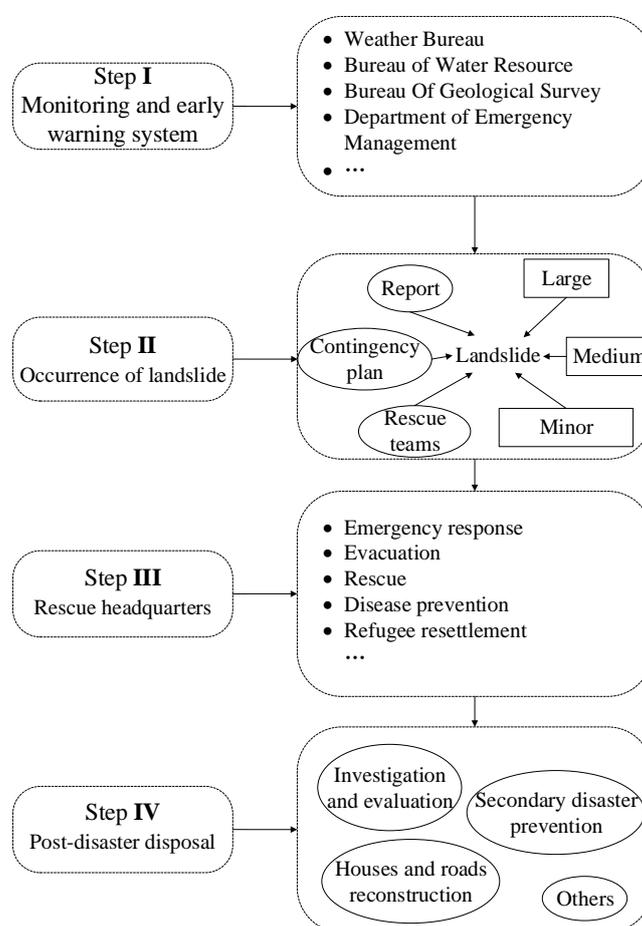


Figure 8. Flow chart of geological disaster emergency treatment in China.

Figure 9 exhibits the disaster preparedness system in Japan. The laws and regulations may provide guidance for disaster prevention. Rescue teams can arrive at a site immediately in a geology disaster with disaster prevention system [24]. In addition, more research on geological disaster prevention may provide more methods to achieve early warning. The most important method to prevent geology disaster is to increase the resilience of citizens; therefore, disaster prevention education and disaster prevention training are necessary [25].

According to the disaster preparedness system in Japan, some recommendations made should be adopted in the geology disasters in China. (1) The government should improve the existing emergency

management legislation and disaster prevention system to strengthen the efficiency and effectiveness of an early warning system. (2) The most important point is that the villagers should reinforce the awareness and knowledge of self-prevention and enhance their ability to save themselves when encountering a natural disaster. In addition, villagers should practice disaster prevention training and evacuation rehearsal regularly.

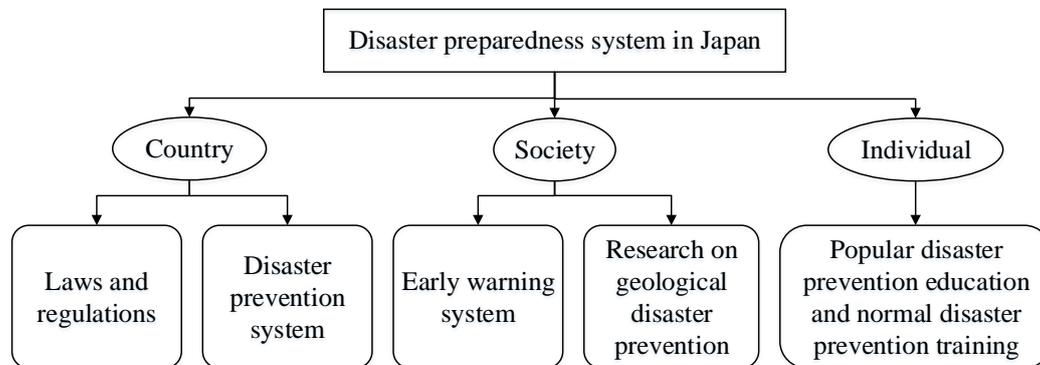


Figure 9. Disaster preparedness system in Japan.

At present, in view of the rapid development of the GIS technology, various quantitative or statistical methods have been proposed to predict landslide susceptibility [26]. For example, Shahabi et al. [27] compared the landslide susceptibility mapping models of logistic regression (LR), analytical hierarchy process (AHP) and frequency ratio (FR). Yalcin [28] compared the susceptibility maps produced by the analytical hierarchy process (AHP), statistical index (Wi), and weighting factor (Wf) methods. Based on the comparative study above mentioned, Yalcin [28] concluded that AHP method yielded a more realistic scenario of the actual distribution of the landslide susceptibility. Zhu et al. [29] applied the load-unload response ratio theory to establish a landslide prediction model. Yang et al. [30] applied a time series analysis and long short-term memory neural network to predict landslide displacement. The RS and permanent scatter interferometry synthetic aperture radar (PSInSAR) techniques are widely used to monitor the development of geohazards [31–37]. In addition, the most straightforward method to establish a territorial landslide early warning system is the definition of rainfall thresholds for landslide initiation [17,38–40]. The application of these model techniques could help in monitoring the occurrence of a landslide.

5. Conclusions

This short communication reports a large landslide that occurred on 23 July, 2019 in Guizhou Province, China. The following conclusions can be drawn based on the preliminary investigation and analysis.

1. A large landslide of approximately 2 million m³ of soil and rock occurred at Pingdi village, resulting in 42 deaths and 9 missing persons (as of July 28) being reported. In the preliminary investigation, the vertical distance between the highest point and toe of the landslide and sliding trajectory along the sliding surface of the landslide were approximately 500 and 1400 m, respectively.
2. Rainfall was considered as the most important causing factor for this landslide. The continuous heavy rainfall significantly deteriorated the stormwater of the sliding interface. The shear stresses due to the deterioration of the sliding interface acted along the shear band, resulting in a reduced shear strength available at the shear band. This in turn caused a displacement of the soil and rock above, thereby triggering this massive landslide.
3. The government should strengthen the ability of warning and communication to inform villagers in time. In addition, the villagers should be educated regarding rescue during natural disasters

and practice evacuation drills regularly. In addition, more risk prediction methods should be applied to prevent geological disasters.

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