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Trend and spatiotemporal distribution of fatal landslides triggered by non-seismic effects in China

Abstract A large number of slope movements occur in China annually. Especially, fatal landslides are the most hazardous, causing serious fatalities and significant socio-economic losses. In this study, we collected data on fatal landslides triggered by non-seismic effects from China's geological environment information site and Ministry of Natural Resources of China for the period 2004–2016. Then, we carried out a statistical analysis of the data to explore the trend and spatiotemporal distribution of the fatal landslides, as well as the distribution of its losses in economic and fatality terms. In the studied period, a total of 4718 deaths were recorded as resulting from 463 landslide events. It represents a frequency of 36 events and an average of 363 deaths every year. Also, an increasing trend of such landslide is observed in the period 2011–2016 with hazard record improvement. But its economic loss has a decreasing proportion of all recorded non-seismic geohazard loss for this period. Even so, the total economic loss in the studied period is still enormous at $981.29 million. The spatial distribution of fatal landslides shows intensive clusters in southwestern and southern China due to the possible distinctive geological environment and precipitation conditions. The temporal distribution reveals significant association with the rainy season, with the largest quantity of events occurring between June and September. Among all the collected landslides during the studied period, 94.2% are associated with rainfall. This research gives a comprehensive recognition of fatal landslide damage and provides baseline information for landslide prevention and mitigation.

Keywords Fatal landslides · Trend · Spatiotemporal distribution · Socio-economic significance · China

Introduction

Slope movements are one of the most important landscape-forming processes, causing great economic and human losses worldwide (Schuster et al. 1986; Alexander 2005). Although a variety of slope movements are very common all over the world, fatalities are mainly caused by a few fatal landslides (Petley 2008, 2012; Haque et al. 2016).

Many researchers studied the trend of such landslide occurrences on a global scale (Oven 2005; Petley et al. 2005; Nadim et al. 2006; Petley 2012; Kirschbaum et al. 2015). Nadim et al. (2006) developed global hazard and risk maps for landslides, which put China in a high landslide hazard class. However, no further research has been conducted in detail. Petley (2012) analyzed the spatial distribution of fatal landslides worldwide, finding that clusters of these events in China are evident along the southeastern coastal regions and in central China, most notably in the mountains surrounding the Sichuan Basin. Also, Kirschbaum et al. (2015) used the data from a new publicly available global landslide catalog from 2007 to 2013 and processed them into a global map of reported landslides. The map suggests that China holds a large number of reported landslides with fatalities or no fatalities. Although the investigation is on a global scale, it reaches the conclusion that China has suffered frequent fatal landslides and has been seriously affected. However, being limited by the native language, data access, and differences in geohazard classification of each country, it still lacks detailed or complete data to evaluate the trend and distribution of the landslides in China.

On the other side, the studies on fatal landslides generally focused on the developed countries or areas (Evans 1997; Guzzetti et al. 2000, 2005; Geertsema et al. 2006; Hilker et al. 2009; Sepúlveda and Petley 2015; Haque et al. 2016). In Italy, landslides are very common and kill many people every year (Guzzetti 2000; Guzzetti et al. 2005). Such severe human and economic consequences have inspired many scholars to study landslide damage in detail in Italy (Guzzetti et al. 1999; Guzzetti 2000; Cascini et al. 2008). Furthermore, the landslide susceptibility mapping at national scale has been conducted for risk mitigation (Trigila et al. 2013). Additionally, an overview of large catastrophic landslides in northern British Columbia was given. It shows that the frequency of large landslides appears to be increasing (Geertsema et al. 2006). A study of the damage of landslides in Switzerland reveals that a large amount of the cost is due to only a few major events (Hilker et al. 2009). All these studies show that landslide represents a major constraint on socioeconomic development for a country. Simultaneously, fatal landslides play a more critical role in causing the major proportion of fatalities; therefore, it has been a crucial factor to consider in government policy-making on hazard prevention and control (Haque et al. 2016). Hence, it is of great significance to analyze fatal landslides to hazard mitigation in China.

This study aims to analyze those non-seismically triggered fatal landslides in China during the period 2004–2016. For this purpose, we compiled the data on all recorded non-seismic geohazards from the Ministry of Natural Resources of China and its subordinate geological environment information site. Then, we made a statistical analysis of the occurrences and losses between fatal landslides and the recorded hazard events. Afterward, the spatial and temporal distribution of the fatal landslides in different geographical zones for each month was analyzed. Given the two kinds of distribution mentioned above, we briefly considered the relationship between the distribution patterns and potential influencing factors.

Data collection and methodology

The Chinese Geological Environment Monitoring Institute began to release the non-seismically triggered geohazard information, i.e., landslides and ground failure in its Bulletin of National Geological Hazards since 2004 (CGEIS 2017). The bulletins include geohazard types, number of geohazard occurrences, rough sites (generally, specific to the villages and towns), economic losses, given in USD based on exchange rates announced by BOC (value as at 1 December 2016: 1 US$ = 6.8823 RMB) (BOC 2016), and human casualties. After 2011, the geohazard information was released in real time by the Ministry of Natural Resources of China (MNR 2016), as well as in the Bulletin of National Geological Hazards by China geological environment information site. The information here includes basic geohazard types, triggering mechanisms such as heavy rainfall or human activities, and its rough sites and its economic and human losses. At the same time, the landslide information, if available, involves details such as deposited material volume and moving distance. Besides, landslide includes slide, debris flow, and fall, following nomenclature by Cruden and Varnes (1996) and Hungr et al. (2014). And ground failure includes ground collapse, ground fissure, and land subsidence.

However, almost all casualties or fatalities came from landslides. Hence, this study focused on the analysis of collected data on fatal landslides for the period 2004–2016, although we also present the collected information of the occurrences of ground failure. Here, we also excluded earthquake-induced landslides due to the lack of accurate data. Therefore, the fatal landslides were triggered by non-seismic effects. According to the regulations on prevention and control of landslides (MNR 2003), fatal landslides in China are classified into four grades: small event, moderate event, large event, and very large event, as shown in Table 1.

To analyze the trend and spatiotemporal distribution and economic damage of fatal landslides in China, we first compiled data on the occurrences and losses of all landslides, as well as ground failure. The losses include fatalities, missing persons, injuries, and economic loss (if any). Then, we selected the data of the numbers and total losses of fatal landslides in each year. Moreover, to explore the distribution of the landslides at spatial and temporal scales, we recognized the specific quantity of the events in different geographical areas and provinces. The cumulative quantities of these landslides in each month have also been calculated during the 13-year period. According to the recorded landslide information, we also analyzed the proportion distribution of fatal landslides under different triggering mechanisms.

Results and discussion

Fatal landslides in recorded non-seismic geohazards

Figure 1 shows the numbers and percentages of different types of landslide and ground failure. During the period 2004–2016, a total of 284,943 non-seismic geohazard events have been collected while slide, fall, and debris flow account for 209,734 (73.6%), 57,558 (20.2%), and 11,588 (4.1%), respectively. The landslides come to a total of 278,880 and account for 97.9% of all recorded hazards. The ground failure only comes to 6063, in which ground collapse, ground fissure, and land subsidence has 4283 (1.5%), 1414 (0.5%), and 366 (0.1%), respectively, only accounting for 2.1% in total. It signifies that landslides are the most prevalent geohazards in China. Meanwhile, fatal landslides have also widely happened.

Table 1 Classification of fatal landslides according to the regulations on landslides prevention and control by MNR

Grade	Fatalities	Direct economic loss (million USD)
Very large	> 30	> 1.45
Large	10–30	0.73–1.45
Moderate	3–10	0.15–0.73
Small	< 3	< 0.15

"Regulations on prevention and control of landslides" was released by MNR in 2003

To further explore the role these landslides play in recorded geohazards damage, we compared the losses from both and then analyzed the relationship between them. Figure 2 presents the distribution of the geohazard occurrences and corresponding damage. As shown in Fig. 2, it seems that more hazards result in relatively high economic damage. However, the year with most events is 2006 (102,804 cases) while the economic loss only has $627.11 million. The highest level of economic loss comes from 2013 ($1482.06 million) while the number of the recorded events is only 15,403, being sixth in comparison with other years. According to the information recorded in Bulletin 2013 (MNR 2016), landslides have caused significant loss in social economy, especially in residential property. The direct economic loss in property of citizens stands at $1156.59 million in total. Such severe consequence on residential property brought by landslides is a crucial factor to total loss in economic terms, as suggested by Hilker et al. (2009) in Switzerland. Also, more geohazard events may not indicate a larger number of fatalities. The largest number of geohazards is in 2006, while the most deaths come from 2010 (2246 persons). Also, the least number of them is in 2004 with only 868 records, but they caused the second largest number of fatalities (697 people). The numbers of fatalities or people missing in 2010 are apparently larger than others, while only 30,670 events have been recorded for this year.

The anomaly between the number of geohazard events and fatalities can be explained by the proportion of deaths due to fatal landslides. As shown in Fig. 3a, there is a large difference between the fatalities of collected geohazards and fatal landslides in the period 2004–2010. Perhaps this is mainly because only more than large landslides were recorded in bulletins for this period. Therefore, many landslides that caused fewer than 10 deaths have been missed. After that, both the curves of fatalities become closer. This suggests that such landslide fatalities increasingly account for a major proportion of the death toll, and ground failure such as ground collapse, ground fissure, and land subsidence cause fewer losses in human lives. On the one hand, fatal landslides are often hard to predict and avoid, and thus always cause lots of deaths. On the other hand, under the policies of nationwide people-centered landslide investigations and village-based early warning system, many landsides have been monitored and evaluated in landslide-prone areas (Zhou et al. 2005; Yin et al. 2010). And thus, the public awareness against landslides has generally improved. As shown in Fig. 4a, the quantities of casualties avoided under village-based early warning are enormous, especially in 2013 for 187,584 people. Furthermore, in the past few years, the government has invested a great deal of financial resource in landslide prevention and mitigation. According to the China Statistical Yearbook (NBSC 2017), the amount of investment continues to increase (Fig. 4b).

When referring to the trend variation of economic loss, Fig. 3b shows an entirely different form from that of deaths. The economic losses of fatal landslides are extraordinarily small in comparison with the losses resulting from all collected geohazards, especially from 2012 to 2015. The economic loss from the recorded geohazards in 2013 is the highest in 13 years, but the landslides only account for $0.18 million. During the whole period of data collection, there are few records of economic damage from these landslides for these years. Based on the above discussion, fatal

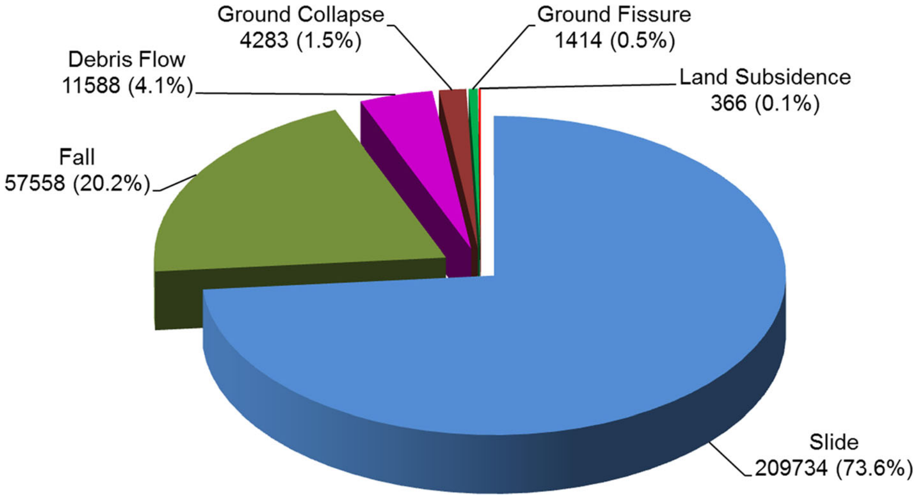

Fig. 1 The composition and percentage of recorded non-seismic geohazards in the period 2004–2016 in China

landslides cause a larger number of fatalities but lead to a lower level of economic loss.

Economic loss and fatalities of fatal landslides

Figure 5 gives a more intuitive distribution of fatal landslides damage and their occurrences. In total, 463 landslides were recorded nationwide during the 13-year period, causing 4718 recorded deaths and nearly $981.29 million in damage. This represents a frequency of 36 events and an average of 363 deaths and approximately $75.48 million loss in socio-economic for every year. As displayed in Fig. 5a, economic losses from the landslides have a high level of variability yearly, with the highest in 2008 of $180.03 million while least for 0.18 million in 2013. Besides, the financial losses in 2012, 2014, and 2015 are also extremely low, only $0.94, $7.30 and $7.79 million, respectively. Although the proportion of economic losses from fatal landslides is small compared to that of all recorded non-seismic geohazards, its total amount is still quite enormous and is of great significance on socio-economic development. But the economic loss has not increased markedly yet possibly due to great efforts of the government in hazard prevention in recent years. However, the number of fatalities varies slightly year by year and an increasing trend of both fatalities and the landslides is observed in the period 2011–2016. We owe this increase to the improved hazard information records since 2011. But exceptionally, there was a sharp increase in 2010 to 2117 deaths. In this year, several very large fatal landslides occurred and led to substantial deaths, including Zhouqu debris flow (1501 deaths, 264 missing) (Tang et al. 2011; Qiu 2014), Guanling landslide (42 deaths, 57 missing) (Tong et al. 2010; Xing et al. 2014), and Dongyuegu debris flow (37 deaths, 55 missing) (Li et al. 2017). But

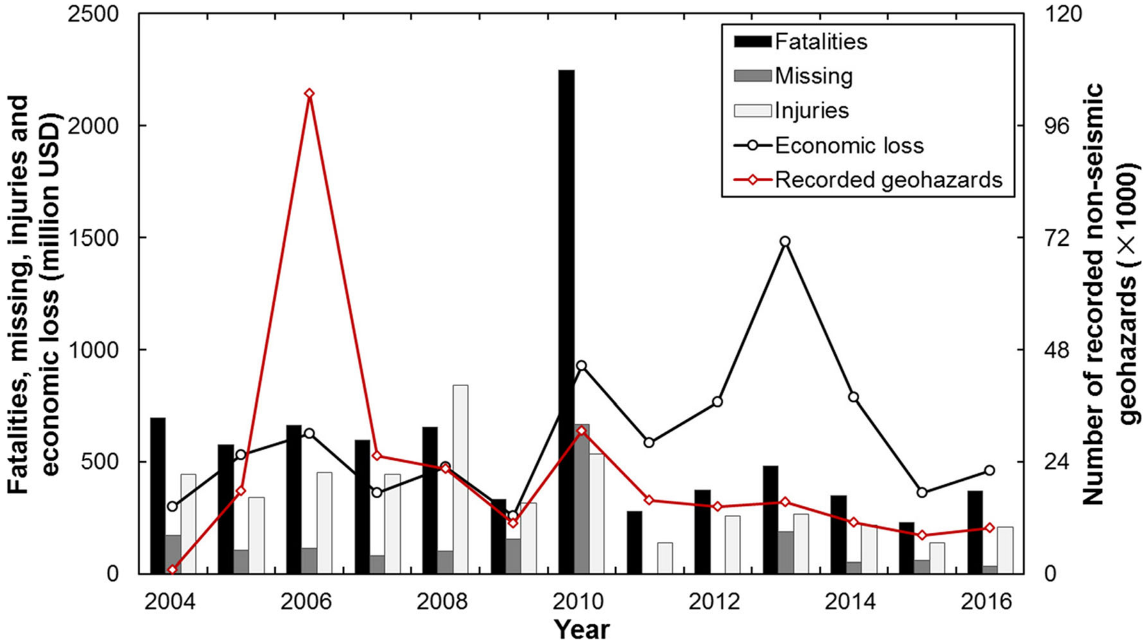

Fig. 2 Graph showing the number of fatalities, injuries, missing persons, and the amount of economic loss and the number of recorded geohazards for the period 2004–2016

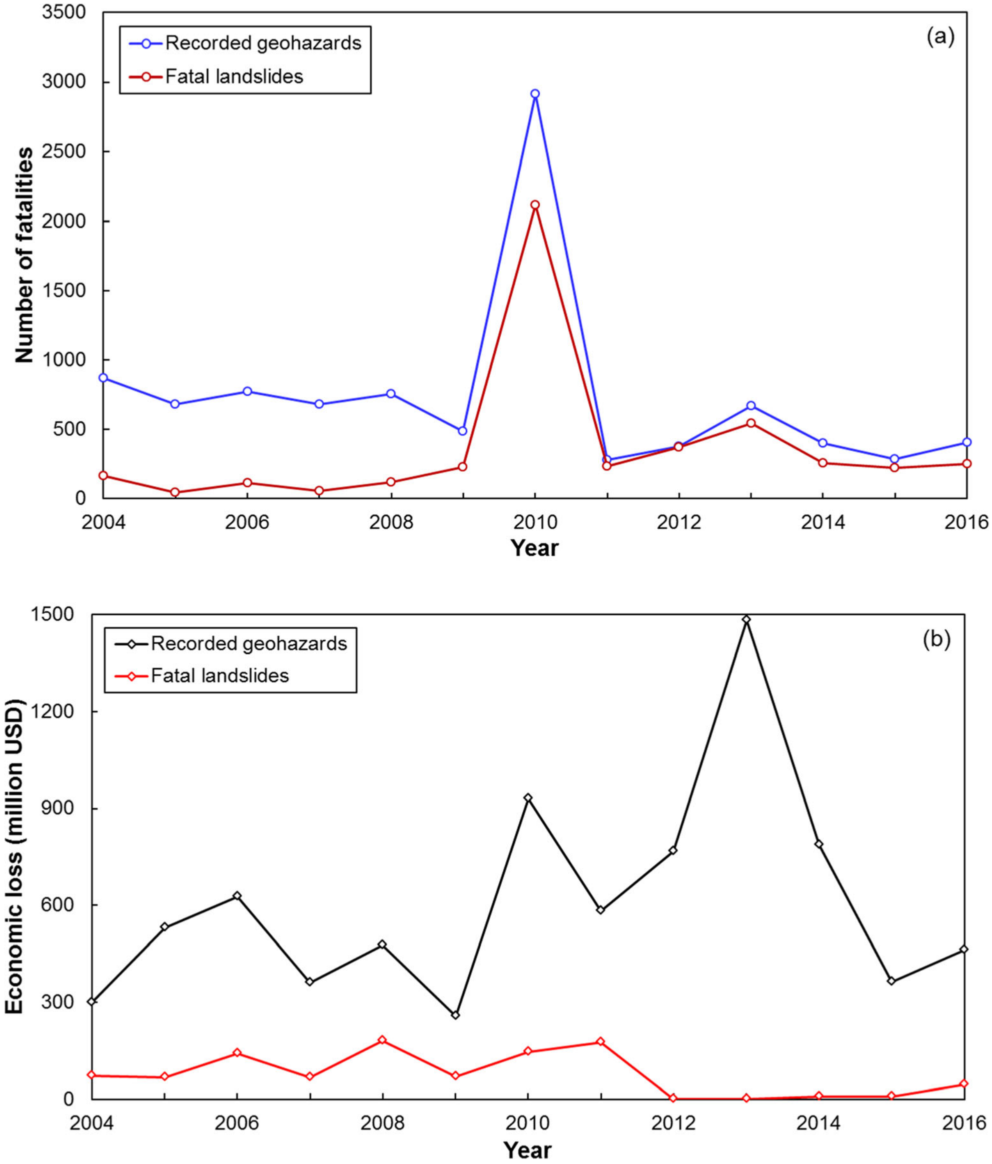

Fig. 3 **a** The number of fatalities caused by recorded geohazards (blue line) and fatal landslides (including missing people, red line). **b** Economic losses due to recorded geohazards (black line) and fatal landslides (red line)

the number of the landslide occurrences was relatively small in 2010 at only 18 events (Fig. 5b). This suggests that a few large or very large fatal landslides dominated the majority of fatalities in that year. Also, this conclusion is consistent with the situation as suggested by Hilker et al. (2009) in Swiss and Sepúlveda and Petley (2015) in Latin America and the Caribbean and Haque et al. (2016) in Europe. However, the number of deaths in 2013 is the second highest under the largest number of the landslides, at 544 deaths from 101 events. The result is not contrary to the previous conclusion. As seen in the data collection process, too many small or moderate fatal landslide events, generally causing fewer than ten deaths, have occurred widely in this year.

Many authors have suggested that the frequency-fatality relationship follows an inverse power law distribution (Brardinoni and Church 2004; Malamud et al. 2004; Petley 2012). The magnitude-frequency distribution for the whole fatalities is displayed here in logarithmic coordinates with scattering diagram (Fig. 6). The power fitting results in a R^2 value of 0.90. Then, we probably assume that the frequency-fatality relationship follows a power law decay, as other scholars have shown in China (Guzzetti 2000; Petley 2012). The number of fatalities presents a cluster around 10–100, but no rollover is apparently observed where the power law no longer applies (Malamud et al. 2004). It is because that the dataset is relatively small and we have considered nearly all the small fatal landslides that only killed one or two people.

Spatial and temporal distributions of fatal landslides

We further analyze the spatial and temporal distributions of fatal landslides based on geographical divisions of China for the period 2004–2016. The Chinese mainland geographical regions and provinces have been presented in Fig. 7, including southwestern, southern, eastern, northwestern, northern, and northeastern China for six zones. Figure 8 shows the change rule of such landslide occurrences in six geographical areas and the whole of China annually.

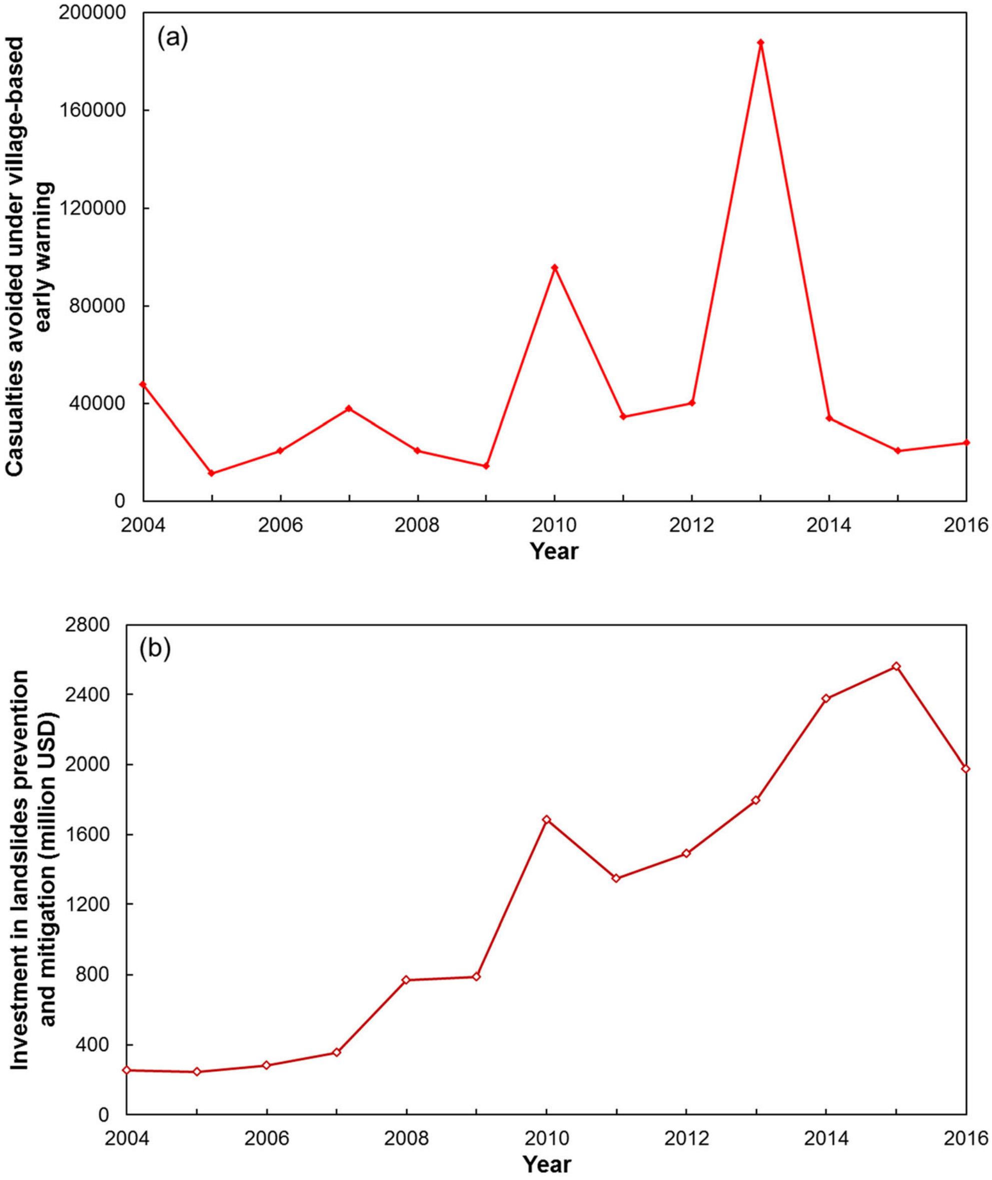

Fig. 4 **a** Number of casualties avoided under village-based early warning system from 2004 to 2016. **b** Government investment in landslide prevention and mitigation in the period 2004–2016 (unit million USD)

It can be seen that the inter-annual trend variations in these landslides in six areas have great similarities and high fluctuation. The numbers of these fatal events in China are few in 2004, 2005, and 2008, with eight, nine, and nine records, respectively. However, nearly all areas suffered the most frequent fatal events in 2013. It is clear that southwestern and southern China occur large quantities of fatal landslides, while northern and northeastern China are almost unaffected by the landslides. Then, Fig. 9 gives the detailed proportion of the landslide occurrences of each area. The distribution of these events presents an extreme imbalance. Southwestern China accounts for nearly half of the total landslides at 199 events (43.0%). According to the information released by MNR, as well as the previous studies, this is mainly resulted from the complex geological conditions and active tectonic movements in the unique mountain settings (Wen et al. 2004; Huang 2009). Then, abundant rainfall will play a critical role in initiating the unstable slopes (Hong and Adler 2008; Zhang and Wang 2018). Southern China, with the same rich precipitation, is the second highest at 146 events (31.5%). Eastern and northwestern China have almost the same number of fatal landslides at 49 (10.6%) and 47 (10.2%), respectively. Northern China has only 20 events in total and accounts for 4.3%. However, there are few landslides in northeast China (2, 0.4%), as the topographical and geological conditions are relatively simple and the precipitation level is low.

Figure 10 shows the specific damage of fatal landslides of each province in the corresponding area. It is obvious that Sichuan, Yunnan, and Guizhou have been worst hit in southwestern China, and even in all of China. They hold 75, 73, and 39 events, respectively, and Sichuan has the largest number of the landslides of all provinces. In southern China, Hunan, Guangdong, and Guangxi have 45, 39, and 39 landslides, respectively, for this period. Then, Fujian in the east, Shanxi in the north, and Shaanxi and Gansu in

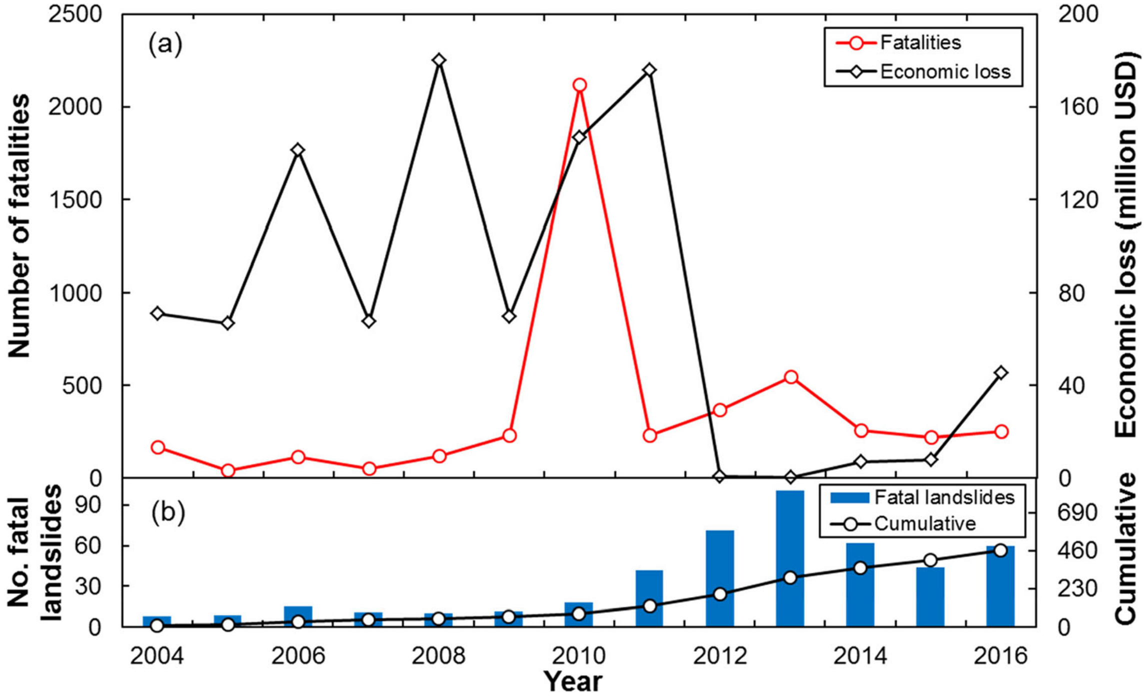

Fig. 5 The number of fatal landslides and their corresponding losses. **a** Fatalities and economic loss caused by fatal landslides. **b** The number and the cumulative number of fatal events in the period 2004–2016

the northwest account for a relatively large quantity of fatal landslides in their respective areas, 18, 16, 21, and 13, respectively. Gansu has also suffered the frequent landslides because a lot of loess landslides have occurred every year (Xu et al. 2007, 2017; Zhang et al. 2013; Zhang and Wang 2018). Only two landslide events occurred in Liaoning in northeastern China. The spatial distribution of the landslides in different regions or provinces shows a strong correlation with its geological, geomorphological, and precipitation conditions (Wen et al. 2004; Huang 2007, 2009). Additionally, landslide risk is an important index for hazard analysis and evaluation and can provide the basis for landslide management and mitigation actions (Corominas et al. 2014). Here, we simply considered the probability of each person suffering landslides. And we use the latest population data,

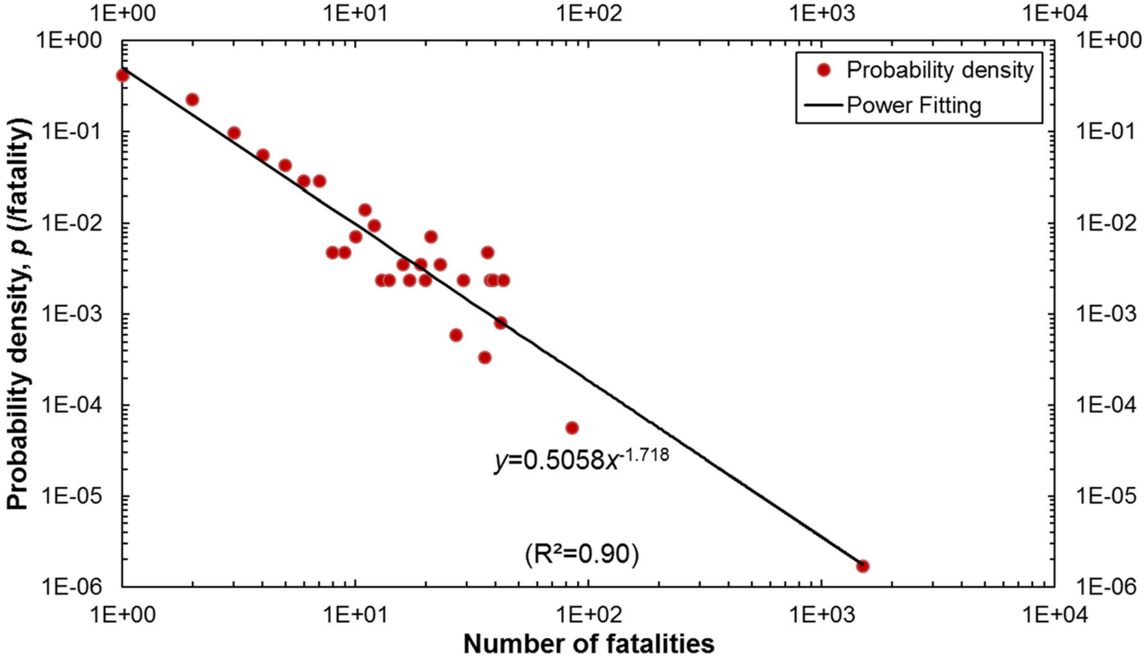

Fig. 6 Probability density function vs. fatalities curve for the whole fatal landslides that caused deaths or missing persons

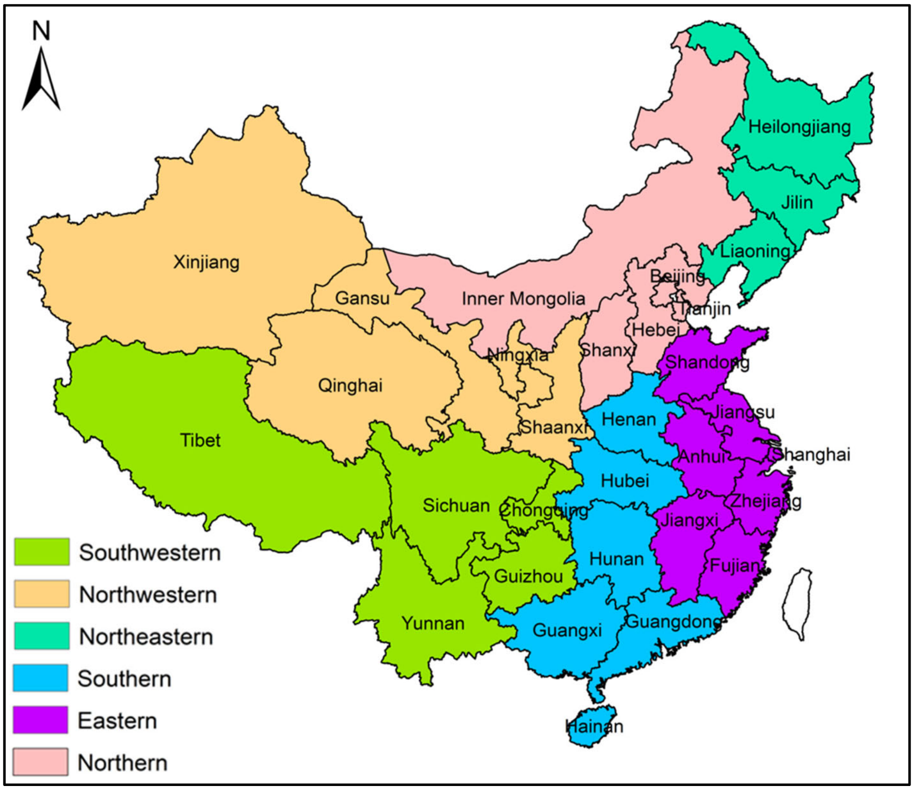

Fig. 7 The map of the location of Chinese mainland geographical regions and provinces. Note that southwestern China includes Sichuan, Yunnan, Guizhou, Chongqing, and Tibet. Southern China includes Hunan, Guangdong, Hubei, Guangxi, Henan, and Hainan. Eastern China includes Fujian, Zhejiang, Jiangsu, Jiangxi, Anhui, Shandong, and Shanghai. Northwestern China includes Gansu, Shaanxi, Xinjiang, Qinghai, and Ningxia. Northern China includes Shanxi, Hebei, Tianjin, Beijing, and Inner Mongolia. Northeastern China includes Liaoning, Jilin, and Heilongjiang

provided by the sixth national population census in 2010 (NBSC 2011), for the probability analysis. As shown in Table 2, in spite of the large variations in population between provinces, the number of fatal landslides mainly affects this parameter. Sichuan, Yunnan, and Guizhou have a large number of the landslides and comparatively high values and have been worst hit. Besides, Hunan, Guangdong, Guangxi, and Fujian have relatively bigger values in their respective area. However, the probability is extremely large in Qinghai (10.7×10^{-7}) and Tibet (9.99×10^{-7}) due to so small population.

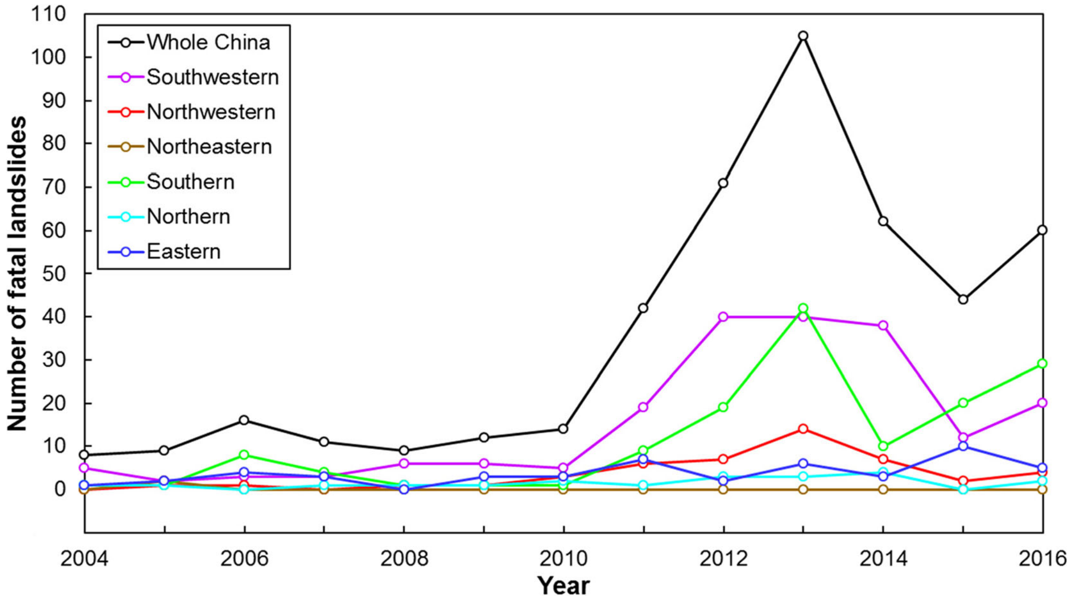

Fig. 8 The cumulative occurrences of fatal landslides in six geographical areas in the period 2004–2016

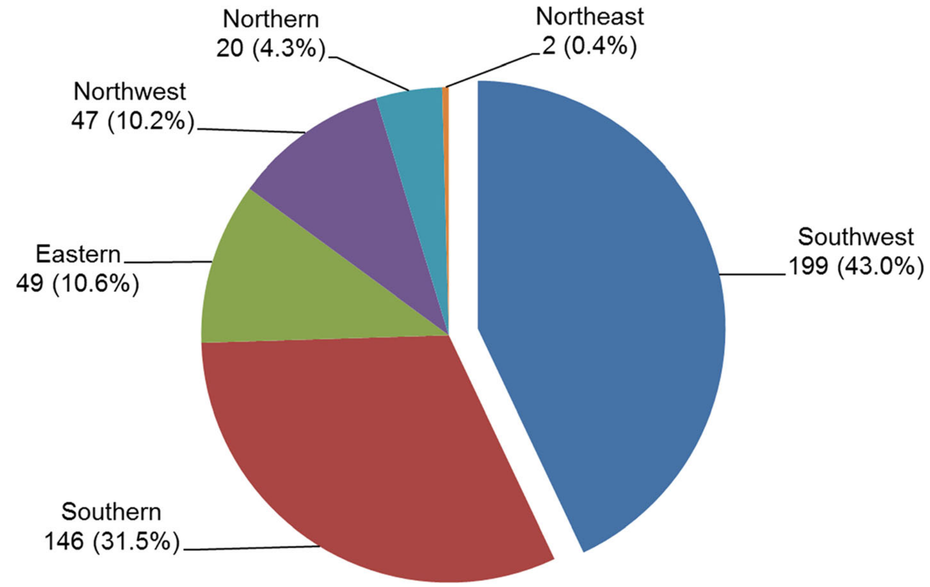

Fig. 9 The percentage of fatal landslide occurrences in different geographical areas

The temporal distribution of fatal landslides shows a strong correlation with the monthly precipitation in China. As shown in Fig. 11, the distribution of the landslides and rainfall presents high consistency. They show an intensive cluster during the rainy season, which usually lasts from May to September. There are 463 landslides in this period in total. Among all 12 months, June and July hold the largest quantities of the landslides at 101 and 142 records, respectively. However, there are fewer landslide occurrences in other months, such as from January to April and from October to December, as well as the rainfall. It is also found that the monthly distribution of fatal landslides and precipitation in six areas shows the same trend (Fig. 12). They concentrated especially on the peak of the rainy season, which usually lasts from June to September in most areas. During this period, more precipitation falls and thus influences the occurrence and distribution of the events (Wen et al. 2004). To make further detailed analysis of such event occurrences and potential triggered factors, the percentages of these events caused by different processes are presented in Table 3. These processes mainly include long-lasting rainfall (the precipitation which is less than 25 mm within 24 h but usually lasts for more than 72 h), heavy rainfall (the precipitation

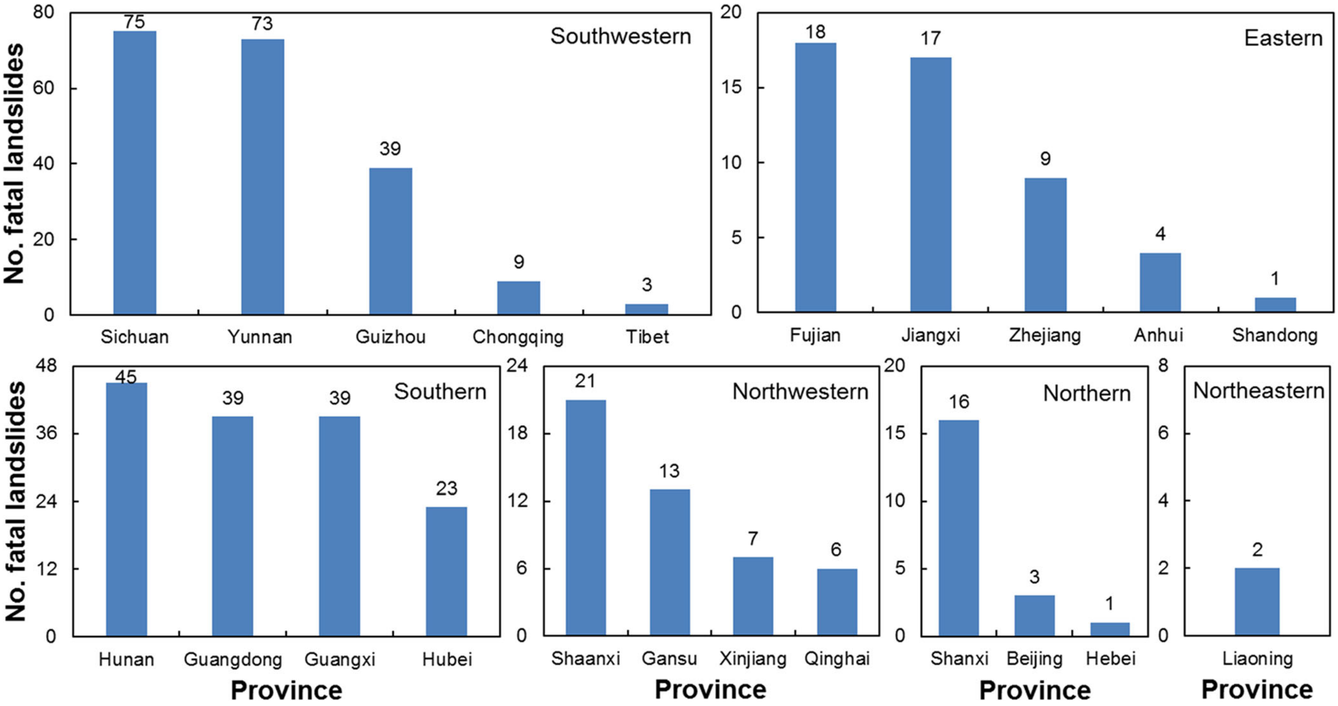

Fig. 10 The cumulative number of fatal landslides in each province from 2004 to 2016

Table 2 The probability of each person suffering fatal landslides in the period 2004–2016

Geographical area	Province	Fatal landslides	Population	Probability value ($\times 10^{-7}$)
Southwest	Sichuan	75	80,418,200	9.33
	Yunnan	73	45,966,239	15.9
	Guizhou	39	34,746,468	11.2
	Chongqing	9	28,846,170	3.12
	Tibet	3	3,002,166	9.99
Eastern	Fujian	18	36,894,216	4.88
	Jiangxi	17	44,567,475	3.81
	Zhejiang	9	54,426,891	1.65
	Anhui	4	59,500,510	0.67
	Shandong	1	95,793,065	0.10
Southern	Hunan	45	65,683,722	6.85
	Guangdong	39	104,303,132	3.74
	Guangxi	39	46,026,629	4.02
	Hubei	23	57,237,740	8.47
Northwest	Shaanxi	21	37,327,378	5.08
	Gansu	13	25,575,254	5.63
	Xinjiang	7	21,813,334	3.21
	Qinghai	6	5,626,722	10.7
Northern	Shanxi	16	35,712,111	4.48
	Beijing	3	19,612,368	1.53
	Hebei	1	71,854,202	0.14
Northeast	Liaoning	2	43,746,323	0.46

The latest population data were provided by the sixth national population census in 2010

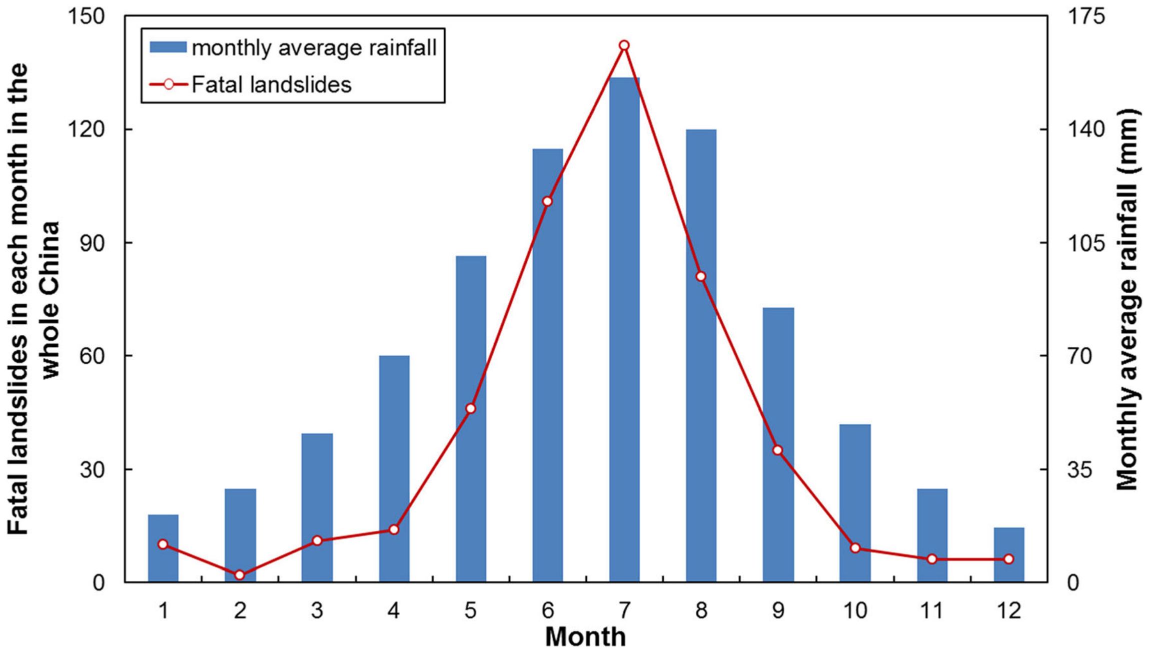

Fig. 11 Graph showing the monthly distribution of fatal landslides (red line) and average rainfall (blue bar graph; unit mm) in the period 2004–2016 in China

Table 3 The percentages of fatal landslides under different triggering factors

Triggering factor	Fatal landslides	Fatalities	Percentage of quantity under triggering factors
Long-lasting rainfall	48	662	10.4%
Heavy rainfall	45	2153	9.7%
Rainstorm	33	328	7.1%
Rainfall with no details	310	1457	67.0%
Snowmelt	1	27	0.2%
Other causes	26	91	5.6%

Long-lasting rainfall is precipitation which is less than 25 mm within 24 h but usually lasts for more than 72 h. Heavy rainfall is precipitation ranging from 25 to 50 mm within 24 h, and rainstorm refers to precipitation amounting to more than 50 mm within 24 h (CMA, China Meteorological Administration 2017). The detail information of the rainfall generally includes the duration or intensity. And other causes include human activities and old landslide reactivation

range between 25 and 50 mm within 24 h) and rainstorms (precipitation of more than 50 mm within 24 h) (CMA, China Meteorological Administration 2017), snowmelt, and other factors. In the studied period, 48 (10.4%) events are triggered by long-lasting rainfall while heavy rainfall and rainstorms account for 45 (9.7%) and 33 (7.1%), respectively. However, there is only one (0.2%) event triggered by snowmelt, which occurred in Yulin, Shaanxi Province in 2010. There are 26 (5.6%) landslide events of which triggering factors mainly include human activities and old landslide reactivation. However, there are 301 (67.0%) landslides of which triggering factors were just recorded as rainfall but lacked the detailed information, i.e., duration and intensity. Thus, the triggering factors of these fatal events are not identified specifically and the information statistics for this term is incomplete. However, among all the recorded fatal landslides of the studied period, 94.2% (436 events) of them are directly associated with rainfall, no matter whether there is detailed information or not. Combing with the discussion above, it indicates that rainfall mainly influences the occurrence and monthly distribution of non-seismic fatal landslides in China.

Conclusions

In this study, we collected the data on fatal landslides triggered by non-seismic effects and analyzed their trend and distribution in the period 2004–2016 in China. The results suggest that the landslides happen widely and cause huge human and economic losses. An increasing trend of landslides is observed in all of China with

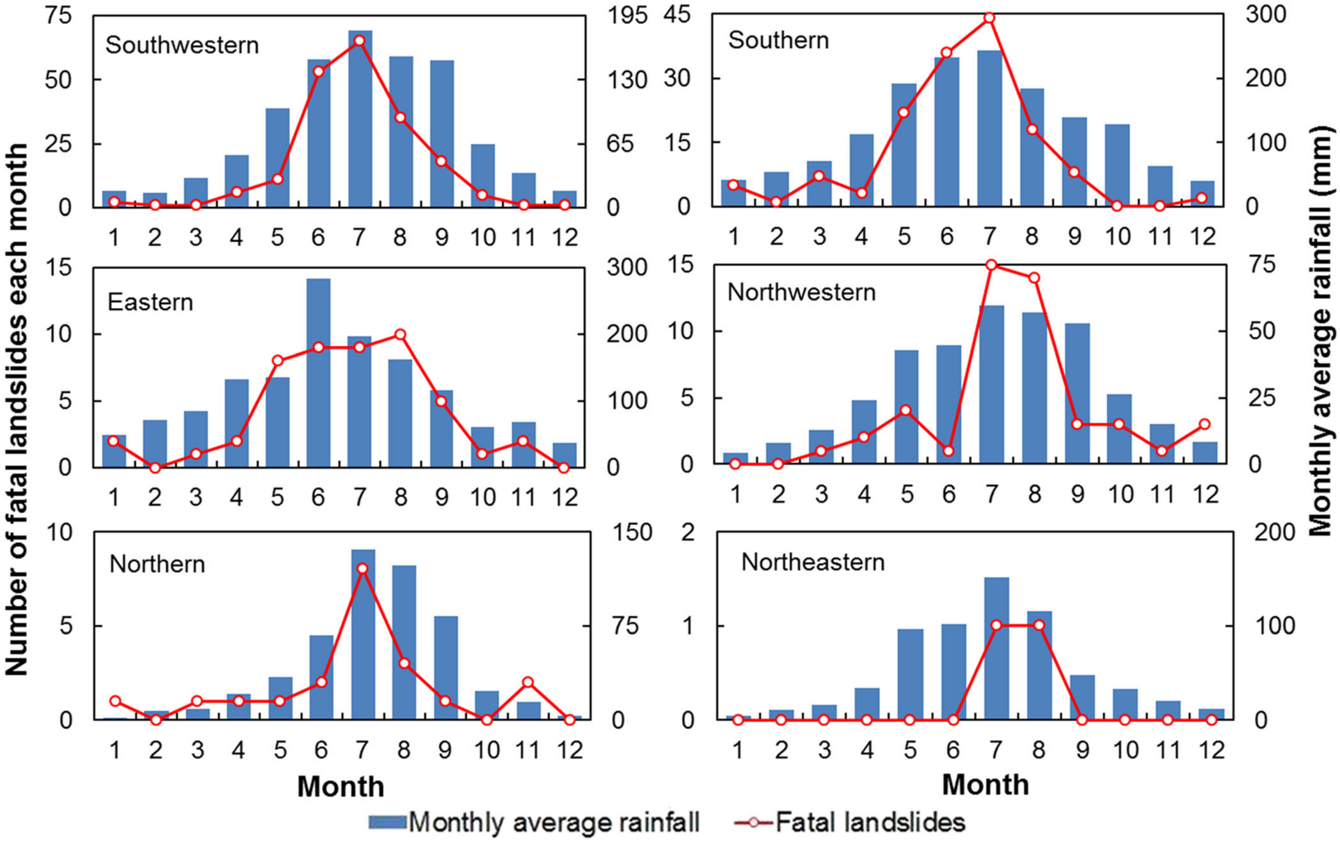

Fig. 12 The monthly distribution of fatal landslides (red line) and rainfall (blue bar graph; unit mm) in each area in the period 2004–2016

the hazard record improvement since 2011. And then, it decreases slightly. Such trend of variation reaches a peak in 2013.

There were 463 events in a 13-year period in total, causing 4718 recorded deaths and nearly $981.29 million loss in economic. The economic loss of fatal landslides accounts for only a small proportion of total economic damage from all recorded geohazards, especially in the period 2012–2016; however, its total amount is still enormous. Because of the great efforts of the Chinese government made, ground failure hardly caused any deaths. Therefore, the number of fatalities in landslides is getting closer to that of recorded geohazards year by year. And with the improvement of the hazard information, the landslides deaths of the period 2011–2016 are clearly larger than the period 2004–2008. However, a sharp increase occurred in 2010 because several large or very large landslides caused significant losses in human lives.

The spatial distribution of fatal landslides shows a large difference in different geographical areas, which are characterized by different geologic and climatic environment. It presents intensive clusters in southwestern and southern China, especially in Sichuan, Yunnan, Guizhou, Hunan, Guangdong, and Guangxi, while there are few landslide events in northeastern China. Such imbalance distribution of the landslides in space is mainly affected by the far different geological and geomorphic conditions. Our results also suggest that the seasonal distribution of the landslides shows a strong correlation with the peak of the rainy season, which usually lasts from June to September. In this period, a large amount of precipitation falls, and many landslides occur. As the results show, 94.2% (463 events) are directly related to the rainfall. This also suggests that rainfall mainly controls the monthly distribution of fatal landslides in China.

With the rapid development of society and economy in China, landslides frequently occur and continue to affect the lives and property of the people seriously. Therefore, the Chinese government has issued a series of policies and taken positive actions for hazard mitigation systemically. And under the policies of nationwide people-centered geohazard investigations and village-based early warning system, the proportion of landslides loss in social economy declines from 2012 to 2016. The Chinese government will also accelerate the early warning system construction and increase the investment on landslide hazard prevention. Such statistical study is helpful to landslide management and decision-making and is of great significance to a better understanding of Chinese fatal landslides for the international communication.

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