Review of natural disasters in Yunnan Province of China

Xiuyi Yao¹, Wenjie Fan²⁺, and Wanqing Wang¹
¹Yunnan University of Finance and Economics, Kunming, China
²Yunnan Earthquake Agency, Kunming, China
⁺Corresponding author: xtaolake@seis.ac.cn

Abstract. Various natural disasters have brought great economic losses and huge social influence under the complex regional environment in Yunnan Province. In this paper, we developed a comprehensive review on variety of natural disasters in Yunnan Province including strong earthquakes, landslides, floods and droughts. Based on the statistical analysis, some important prevention measures and suggestions were provided. This review will provide some references on the comprehensive natural disaster studies and it is helpful for natural disaster prediction.

1. Introduction
Yunnan Province is located in the southwest of China with a high incidence of natural disasters such as earthquakes, landslides, floods and droughts due to its special geographical location, complex topography and diverse climate types. Under the interactive influence of global climate change and natural geographic environment, the frequency of natural disasters in Yunnan Province has become higher and the causes of natural disasters have become more complex. In such complex conditions, many researchers have developed a lot of studies on a single disaster type and have achieved some research results.

Luo et al.¹ and Qu et al.² have found that the seismic activity in Yunnan area showed active and quiet characteristics, and its recurrence period was related to the earthquake magnitude. Zhang et al.³ have analyzed the spatial distribution characteristics of earthquake disasters and found that the earthquake disasters in Yunnan were marked with apparent regional characteristics and the damages in northeast area of Yunnan were the worst. Some researchers⁴⁻⁵ have analyzed the factors affecting the occurrence of landslides in Yunnan Province, and found that the degree of influence factors in descending order was elevation difference, terrain slope, earthquake, active fault, rock petrographic composition, and rainfall. Wan et al.⁷ have used daily rainfall data of 124 stations to conducted an analysis on the spatial distribution characteristics of landslide disasters. The study result showed that the high-risk regions of landslide disasters in Yunnan Province are mainly distributed in the northwest, northeast and southwest. He et al.⁸ have used rainfall data from meteorological stations in Yunnan Province to analyze the temporal characteristics of drought disasters in Yunnan Province. Wang et al.⁹, Rong et al.¹⁰ and Qi et al.¹¹ have used data of temperature, rainfall and humidity to analyze the spatial distribution of drought disasters in Yunnan. Zhang et al.¹² have analyzed some extreme drought events and their important impacts on social economy. These study results revealed that, the drought intensity in Yunnan Province generally showed an increasing trend with time series, especially after 2000, the incidence and intensity of droughts increased significantly. In terms of spatial change, drought disasters occurred in a large area of Yunnan, and the intensity of droughts gradually increased from northwest to southeast.
The hazards of natural disasters are gradually getting heavier with the development of economy, and the risk of natural disasters will be higher in the future under the increasingly complex conditions. However, the current field of disaster researches mainly focuses on the study of a single disaster type. The suddenness, uncertainty and severity of multiple natural disasters make it important to develop some studies on comprehensive natural disasters. There is an urgent need for statistical analysis and risk assessment of comprehensive natural disasters. The statistics of various natural disasters on regional scale is necessary for further comprehensive researches.

In this paper, we developed a comprehensive review on variety of natural disasters in Yunnan Province including earthquake, landslide, flood and drought. Based on the statistical analysis result, some important prevention measures and suggestions for the comprehensive natural disasters were put forward. This review will provide some references on the comprehensive natural disaster studies and it is helpful for natural disasters prediction and emergency rescue planning.

2. Strong earthquakes
Yunnan area is located in the southeast margin of Tibetan Plateau, and its seismic activity is active due to the long-term compression of the Indian plate and the Eurasian plate. Statistical results show that, 422 earthquakes with \( M_s \geq 5.0 \) occurred in Yunnan area from 1900-2020 and one earthquake with \( M_s \geq 6.0 \) occurred in a year on average.

Figure 1 shows the temporal characteristics of earthquakes with \( M_t \geq 6.7 \) in Yunnan from 1900 to 2020. It is obvious that the strong earthquakes with \( M_t \geq 6.7 \) show a temporal characteristics of time clustering in Yunnan area \((19.7^\circ E-30.0^\circ E, 96.0^\circ N-107.0^\circ N)\)\(^{[13]}\). Time series of these strong earthquakes can be divided into 4 complete active periods. They are 1913-1925, 1941-1955, 1970-1955 and 1988-1996. The duration for an active period is 8-14 years with the relative quiescence for 9-16 years. The number for strong earthquakes during an active period is about 4-5. As shown in Figure 1, the occurrence of a \( M_t \geq 7.2 \) earthquake in Myanmar on March 24, 2011 marked the beginning of an new active period in Yunnan area. Moreover, the earthquakes during first and third active periods were located in eastern Yunnan, and earthquakes during second and fourth active periods were located in western Yunnan. Meaning that the major areas for seismic activities show a pattern of alternative changes in east and west. Therefore, the possibility of strong earthquakes occurrence is extreme high, and the possible region is may be located in the east of Yunnan area according to historical case statistics.

![Figure 1 MT plot with Ms≥6.7 during 1900-2020 in Yunn area](image1)

![Figure 2a The distribution of earthquakes with Ms≥5.0 during 1900-2020 in Yunnan](image2a)

![Figure 2b The distribution of economic losses from earthquakes in Yunnan from 1992 to 2018 (unit: ten thousand RMB)](image2b)
The distribution of seismic events with magnitude greater than 5.0 from 1900 to 2020 in Yunnan area (Figure 2a) shows that most earthquakes are distributed along active faults. The 4 regions with high frequency of seismic events are west region, northwest region, southwest region and region along 103°E. Based on statistics of 76 strong earthquakes in Yunnan area from 1990 to 2018, Tang et al.\[14\] have found that 84 counties of Yunnan Province were directly affected by earthquake disasters. The statistical result shows that the total economic loss caused by earthquakes from 1990-2018 is about 13614 billion RMB (Figure 2b), and Ludian which located in the northeast region suffered the largest economic loss due to the earthquake of $M_{s}6.5$ occurred on August 3, 2014. Its economic loss exceeded 9 billion RMB. Followed by some counties of Zhaotong, Lijiang, Diqing, Dali and Pu'er, with economic losses of 3-9 billion RMB.

3. Landslide
Landslide disasters also have a greater impact on Yunnan Province as earthquakes. As of 2019, there are 11682 landslide points in Yunnan Province, which are distributed in all 129 counties as shown in Figure 3a\[14\]. Among them, there are 91 extra large-scale landslide points, 837 large-scale landslide points, 3366 medium-scale landslide points, and 7388 small-scale landslide points.

It is obvious that the ex-large scale landslide points are mainly distributed in Honghe, Sthe south of Yunnan Province and Baoshan, the western Yunnan. The Ailaoshan fault in the Honghe city is developed, and a lot of metamorphic and weak rocks are widely distributed. As a result, the geological structure of Honghe city is fragile, and ex-large scale landslide points are distributed. Most of the ex-large scale landslide points in Baoshan area are due to several factors including the strong neotectonic movement, complex geological structure, and strong physical and chemical weathering.

According to the distribution characteristics of landslide points and the economic loss of historical landslide disasters, the risks of landslide disasters in Yunnan Province are divided into high-risk, middle-risk and low-risk. According to statistic result, there are 17 counties in low-risk areas, 62 counties in middle-risk areas, and 50 counties in high-risk areas. Figure 3b shows that the high-risk areas are mainly distributed in the northeast, northwest and parts of central Yunnan. The low-risk areas including Jinghong, Honghe and Wenshan cities which located in the southern and eastern Yunnan. The remaining cities are medium-risk areas.

4. Flood
Flood disasters refer to the natural disasters that result in reduced crop yields, casualties, and serious economic losses due to long-term rainfall. Flood disaster is the most influential meteorological disaster in Yunnan Province. The annual food loss caused by floods accounts for about 27.5% of the total food loss caused by meteorological disasters. The direct economic loss caused by flood disasters in Yunnan Province is as high as 5.5 billion RMB every year.
Xie\cite{15} has found that an average of 60 flood disasters occurred in Yunnan Province based on the statistics of flood disasters from 1950 to 1979. In recent years, as the global climate has changed, extreme weather events have occurred continually, and the number of flood disasters in Yunnan Province has been increasing. Statistical result shows that most floods occurred from May to September each year, and 80% of them are concentrated from June to August.

The study on the spatial distribution characteristics of flood disasters found that the flood disasters in Yunnan Province are obviously regional\cite{15}. Figure 4 shows that the mountains of Cang and Ailao as the boundary, and more flood disasters in the northeast with less in the southwest. The main reason for the regional distribution of flood disasters is that the mountain of Ailao is relatively large, and combined with the mountain of Cang to prevent the cold wave and rainfall from north going south. As the result, more rainfall and serious flood disasters in the north and less rainfall and flood disasters in the south.

The reasons for the high frequency of flood disasters in Yunnan Province are mainly related to its geology environment, landform feature, climate type and vegetation condition. First of all, Yunnan Province is located on the eastern edge of the collision zone between the Eurasian plate and the Indian Ocean plate, so a series of deep faults have been formed. Secondly, Yunnan area is dominated by mountains with high elevation and large terrain slopes. These two internal factors lead to a wide distribution of landslide points with serious hazards. Thirdly, the climate of Yunnan Province is affected by the subtropical and southeastern Pacific monsoon. Therefore, there is continuous and abundant rainfall in Yunnan Province. This is the external factor that causes the high frequency of landslide disasters. Finally, the extensive farming methods in Yunnan Province have caused serious damage to forest vegetation, so its soil and water conservation capabilities are poor, which is a human factor that causes the high frequency of landslide disasters in Yunnan.

![Figure 4 The distribution of flood disasters in Yunnan\cite{15}](image)

5. Drought
Drought disaster refers to a climatic phenomenon in which the amount of water is insufficient to satisfy human survival and crop growth due to the long-term lack of rainfall. Drought disaster is one of the most serious meteorological disasters in Yunnan Province. The annual reduction in grain production caused by drought disasters accounts for 50% of the total grain loss caused by meteorological disasters.

Li\cite{17} have developed a statistical research on drought disasters in Yunnan Province from 1965 to 2011. The statistical results indicate that nearly 47 years rainfall precipitation showed an upward trend, so the drought disasters have a contrary downtrend. Statistics of 60 drought events have found that the drought disasters in Yunnan Province mainly occurred in spring and winter, and most drought disasters occurred in January and December\cite{18}.

The regional distribution of rainfall precipitation in spring and winter of Yunnan area is uneven, with less in the north and more in the south. Therefore, drought disasters in Yunnan Province are prone to occur in the northeast and northwest regions. As Figure 5a shows, the cities with the highest frequency
of drought disasters are Dali and Lijiang, followed by Wenshan, Qujing, Zhaotong, Kunming and Chuxiong\cite{17}.

He et al.\cite{18} have collected data of direct economic losses caused by drought disasters in 129 counties of Yunnan Province from 2004 to 2013. The spatial distribution of total economic losses (Figure 5b) shows that the areas with more severe drought impacts are Wenshan which located in southeast of Yunan, some cities of Dali which located in northwest of Yunan, Qujing which located in east on Yunnan and Honghe which located in south of Yunnan. Because of the different living environment, population distribution and economic development in different counties, the distribution of direct economic losses caused by drought disasters in Yunnan are also different from their disaster points distribution.

![Figure 5a](image1.png)

**Figure 5a** The distribution of drought disasters from 1965-2011 in Yunnan\cite{16}

![Figure 5b](image2.png)

**Figure 5b** The distribution of total economic loss caused by drought disasters from 2004-2013 in Yunnan (unit: ten thousand RMB)\cite{18}

The causes and risk analysis results of drought disasters in various regions of Yunnan show that the central and eastern areas have relatively flat terrain, developed Karst landforms, thin soil layers and poor water retention, so the risk of drought disasters in these areas are high. On the contrary, lots of mountains, valleys and forests are distributed in the northwest of Yunnan, so the risk of drought disasters is relatively small. Moreover, the southwest areas of Yunnan have lots of rainfall, abundant water resources, and developed river networks which are conducive to agricultural irrigation, so the risk of drought disasters is low.

### 6. Prevention measurements

Based on the characteristics of natural disasters such as strong earthquake, landslide, flood and drought in Yunnan Province, some disaster prevention measures and suggestions are provided.

1. Some investigations and information collection tasks on the natural disaster points should be developed so that we can take preventive measures to reduce casualty number and economic losses caused by natural disasters.

2. The fund invested in disaster emergency management should be reinforced. Each county should be equipped with natural disaster emergency equipment and make some feasible emergency plans to improve the effectiveness of natural disaster emergency response.

3. A lot of researchers on natural disaster prevention, natural disaster prediction, and warning technology should be developed.

4. Some regulations about how to make appropriate use of natural resources (such as water resources, land resources, forest resources, etc.) should be made. In addition, some improper farming methods that are prone to cause natural disasters should be changed.

5. The scientific popularization about natural disasters should be intensified so that the awareness of natural disaster prevention of public will be increased, and their ability to deal with natural disasters will be improved.
Acknowledgments
Financial support for this study was granted by the National Key R & D Program of China (Grant Number: 2018YFC1503806).

References
[1] Luo Guofu, Yang Mingzhi. (2005) Space-time Distributed Characteristics on Energy Field of Earthquake in the Yunnan Region. Earthquake Research in China, 21(3): 332-340.
[2] Qu Mengru, Xu Xiaoya. (2012) The sequential characteristic of seismic motion of Yunnan. Journal of Yunnan University, 34(S2): 40-42.
[3] Zhang Fanghao, Lu Yongkun, Deng Shurong et al. (2020) Regional Characteristics of the Earthquake Disasters in Yunnan Area. Journal of Seismology Research, 43(2): 134-143.
[4] Wu Ruijiang. (1994) Analysis of the forming of landslide and mud-rock flow in Yunnan and the prevention measures. International Symposium on Water Resources and Environment in Central Asia; 32-38.
[5] Zhang Hongbing, Jin Deshan. (2004) Some natural factors influencing on activity of landslide and debris flow in Yunnan Province. Journal of Hydrogeology and Engineering Geology, 5: 38-41.
[6] Tao Yun, Tang Chuan, Duan Xu. (2009) Landslide and debris flow hazards in Yunnan and their relationship with precipitation characteristics. Journal of Natural Disasters, 18(1): 180-186.
[7] Wan Shiyun, Li Huahong, Hu Juan. (2013) Hazard zoning of landslide and debris flow disasters in Yunnan Province. Journal of Catastrophology, 28(2): 60-64.
[8] He Jiaonan, Li Yungang, Li Xue, Huang Jiangcheng. (2016) Temporal and spatial characteristics of droughts over Yunnan Province during 1961-2012. Mountain Research, 34(1): 19-27.
[9] Wang Tao, Feng Ruisi, Chen Lu, Zhang Chao. (2017) Temporal and spatial analysis of drought in Yunnan Province based on meteorological. Forest Inventory and Planning, 42(2): 20-29.
[10] Rong Yanshu, Gong Lin, Lu Shoude. (2018) Analysis on characteristic and cases of persistent meteorological and hydrological drought in Yunnan from 2009 to 2014. Water Resources Protection, 34(3): 22-29.
[11] Qi Junqing, Yu Wenjin, Xie Tao, Ren Manliang. (2019) Spatial and temporal variation characteristic of drought disasters in Yunnan Province. Jiangsu J. of Arg. Sci., 35(3): 631-638.
[12] Zhang Wancheng, Zheng Jianmeng, Ren Juzhang. (2013) Climate characteristics of extreme drought events in Yunnan. Journal of Catastrophology, 28(1): 59-64.
[13] Huangfu Gang. (2009) Research on the seismicity in Yunnan, Chian. University of Science and Technology of China: 83-85.
[14] Tang Xiaoji, Lu Yongkun, Zhang Fanghao. (2019) Analysis on the characteristic and countermeasures of earthquake disaster in Yunnan Province. City and Disaster Reduction, 6: 52-58.
[15] Xie Yingqi, Huang Huaqin, Zhao Huazhu. (1994) A study of flood disaster in Yunnan. Journal of Yunnan University, 16(sup.1): 77-81.
[16] Li Zhen. (2014) Study on the temporal and spatial characteristics of drought occurrence in Yunnan Province. Kunming University of Science and Technology
[17] Peng Guifeng, Liu Yu, Zhang Guiping. (2009) Research on characteristics of drought and climatic trend in Yunnan Province. Journal of Catastrophology, 24(4): 40-44.
[18] He Jiaonan, Li Yungang, Li Xue, Huang Jiangcheng. (2016) isk assessment of drought disaster in Yunnan Province. Journal of Natural Disasters, 25(5): 37-45.