Article

Analysis on the losses of flood and waterlogging disasters in China during 2006 to 2017

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Abstract: China is in a period of rapid urbanization. Due to the high concentration of population and industries, the loss of flood and waterlogging has become more and more serious. Therefore, it is of great significance to strengthen the analysis and evaluation of the the losses of flood and waterlogging disasters in China for the recent years. This study analyzed of the losses caused by flood and waterlogging disasters in China from 2006 to 2017. The results show that it is the most serious year affected by floods and waterloggings in 2010. However, the relationship between rainfall and flood disaster losses is not significant, which may because the occurrence of flood disaster is the comprehensive effect of many factors. From the spatial distribution, it shows the eastern and southern parts of China suffer a greater losses from the flood and waterlogging disasters. Because these areas are more vulnerable to floods and waterlogging disasters under the impact of both monsoon and typhoon. The study is hoped to provide some reference for flood disasters control and disaster mitigation in the future.

Keywords: flood and waterlogging disasters; flood-affected population; direct economic loss; precipitation

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1. Introduction

Flood and waterlogging disaster has been one of the greatest threats to human survival and social development since ancient times. In terms of the space-time scope of disaster occurrence and intensity of disasters, floods rank first among all kinds of natural disasters. In the 20th century, the global average annual economic losses caused by floods amounted to \$ $3.0*10^{10}$, accounting for about 1/3 of the total losses caused by various natural disasters, and the death toll of floods is only less than plagues and droughts. In recent decades, especially since the 1990s, with the enhancement of human activities and economic development, the frequency and intensity of floods and waterloggings have been increasing [1]. China is one of the few countries in the world with the most frequent flood and flood losses. Flood prone areas are often the areas where population, economy and social factors are relatively concentrated [2]. In recent years, with the rapid development of urbanization in China, impervious pavement widely exists and buildings stand up, which has changed the state of underlying surface of the region and also affected the local climate [3]. The construction of water conservancy projects and drainage facilities in cities has made social and economic factors more intensive. Taking the Yangtze River Delta as an example, in 2016, the region had caught in serious rainfall processes and heavy rainfall intensity happened in some areas, which led to some river silting, some road traffic interruption, casualties and serious economic losses. Taking the Pearl River Delta as an example, typhoons and tropical storms often bring heavy rains and storm surges in the offshore areas, which would cause flood and waterlogging disasters. It make urban agglomerations vulnerable to flooding disasters, and the flooding range is wide, with the intensity is large and the duration is long. Thus, the frequent occurrence of flood and waterlogging disasters has a serious impact on China's social security and economic development. Therefore, it is of practical significance to analyze the loss of flood and waterlogging disasters in China for understanding the situation of flood disasters, and it would help future flood control and disaster relief.

2. Data and Method

This study collects data of flood and waterlogging disasters in China during 2006 to 2017, which are mainly based on the data of China Flood and Drought Disaster Bulletins from the State Flood Control and Drought Relief Command and the Ministry of Water Resources of China. The study does not consider the data from Hong Kong, Macao and Taiwan region. Based on the statistics of flood data in China, this paper analyses the trend of flood disasters in recent 12 years by correlation analysis and trend analysis methods. On the other hand, the relationship between precipitation and flood disasters is analyzed, and the distribution of flood disasters among provinces during theses years in China is discussed.

3. Results and Discussion

3.1 Trend of flood and waterlogging disasters in China

From 2006 to 2017, the average annual population affected by flood and waterlogging disasters in China was about 118.09 million, and the average annual direct economic loss caused by flood and waterlogging disasters was 201.30 billion yuan. Based on the data, the variation curves of annual flood-affected population and direct economic loss were established respectively, as shown in Figure 1 and Figure 2.

The year 2010 was the most serious year of flood disasters, in which 210.85 million people were affected by floods, and the direct economic loss was 374.543 billion yuan. Flood disasters occurred in the 30 provinces (or autonomous regions/municipalities) throughout the country. Spring floods occurred in southern parts of the Yangtze River basin during the same period. Floods in rivers and lakes exceeded the warning water level. The serious floods occurred in the upper reaches of the Yangtze River since 1987 [4], and the largest inflow peaks has occurred in the Three Gorges Reservoir since the reservoir was built. Zhouqu region in Gansu province, Guanling region in Guizhou province, Qiaojia region in Yunnan province, and Sichuan earthquake devastating areas have also successively experienced huge mountain torrents. In addition, in 2010 seven typhoons landed in China, causing Guangdong, Hainan, Fujian, Zhejiang and Guangxi provinces (autonomous regions) suffered from different degrees of floods [5].

During the period, the flood-affected population was the second highest in 2007, reaching 176. 98 million in the whole year, of which the Huaihe River suffered from catchment floods and the floods were prominent; Chongqing and Jinan suffered from catastrophic floods caused by heavy rains, and cities such as Wuhan, Xi'an, Zhengzhou, Hangzhou and Nanjing also suffered from waterlogging caused by local rainstorms throughout the year. There were 122 mountain torrents causing casualties, and the death toll accounted for 75% of the total number of deaths caused by floods [6].

During the period, the second highest direct economic loss was in 2016 with 364.33 billion yuan in the whole year. Influenced by the strong El Nino, there were many large-scale heavy rainfall processes in 2016. The flood area in China was wide and the local losses were heavy, including the floods in Hubei, Hebei, Anhui, Fujian and Hunan provinces. The direct economic losses caused by floods and waterloggings in these five provinces accounted for 64.9% of the whole country, and disasters occurred many time in parts of Anhui, Fujian and Hubei provinces. Severe flood disasters have occurred in some basins and regions, which reveals that there were still many weak links in the flood control and drainage system [7]. It would be necessary to make efforts to fill the "short slabs" of of flood control and drainage and disaster reduction, such as small and medium-sized river basins management, dangerous reservoirs reinforcement and urban drainage & waterlogging prevention, so as to enhance the capacity of prevent floods [8].

As far as the general changes of the flood-affected population and direct economic losses are concerned, there are fluctuations among these years, and there is no obvious trend of increasing or decreasing, and there are great differences among years. During the statistical period, the ratio of the maximum (in 2010) to the minimum (in 2017) of the flood-stricken population is 3.82, and the ratio of the maximum (in 2010) to the minimum (in 2009) of the flood-affected direct economic loss is 4.43. As can be seen from Figure 1 and Figure 2, both the flood disaster stricken population and flood-affected direct economic loss may show some periodicity over time. However, since the number of samples are limited, this cyclical change still calls for further study.

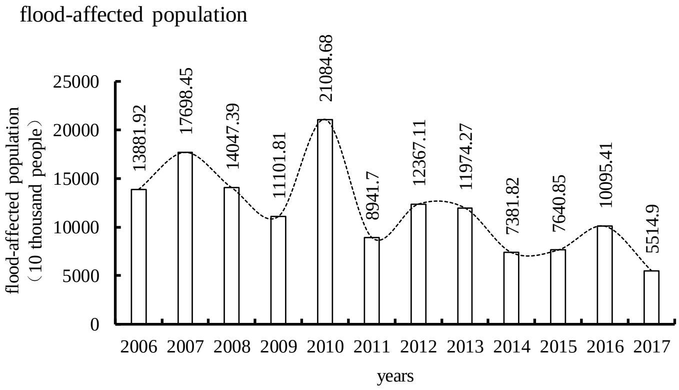

Figure 1. Changes of the flood-affected population during 2006-2017.

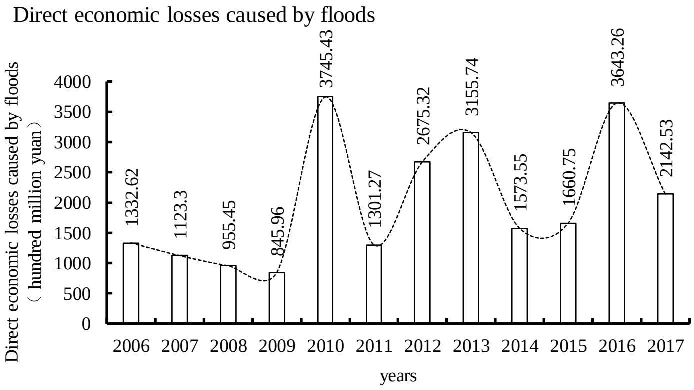

Figure 2. Changes of direct economic losses caused by floods during 2006-2017.

Considering the impact of flood and waterlogging disaster on China's economic and social development, the relative coefficient of economic loss affected by floods and waterloggings (M) is established [9]. The expression is as follows:

$$M = \frac{Direct\ economic\ losses\ of\ flood\ and\ waterlogging\ disasters\ in\ that\ year \times 10000}{Gross\ domestic\ product\ of\ China\ in\ the\ year} \quad (1)$$

M could indicate the impact of direct economic losses caused by floods and waterloggings in the year on the national economy [9]. Since the gross domestic product in 2017 of China has not yet been released by the National Bureau of statistics, the relationship between the relative coefficient of flood economic loss and time is established in the past 2006-2016 years, as shown in Figure 3. From Figure 3, it can be seen that the relative coefficient of economic loss affected by floods and waterloggings has a significant decreasing trend before 2010 and there is a significant abrupt change in 2010, which indicates that the occurrence of extreme weather in that year led to serious losses of flood disasters.

However, the relative coefficient of economic loss affected by floods and waterloggings after 2010 varies greatly from year to year, and it does not have significant increasing trend or decreasing trend with time.

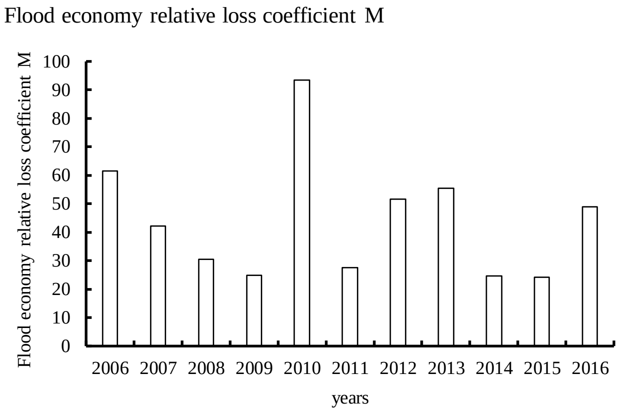

Figure 3. Changes of the relative coefficient of economic losses from floods during 2006-2016.

3.2. Relationship between precipitation and flood loss

During 2006 to 2017, the change of annual average precipitation in China is shown in Figure 4. It shows that the annual average precipitation in China from 2006 to 2017 is about 647.68 mm, of which 5 years are below the average precipitation and 7 years are above the average precipitation. Influenced by the strong El Nino in 2016, it had the largest annual precipitation as 730 mm among the past 12 years. The annual precipitation in 2010 is 695.4 mm, only next to 2016, and the lowest annual average precipitation in recent 12 years is in 2011, with 582.3 mm. It is generally believed that precipitation is the direct cause of flooding. From 2016 and 2010, the flood-stricken population and the direct economic losses caused by floods and waterloggings are serious, while in 2011, when the precipitation is small, the damage is relatively light. Considering the influence of precipitation on flood and waterlogging disaster losses, the relative coefficient of economic loss affected by floods and waterloggings (M) and the disaster-stricken population were selected to establish the correlations with annual average precipitation. Howerver, the correlation coefficient between the average annual precipitation and the flood disaster-stricken population is 0.01, and the correlation coefficient between the average annual precipitation and the relative coefficient M is 0.245, which indicates that the relationship between precipitation and flood damage is not obvious. Considering its causes, on the one hand, the average annual precipitation weakens the impact of heavy precipitation process on flood disaster caused by extreme weather; on the other hand, the flood disaster is the result of the comprehensive effect of many factors, and it will also be affected by the ecological environment and human activities. For example, the shrinkage of lakes will reduce the regulation and storage of floods; the decreasing vegetation coverage will reduce water conservation capacity and lead to soil erosion, thus forming a vicious cycle of river and lake siltation [10]. In addition, the change of urban underlying surface shortens the time of runoff yield and confluence, and the unreasonable design of rainwater pipe networks aggravate the occurrence of urban waterlogging [11].

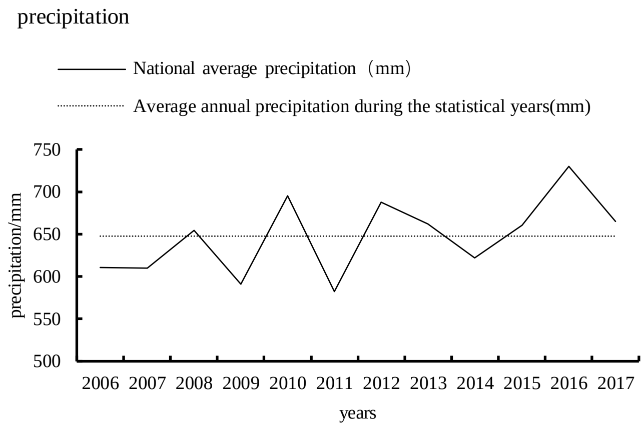

Figure 4. Annual average precipitation changes from 2006 to 2017.

3.3 Spatial distribution analysis of flood and waterlogging disasters

China is located in the eastern part of Asia and the west coast of the Pacific Ocean. The territory of the country is vast, the north-south spanning dimension of the territory is nearly 50 degrees, the east-west spanning longitude is more than 60 degrees. The combination of temperature and precipitation is diverse for China, forming a variety of climate, so the losses caused by flood and waterlogging disasters are not the same.

The statistical data of flood and waterlogging during 2006-2017 for the provinces (municipalities or autonomous regions) in China are shown in Figure 5 and Figure 6. From the data, it is shown the occurrence of floods in the country has a wide range, basically occurring in almost every province (municipality or autonomous region), causing significant losses and serious threats to people's life and property safety.

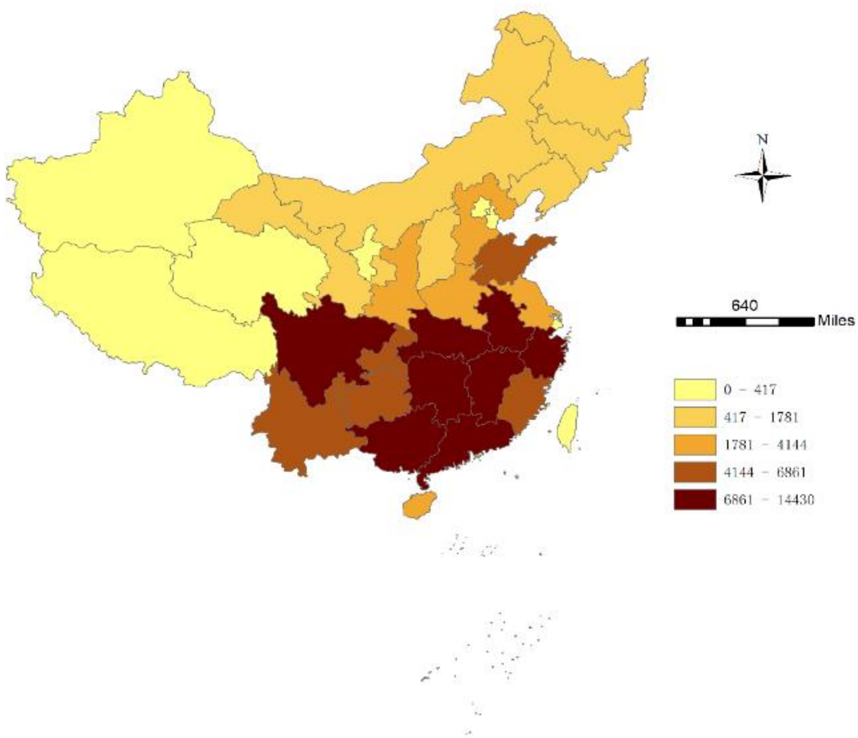

Figure 5. Distribution of the accumulated flood-affected population from 2006 to 2017 in China.

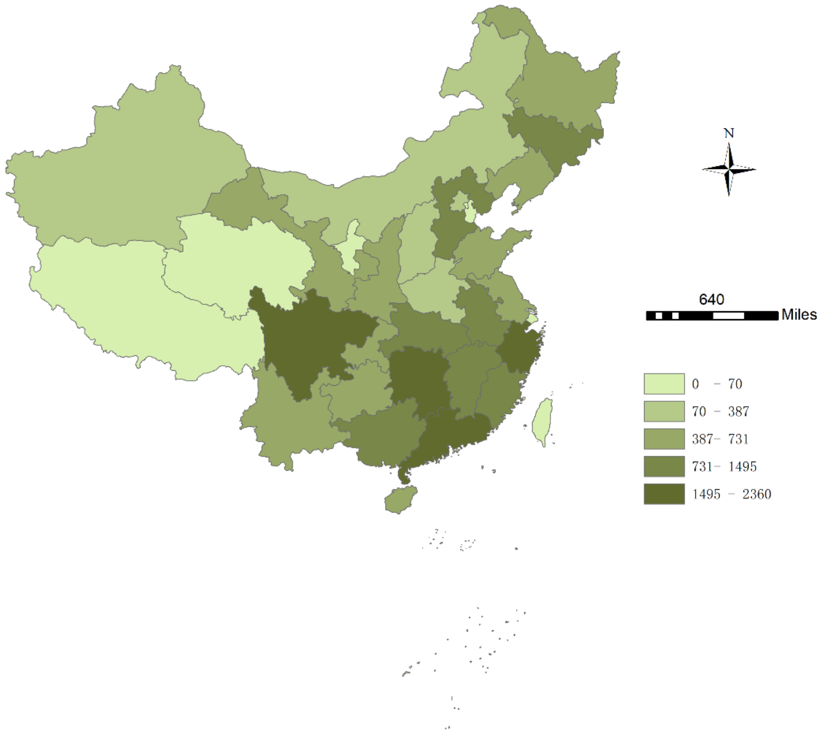

Figure 6. Distribution of the accumulated direct economic losses caused by floods from 2006 to 2017 in China.

Figure 7 and Figure 8 show the composition and cumulative direct economic losses and the cumulative affected population of the flood and waterlogging disasters of China. It can be seen from Figure 7 the top six areas of the flood affected population are Sichuan, Hunan, Hubei, Guangdong, Guangxi and Anhui provinces, and flood affected population of each province is over 90 million, with the total affected population accounting for 50. 42% of the disaster affected population in China. It can be seen from Figure 8 the top six areas of the cumulative direct economic loss due to flood and waterlogging disasters are Guangdong, Sichuan, Zhejiang, Hunan, Hubei and Fujian provinces, and the total direct economic losses of these six provinces accounted for 47.24% of the whole country. It shows that, due to the combined influence of monsoon and typhoon, most of China's flood and waterlogging losses are concentrated in the eastern and southern regions.

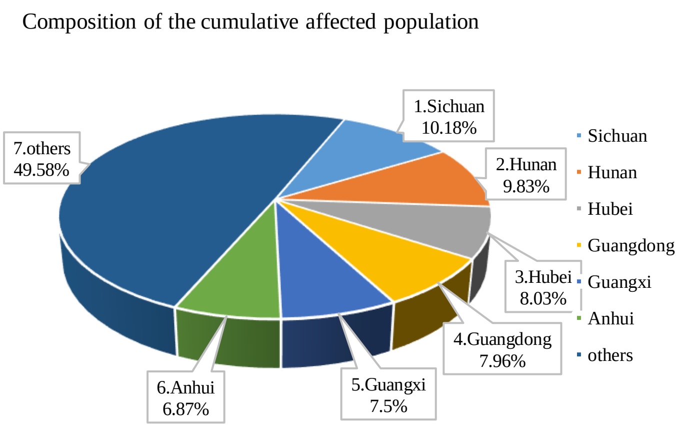

Figure 7. Composition of the cumulative population affected by floods of China.

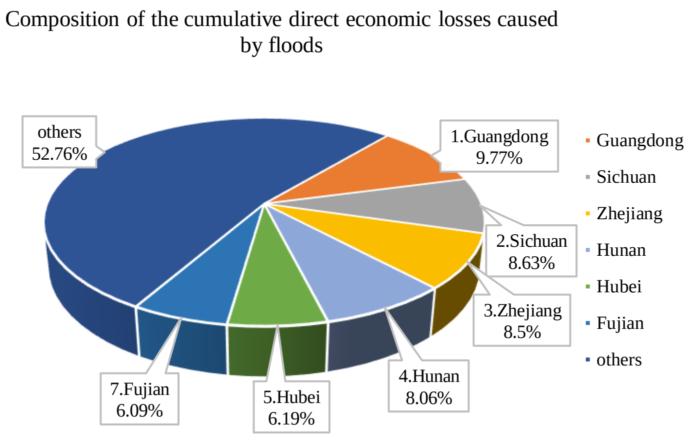

Figure 8. Composition of the cumulative direct economic losses caused by floods of China

5. Conclusions

This study conducted the analysis of the losses caused by flood and waterlogging disasters in China from 2006 to 2017. The results show that the losses caused by floods and waterloggings in China in the past 12 years are very serious, especially in 2010, which is the most serious year affected by floods and waterloggings, and almost all provinces have suffered from floods and serious losses in that year. However, by analyzing the relationship between rainfall and flood disaster losses, it is found that the correlation is not obvious, which may because the occurrence of flood disaster is the comprehensive effect of many factors and it will also be affected by the ecological environment and human activities. From the spatial distribution, it shows the eastern and southern parts of China suffer a greater losses from the flood and waterlogging disasters, which mainly because these areas are affected by both monsoon and typhoon, so they are more vulnerable to floods and waterlogging disasters. The study is hoped to have practical significance for understanding flood disasters and contributing to disaster resistance in the future.

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Conflicts of Interest: The authors declare no conflict of interest.

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