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Indoor Property Flood damage Assessment and Insurance for Residential Buildings based on HAZUS -- A case study of Mayangxi River Basin

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Abstract. The flood disaster is one of the most common natural disasters in China, and the indoor property loss of residents is huge every year due to the flood. Therefore, it is of great significance to study the evaluation of the indoor property flood loss of residential buildings. Based on HAZUS flood loss assessment method, this paper reclassifies the residential buildings in China according to the number of households. The post-disaster loss data and household income level were used to establish the depth-loss percentage function. It provides an important method for the rapid evaluation of the loss after disaster in this area. In order to transfer the risk of flood loss of indoor property of residents in Mayangxi River Basin, an insurance scheme is designed, which provides an important idea for disaster prevention and mitigation in similar areas.

1. Introduction

China is one of the countries plagued by flood disaster in the world, especially in the south of China, summer flood occurs most frequently, and flood disaster will cause huge economic loss of indoor property every year. With the continuous improvement of China's overall economic strength, the gap between the rich and the poor increases, and there is a large gap in indoor property value in regions with different income levels. Therefore, the indoor property losses caused by the flood show a strong regional. In terms of flood loss assessment, the research in China started relatively late. In the early 1990s, Chinese scholars Wenkang and Jinguan began to study the statistical assessment of flood disaster. In 1999, Chen Xiuwan et al. studied the loss system of flood disaster by using remote sensing and GEOGRAPHIC information system technology, and conducted real-time assessment of flood loss. In 2002, Su Mingdao, a scholar in Taiwan province, divided residential buildings into single residential buildings and collective residential buildings, conducted classified investigation and summary of the internal properties, and established the relationship curve between flood loss and water depth. In 2014, Cao Shijia and other scholars took the secondary coastal flood disasters caused by typhoons "Ramason" and "Gull" as examples to construct the vulnerability curve of residents' indoor property. Cheng Xiaotao, Li Shuaijie and Wang Shan analyzed the characteristics of urban flood disaster in China, and put forward different flood coping strategies for coastal city, plain city and hill city respectively. To the problem of flood disasters caused by indoor property need to take into account the different regions in different economic levels, to better assess the size of the loss, but now our country has not formed by economic income level for the division standard of flood loss curve, mostly based on normal loss data as the basis, not rich gradually along with the continuous development of economy, the lack of development.

Foreign developed countries have developed specialized software for flood loss assessment. The current flood evaluation model for the HAZUS-MH, it used since the 1960s, the army corps of engineers (USACE) with different types of residential and commercial buildings depth-relation estimation method of flood damage loss, unceasingly absorb more building environment factors and update the data in the flood losses, have the function of the post-disaster fast loss estimation; current software in Australia is EMA-DLA, which can directly and accurately assess the flood, repeat the assessment of the results, and also assess the business interruption, rescue and other indirect losses caused by the flood. The ECLAC system is the disaster loss assessment theory of the United Nations Economic and Social Council for Latin America and the Caribbean in 2003. It combines loss assessment with socio-economic development and focuses on the overall impact of disasters. The PDNA developed by the Leadership Group Of the United Nations can assess flood losses based on pre-disaster and post-disaster information, with the focus on providing strategies and guidance for early post-disaster recovery. Although different countries use different loss assessment systems, they all have rich national databases and detailed historical loss information to form a complete system, and update and improve the data regularly. If China wants to be more mature in flood loss assessment, it must learn the assessment methods of other countries and modify them in combination with the actual situation, so as to continuously optimize the existing flood loss assessment methods.

This paper use HAZUS-MH evaluation model of flood damage assessment model of theoretical method, try to our country housing indoor property flood disaster loss assessment, choose Mayangxi River Basin as the research object, setting depth-percentage loss function, thus rapid estimation of residential buildings in the area of flood may cause indoor property loss, and insurance Suggestions according to the damage situation of science, system, rapid flood damage assessment is of great significance.

2. Introduction to HAZUS-MH flood damage Assessment model

The HAZUS-MH disaster Assessment model, developed jointly by the Federal Emergency Management Agency (FEMA) and the National Academy of Building Sciences (NIBS), is a risk-assessment and loss-assessment software for earthquake, flood and hurricane disasters. The software uses national databases containing information on buildings of different types and sizes to assess the physical damage, economic loss and social impact of buildings in a census area.

The damage assessment method of flood model is to extract different depth-loss functions from the database to calculate the degree of damage and loss. Based on the existing historical loss records of disasters, the possibility and frequency of floods are calculated, the damage caused to buildings, infrastructure, transportation facilities and other facilities is assessed, and the direct and indirect economic and social impacts are analyzed and calculated.

Since this model is only applicable to the United States, this paper only uses its theoretical method to establish the depth-loss function according to the different levels of economic income in each region to carry out the assessment of local indoor property losses in floods.

3. Building classification

《Standard for terminology of civil architectural design》GB/T50504-2009 in our country now with the most complete, most detailed classification standard, the standard will be according to the building height, the number of layers, and use function classification, and the size of the damage to the building and construction of flood layer is not too big relations, so if classified according to these standards is still too rough, and this kind of classification method does not take into account the flooding velocity of damage to the building structure, building contents and value of the inventory and didn't mention, unable to form a flood damage assessment method suitable for residential buildings. Therefore, this paper reclassifies buildings based on China's residential building classification standards and the building classification method in the HAZUS flood model user manual, as shown in Table 1.

Table 1. Residential building classification based on HAZUS classification method.

Classification	Corresponds to the HAZUS class	Corresponding to Chinese standard classification
Single-family construction	RES1	
Duplex multi-family building	RES3A	Low-rise civil building
Multi-family building with 3-4 units	RES3B	
Multi-family building with 5-9 units	RES3C	High-rise civil building
Multi-family building with 10-19 units	RES3D	
Multi-family building with 20-49 units	RES3D	Super tall civil building
Multi-family building with more than 50 units	RES3F	

4. Building flood damage assessment

4.1. Overview of the study area

Mayangxi River basin is located in Changtai County, Zhangzhou city, Fujian Province. It is the main river in Changtai County, with a total length of 30.4km, a drop of 222m and a slope of 7.3‰. The average annual rainfall in the region is 1688mm, the highest altitude is 965.8m, and the average altitude is about 450m. The elevation is gradually decreasing from northeast to southwest, and the geographical landform is relatively complex, with the mountain area reaching 76%. The schematic diagram of Mayanxi River basin is shown in Figure 1.

Figure 1. Map of Mayang River basin.

Mayangxi flows through the three villages of Shanzhong Village, Houfang Village and Shili Village. The specific conditions of the villages are shown in Table 2. Shanzhong Village is close to Hongyan Reservoir, the upstream slope of which is steep, the water flow is slow and rapid crisscross, mountain flood disaster occurs all the year round. Houfang village is mainly engaged in fruit tree planting. Shili village is the central area of Mayanxi tourist area, with more than ten enterprises settling in the area and the most developed economy.

Table 2. The number of residential buildings and the annual per capita income in each village.

	Number of residential buildings	Annual per capita income (yuan)
Shanzhong Village	1221	14194
Houfang Village	713	13502
Shili Village	1310	18238

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4.2. The data source
Flood depth and flood loss is derived from the questionnaire data, satellite image data from bigemap software of Google map (not offset).

4.3. Establish a depth-loss percentage curve
The value and type of a family's indoor property are closely related to economic income. Therefore, this paper takes annual per capita income as the entry point to establish the depth-loss percentage function of different economic zones. Because the average annual income levels of Shanzhong Village, Houfang Village and Shili Village are different, they are divided into middle income areas, middle-high income areas and high income areas respectively.

According to the statistics of household appliances and purchase quantity at different prices on JD.com in 2016, the average prices of the top 10 domestic products with different levels of domestic property sales are selected, as shown in Table 3.

Table 3. Classification and average price list of indoor property.

	Annual per capita income (yuan)		
	Middle income area	Middle-high income area	High income area
Large household appliances	3674.6	3729.3	4502
Oil absorption	972.6	1016.8	1588.7
The water heater	856.3	998.9	1498.5
Desktop computer	2867	3079.9	3469
Air conditioner	2087	2293.9	2683
Food and Commodities	117	209	483
Furniture	1701.6	2073.6	2592
Bedding	204.9	307.9	491.8
Total	11981	13709	17308

Assuming that all indoor properties above the area are included, the ratio of loss to total indoor property value can be calculated to obtain the loss percentage of each flood depth. The established depth-loss percentage function is shown in Figure 2.

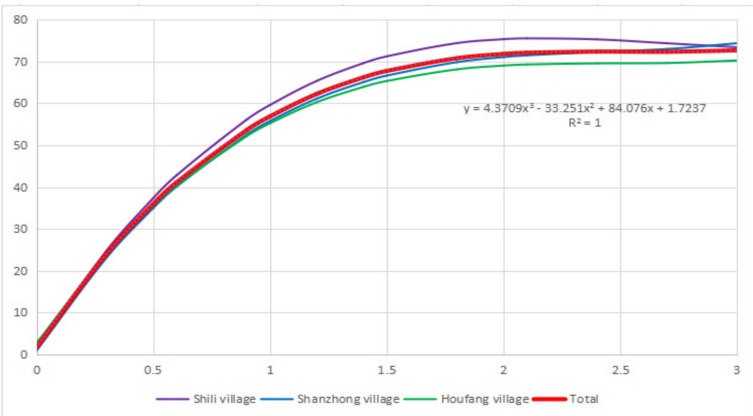

Figure 2. Depth-loss percentage function of interior property in residential buildings.

By comparing the depth-loss percentage function of the three villages, it can be clearly seen that the relationship between the loss percentage and flood depth has a strong consistency and a very similar trend. Therefore, the corresponding relationship between the percentage of indoor property flood loss (Y) and flood depth (x) of residential buildings in The Mayanxi River Basin is obtained by fitting the three curves: $y=4.2763x^3-32.479x^2+82.005x+1.6904$.

From the distribution of depth-loss percentage function, when the flood depth is 0-0.1m, the loss to indoor property is slight and basically has no influence. When the flood depth rises from 0.1m to 0.4m, the damage degree becomes moderate, and the loss value of indoor property increases rapidly, mainly because the first floor and basement property are eroded by the flood at that time. As the water level continues to rise to 1.2m, the interior furniture, floor items and bedding are damaged and the damage becomes serious, while most household appliances and kitchen utensils are not damaged. When the depth of the flood is over 1.2m, a large number of household appliances and kitchen utensils are affected, and more than half of the family's property is lost, which is considered as a disaster. After 1.7m, no matter how the depth of the flood increases, the loss will be basically maintained at around 70%, and the main family property will be completely lost.

5. Insurance proposal

In order to transfer the risk of flood loss to the indoor property of the residents in The Mayanxi River basin, it is an effective method and measure to choose to insure the disaster loss of household property. The product of the number of residential buildings in Shanzhong Village, Houfang Village and Shili Village and the indoor property value was used to determine the total value of family property. According to the depth-loss percentage function, the percentage of property loss in the three villages can be determined, and the total insured amount is finally obtained, as shown in Table 4. Due to the characteristics of home property insurance, the insured amount is rounded.

Table 4. Total insured amount.

	Indoor property value (yuan)	Percentage loss (%)	Amount insured (yuan)
Shanzhong village	16738689	23.4842501	3930399
Houfang village	8542453	44.6459609	3813837
Shili village	22673480	68.2440519	15472410

The family property insurance that our country opens at present is carried out inside area limits without difference rate, the standard of rate is between 2‰ and 5‰. According to the rate table of home property insurance stipulated by PICC, the basic rate of ordinary home property insurance is r_0 =1‰, and the basic rate of additional flood insurance is 0.1‰~0.2‰. Due to the high frequency of the flood disaster in The Mayanxi River basin, and the severity of the flood level, flood submergence range and depth in the past, the additional insurance rate is set as r'=0.2‰. Total rate: $r= r_0+ r'$=1.2‰. The premium payable by each village household is finally determined as shown in Table 5.

Table 5. Insurance premium.

	The premium
Shanzhong village	4716.4788
Houfang village	4576.6044
Shili village	18566.892

6. conclusion

Based on the theoretical method of HAZUS flood disaster loss analysis model, choose the Mayangxi River Basin as the study area, use the flood disaster loss data happened on September 15, 2016. According to the different income levels divided economic zone, to determine the indoor property of different economic value, ultimately determine the depth - percentage loss function, fitting get Mayangxi River Basin flood loss percentage of residential building indoor property (y) and water depth(x). The curve can be used directly in the next flood disaster, the initial loss assessment is fast and accurate, and has strong availability. According to the flood loss data, a new curve is generated, and the old curve is fitted to form a flood loss curve suitable for this area.

The main conclusions of this paper are as follows:

(1) Referring to the HAZUS building classification method, using the number of households and combining with China's national standards, the existing residential buildings in China are reclassified.

(2) The Mayangxi Basin is selected as the research area, which is rich in water resources, abundant in rainfall and prone to flood disasters, with a high risk of flood disasters.

(3) Using the data from the 2016 flood loss combined with the local market value of all kinds of indoor property, based on the three villages of different income levels deep-percentage loss function, and eventually find Ma Yang fitting creek watershed flood loss curve of residential building indoor property: $y = 4.2763x^3-32.479x^2 + 82.005x + 1.6904$.

(4) Designed insurance scheme for Mayangxi River Basin residential building indoor property, Eventually, determine the region covering family property damage insurance coverage and premium.

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