Insurance Principles for Sustainability in Extreme Weather

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Abstract. Climate change-related extreme weather imperils people's lives, health, and property. This research constructs an insurance evaluation model and a landmark protection model to boost property insurance sustainability. Taking China and the United States as cases, the insurance evaluation model uses a competitive screening model for pricing and the TOPSIS method for impact scoring. It can distinguish underwriting risks (scores over 60 indicate low-risk underwriting, 20-60 suggest cautious underwriting, and below 20 mean no underwriting) and has 5% sensitivity stability. Based on this, property site selection is evaluated. For instance, Fujian Province was analyzed, and Fuzhou City with a score of 83.2 was selected as a suitable location, with a preference for areas scoring over 60. The landmark protection model, relying on the object element topable model, scores landmarks (preserving those over 60) and quantifies protection measures. The models were applied to the Mogao Grottoes, and a community protection letter was formulated. These models offer valuable tools for the insurance industry, real-estate developers, and heritage conservation, enhancing the understanding of the relationship between extreme weather, property insurance, and landmark protection.

Keywords: Property insurance; TOPSIS integrated evaluation approach; Objective element topological modeling; Extreme weather; Landmark protection

1 Introduction

Global warming is having alarming consequences around the world, including more frequent extreme events and rising sea levels. And climate change is increasing extreme weather instability, with a marked increase in the frequency and intensity of extreme weather events, which have already caused more than $1 trillion in damages and a significant increase in claims. Climate change is expected to drive premiums up by 30-60% by 2040 [1].

Extreme weather occurs differently around the world due to unique local geographic locations and climatic conditions, resulting in the cost of property insurance premiums varying from place to place. In recent years, the price of property insurance has continued to rise and the number of property insurance policies has declined cumulatively as the incidence of extreme weather has continued to increase [2]. In addition, the insurance

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coverage gap, which averages 57%, has widened. All of these factors have led to an ongoing crisis in the profitability of insurance companies and the affordability of property owners. For details, see **Fig. 1**.

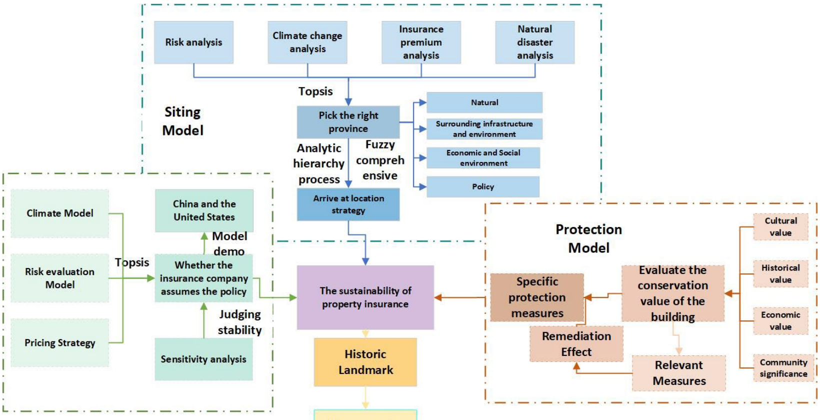

Fig. 1. This article mainly technical roadmap.

2 Method

In the research methodology, data on the occurrence time and frequency of extreme weather events in the US and China was sourced from NASA GMAO's GEOS - 5. Data preprocessing, including cleaning missing values, handling outliers, and standardizing variables, was done in Excel. The constructed TOPSIS model was implemented and evaluated in MATLAB, using its numerical capabilities to calculate the relative closeness of data points for risk assessment in the insurance evaluation model. A technical roadmap, created with Microsoft Visio, visually presented the process from data acquisition, through preprocessing and model implementation, to the application in property insurance and landmark protection, helping to understand and replicate the study [3].

3 Results

3.1 Climate models

Calculation of the intensity of extreme weather events:

$$s = \frac{a_i}{\sum a} * 0.3 + \frac{d_i}{\sum d} * 0.4 + \frac{e_i}{\sum e} * 0.3 \tag{1}$$

Where: ‘ a ’ is the number of people affected (in tens of thousands), ‘ d ’ is the number of people who died, ‘ e ’ is the economic loss (in thousands of US dollars), and data such as 0.3 are the weights obtained through the hierarchical analysis method, the calculation process of which will be described in detail later.

Extreme weather event risk index calculation:

$$P = \sum p_i \times s_i \tag{2}$$

Through the above calculation method, we can get the risk index of the four extreme weather in China and the U.S. In order to have a better view of the data, the frequency is used here instead of the frequency for the calculation, and the results are as follows: For details, see **Table 1**.

Table 1. 2015-2021 Probability of four weather extremes in China and the United States

Country	China				American			
	Floods	Storms	Wild-fires	Drought	Floods	Storms	Wild-fires	Drought
2015	0.85	22.69	0.00	0.09	1.18	1.60	0.18	0.06
2016	4.54	79.60	0.00	0.36	2.33	1.09	0.18	0.00
2017	1.10	9.12	0.00	0.05	0.18	4.54	0.51	0.03
2018	0.47	30.47	0.00	0.00	0.06	0.27	1.67	0.04
2019	0.50	8.64	0.24	0.00	0.51	1.26	0.03	0.00
2020	0.81	1.09	0.46	0.00	0.09	2.65	0.11	0.46
2021	0.62	2.72	0.00	0.10	1.46	7.41	0.32	0.11

3.2 Premium Pricing Strategy

Based on risk assessment, a premium pricing strategy for different-risk regions was developed [1], considering the time value of money and using a competitive-screening model. Key formulas include $D = P * D * C * \frac{1}{(1+j)^t}$ for total claims and $B = M * Q$ for premiums. Premiums for China and the US from 2015-2021 were calculated, as shown in **Table 2**.

Table 2. Schedule of premiums to be paid in China and the United States, 2015-2021

Country	China		United States	
	Frequency Premium	Premiumuency Premium	Frequecyuency Premium	Premiumuency Premium
2015	30	2738	30	19726
2016	24	2758	24	19786
2017	23	2715	23	19803
2018	16	2680	16	19678
2019	23	2717	23	19652
2020	24	2734	24	19881
2021	42	2734	42	19967

3.3 Topsis evaluation

TOPSIS is a method of ranking the evaluation objects according to their proximity to the idealized target, and it is a distance synthesis evaluation method that performs the ranking of the advantages and disadvantages of each evaluation object [4,5,6].

The value of which ranges from [0,1], the closer to 1 indicates that the closer the situation is, the closer the degree of closeness is converted into a score situation G_i show, the score situation indicates that the insurance company to bear the risk of the policy, the higher the score represents the lower the risk [7], to get the score of China 2015-2021 G_i = {65.2, 11.9, 82.3, 84.4, 89.2, 79.5, 83.6}, US G_i={80.0, 83.8, 82.2, 86.2, 91.8, 37.3, 37.1}

Based on the results obtained from the above modeling, we select that when the score is more than 60 points, the insurance company can assume the policy; the score is between 20-60 points (including 20, excluding 60) the insurance company can choose to assume a certain amount of risk for underwriting; if the score is lower than 20 points, it may be due to the large gap in the insurance coverage, the insurance company's lack of profitability is not conducive to its sustainability, and so it can not be underwritten Insurance Policies [4,5,8].

3.4 Object element table

According to the superiority of the restoration effect of China's historically protected buildings from high to low is categorized into: Class I (good protection and restoration effect), Class II (better protection and restoration effect), Class III (general protection and restoration effect), Class IV (poor protection and restoration effect), and quantitatively outlines the protection and restoration effect level as follows: N_p= { Class I→Class II→Class III→Class IV}, N_{01}={ Class I} ..., for any object p to be evaluated in the N_p, determine the degree of affiliation of p [9,10,11].

Finally, we selected five landmarks in China for the evaluation of the index of expandability, respectively, to obtain a comprehensive evaluation index, the higher the index means that the feasibility of the measure in this place is better, the restoration effect of applying this measure is the best, and the benefits generated are also higher. The obtained data were visualized as follows. For details, see **Fig. 2**.

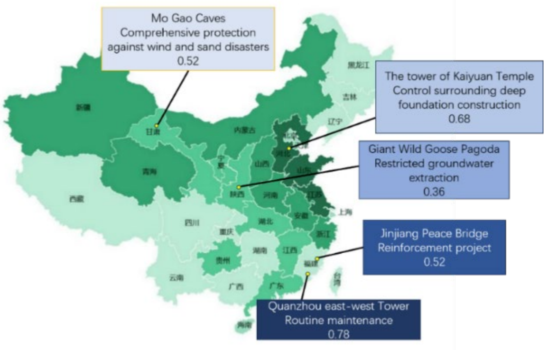

Fig. 2. Surface building expandability evaluation

4 Conclusion

This study developed an insurance evaluation model and a landmark protection model to address the challenges posed by extreme weather. The insurance evaluation model, using competitive screening, and TOPSIS, predicts risks, sets premiums, and assesses insurance - taking risks. It shows 5% sensitivity stability, helping insurance companies make more informed underwriting decisions.

For property site selection, areas like Fujian were evaluated. Fuzhou, with a high score, was chosen as a suitable location. This evaluation method provides a scientific basis for property developers and investors to reduce risks related to extreme weather.

The landmark protection model, based on the object element topable model, scores and protects landmarks. Applying it to the Mogao Grottoes offers practical conservation plans, which are crucial for preserving cultural heritage. In conclusion, these models enhance our understanding of the relationship between extreme weather, property insurance, and landmark protection. They provide practical tools for the insurance industry, real-estate developers, and heritage conservationists. Future research could focus on improving model accuracy by incorporating more complex environmental and social factors. In practice, these models can be directly applied to regions prone to extreme weather, guiding decision - making in insurance policies, property development, and landmark conservation.

References

1. Ting Tang.(2023). Master's Thesis on Development Strategy of M Property Insurance Company, Dalian Maritime University, China). 2023.000180.
2. Hua Xu.(2010). Doctoral Dissertation on Factors Influencing the Capital Structure of Insurance Companies, Southwestern University of Finance and Economics, China).
3. Haoran Liang. (2013). On the Legal Construction of China's Catastrophe Insurance System Doctoral Dissertation, Jilin University).
4. Ning Sun.(2019). Ph.D. Thesis on the Design of Optimal Earthquake Index Insurance Policies, Wuhan University. 2019.000929.
5. Lisheng Sun, Yu Deng, Yandi Wang. (2017). Study on the rationality of real estate project site selection--Taking "Golden Waterfront" in Huinong District, Ningxia as an example. Ningxia Engineering Technology (02),173-177.
6. Yue Xie.(2023). Master's Thesis on Investment Decision Making in Real Estate Projects Based on Improved TOPSIS Modeling, Jiangxi Normal University of Science and Technology).
7. Shaou H.(2016). Evaluation of Real Estate Site Selection Factors Based on Hierarchical Analysis. Sichuan Water Conservancy (04),100-103.
8. Qin Li, Junning Liu, Xingwang Pei. (2019). Modeling and Application of Reinforcement and Restoration Effectiveness in Historically Conserved Buildings. Heritage and Conservation Research (04), 13-17. doi:10.19490/j.cnki.issn2096-0913.2019.04.004.
9. Lu Chen, Xueqing Zhang. (2022). A Quantitative Evaluation Model for the Conservation and Reuse of Red Buildings in Shanghai. Furniture and Interior Decoration (07), 114-119.doi:10.16771/j.cn43-1247/ts.2022.07.019.

10. SUN Shao, LI Duo, LIU Lüliu, et al, 2017. Global Major Weather and Climate Events in 2016 and the Possible Causes. Meteorological Monthly, 43(4): 477-485. DOI: 10.7519/j.issn.1000-0526.2017.04.010.
11. YIN Yizhou, LI Duo, SUN Shao, et al, 2020. Global Major Weather and Climate Events in 2019 and the Possible Causes. Meteorological Monthly, 46(4): 538-546. DOI: 10.7519/j.issn.1000-0526.2020.04.008.