| Problem Chosen | 2024 MCM/ICM Summary Sheet | Team Control Number |
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# Solutions to Climate Risk Insurance Underwriting


**Summary**

Climate change caused by human activities has affected every region of the globe, resulting in a high incidence of extreme weather and climate events. Extreme weather has a negative impact on people's productive lives and can also cause significant property damage. In this context, we use mathematical modeling to explore the issues of property security and building protection in extreme weather to help people better cope with possible uncontrollable factors in the future.

For Task 1, we constructed an insurance model of whether to underwrite insurance in places where extreme weather is frequent based on risk and benefit considerations through a task disassembly approach. First, we build a weather prediction model to predict the frequency and degree of loss of extreme weather in the study area in the future using the time series analysis **ARIMA** method. Second, we built an engineering model to evaluate the damage caused by extreme weather to buildings such as houses. Finally, we built a **dynamic planning** model to help insurance companies make extreme weather insurance decisions based on risk-benefit analysis. Taking two regions, the United States and Japan, as examples.

For Task 2,we use dynamics programming in Task1, which enables communities and property developers to decide how and where to build and grow.

For Task 3,We developed the Conservation Value of Landmarks Evaluation Model to help community leaders identify buildings of conservation value in their neighborhoods. Indicator weights were determined using **AHP** from four dimensions: cultural value, historical value, economic value, and social value. The landmarks in the community were then scored and ranked using the Weighted Improved **Topsis** method to provide a reference for conservation prioritization.

For Task 4, we selected the city of New Orleans, Louisiana, USA to apply our insurance model and evaluation model. Due to risk and cost considerations, insurance companies may not choose to insure in this city in the coming years. The government needs to spend more effort to identify and protect important neighborhood buildings. The results of the model evaluation yielded that St. Louis Cathedral is the most deserving building to be prioritized for preservation. Finally, through the modeling and theoretical analysis of architectural preservation, we propose a preservation project for St. Louis Cathedral from a variety of perspectives, including building structure, resource use, and community support, which is expected to cost.



**Keywords**: Dynamics Programming; ARIMA; AHP-TOPSIS

# Contents

# 1 Introduction

## 1.1 Problem Background

The recent spate of extreme weather events around the world is posing a serious challenge to property owners and insurers. According to statistics, more than 1,000 extreme weather events over the past few years have resulted in more than $1 trillion in damages. In particular, natural disaster claims in the Kaw area have increased by a staggering 115% in 2022 compared to the 30-year average. Loss scenarios are expected to become even more severe in the future due to the frequency of severe weather events such as floods, wind restrictions, cyclones, droughts and wildfires.

At the same time, insurance costs are rising at a rapid pace, with climate change predicted to cause insurance costs to rise by 30 to 60 percent by 2040. This is not only making property insurance more expensive, but also more difficult to obtain as insurers adjust how and where they write coverage. The rising cost of property insurance is influenced by weather events related to geographic location.

In addition, the global insurance coverage gap averages 57% and continues to grow. This highlights the dilemma facing the industry as a whole - the profitability of insurers and the affordability of property owners are both in crisis. This issue not only affects individuals, but also involves the stability of the industry and society as a whole.

Figure 1: Storm

Figure 2: Hurricane

## 1.2 Restatement of the Problem

We were asked by COMAP's Illumination Control Mission(ICM) to decide whether or not to insure in extreme weather areas and to propose plans for landmark improvement and protection.

**Task 1:** Develop a model to evaluate whether coverage should be available in areas where extreme weather events are common and applied to two areas on different continents.

**Task 2:** Adapt the model to evaluate options for where, how, and whether to build in certain locations.

**Task 3:** Propose a preservation model for use by community leaders to determine the extent to which steps should be taken to preserve historic buildings in the community.

**Task 4:** Select a historic landmark, apply the insurance and preservation model, present the community with a detailed plan, including a timeline and cost proposal, and write a letter of recommendation aimed at preserving the landmarks they cherish.

# 2 Task1: Climate Risk Underwriting Model

## 2.1 Problem Analysis and Overviews

To stimulate the climate risk impact on property insurance products, our model is based on three key drivers: hazards, vulnerability, and financial health of an insurance company.

- **Hazard:** This includes the frequency, severity, or intensity of a hazard.
- **Vulnerability:** The actual characteristics of the property, which can mitigate the climate risk, should be taken into consideration as well.
- **Financial Health:** This evaluates an insurance company's fiscal resilience, considering its ability to endure and recover from the consequences of climate-related challenges.

In order to identify and measure the three factors mentioned above, we divide the CRUM (Climate Risk Underwriting Model) into three distinct modules: catastrophe prediction, engineering, and insurance. Each of these modules represents a mathematical model. The modules are used sequentially, with the output from one being used as input to the next.The relation between the factors and models is shown in Figure 3.

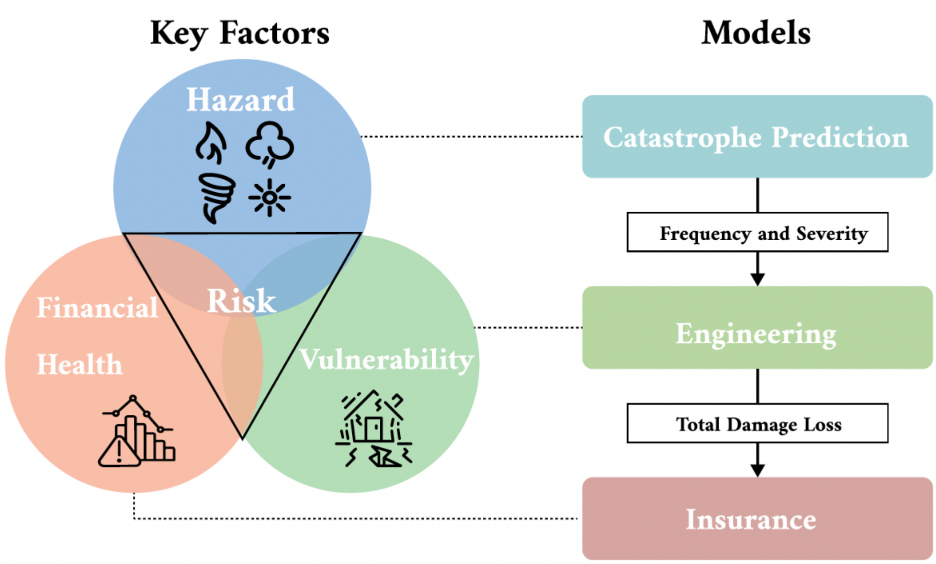



Figure 3: Key factors and models in CRUM

**Step 1: Catastrophe Prediction Model**

Based on the theory of Time Series Analysis, we establish an ARIMA model to predict the frequency and severity of different types of climate events in the future, which would be the output of the prediction model. The input to the model is the historical data of extreme weather disasters.

**Step 2: Engineering Model** The output of the catastrophe prediction module is used as one of the inputs to the engineering module, so are the damage-mitigate features of the property: construction type, ages, anchoring, etc. The engineering module uses the characteristics of the structures to estimate the degree of damage for an event.

**Step 3: Insurance Model** The total damage computed in the engineering model would be used to compute the insured damage at a location, which serves as the cost of the insurance underwriting decision.

## 2.2 Catastrophe Prediction Model Based on ARIMA

ARIMA, which stands for Auto Regressive Integrated Moving Average, is a popular time series forecasting model that combines autoregression, differencing, and moving average components.

For the equation of $ARIMA(p,d,q)$ model, we have (1):

$$\varphi(B)(1-B)^d X_t = \varphi_0 + \theta(B)\varepsilon_t \tag{1}$$

Where $\varphi(z) = 1-\varphi_1 z - \cdots - \varphi_p z^p, \theta(z) = 1+\theta_1 z + \cdots + \theta_q z^q, \{\varepsilon_t\} \sim \mathrm{WN}(0, \sigma_\epsilon^2), 0 < d < 1$ and $\varphi_0$ is the intercept (const).

if $Y_t = \varphi(B)(1-B)^d X_t$ is stationary, $(0 < d < 1)$,it is an $ARIMA(p,d,q)$ model.

The ARIMA models for the frequency and severity of three main climate catastrophes—earthquakes, floods, and storms—are as follows:

$$\varphi(B)(1-B)^d Frequency_t = \varphi_0 + \theta(B)\varepsilon_t \tag{2}$$
$$\varphi(B)(1-B)^d Severity_t = \varphi_0 + \theta(B)\varepsilon_t \tag{3}$$

The basic principle of the ARIMA model in our catastrophe prediction model can be broken down into four main steps: **1. Stationary test:**

In our model, we use $Y_t = log(X_t)$ to transform the original nonstationary data into stationary data. Also, we plot the time series data (time plot and ACF) and perform a stationary test.

**2. Identifying the model:**

We select the order $(p,q,d)$ of the model.

**3. Estimating parameters:**

We selected two regions, Japan in East Asia and the United States on the North American continent, both prone to frequent extreme climate events, as case studies to validate our prediction model. We forecast the occurrence frequency and insurance losses for three common disasters—earthquakes, floods, and storms—over the next seven years. Our data is sourced from the EM-DAT database.

- **Analysis steps**:

As an example of storm frequency prediction in the U.S., the model prediction steps are as follows.

The ARIMA model requires the series to satisfy smoothness, view the results of the ADF test and analyze whether it can significantly reject the hypothesis that the series is not smooth based on the analysis of the t-value

The results of the test of this series show that based on the variable Storm Frequency :

| Variant | Difference Order | t | P | AIC | Threshold Value | | |
|---|---|---|---|---|---|---|---|
| | | | | | 1% | 5% | 10% |
| Storm Frequency | 0 | -0.438 | 0.904 | 462.104 | -3.508 | -2.895 | -2.585 |
| | 1 | -2.843 | 0.052* | 456.312 | -3.508 | -2.895 | -2.585 |
| | 2 | -4.91 | 0.000*** | 456.639 | -3.509 | -2.896 | -2.585 |

Figure 4: ADF Test

At the difference of order 0, the significance p-value is 0.904, do not present significance at the level, the original hypothesis cannot be rejected and the series is an unsteady time series.

At the 1st order of difference, the significance p-value is 0.052*, do not present significance at the level, the original hypothesis cannot be rejected and the series is an unsteady time series.

When the difference is divided into 2nd order, the significance p-value is 0.000, presenting significance at the level, rejecting the original hypothesis, and the series is a smooth time series.

View the data comparison graph before and after differencing to determine whether it is smooth (not much up and down fluctuation), and also bias the time series (autocorrelation analysis) to estimate its p and q values based on the truncated tails.

Automatic search for optimal parameters based on AIC information criterion, model results in ARIMA model (0,1,2).

- **Prediction**:

Based on the above steps, we forecast the frequency of common natural hazards with Insured Damage for the next seven years for the U.S. and Japan, respectively. The historical data and forecast results are shown below.

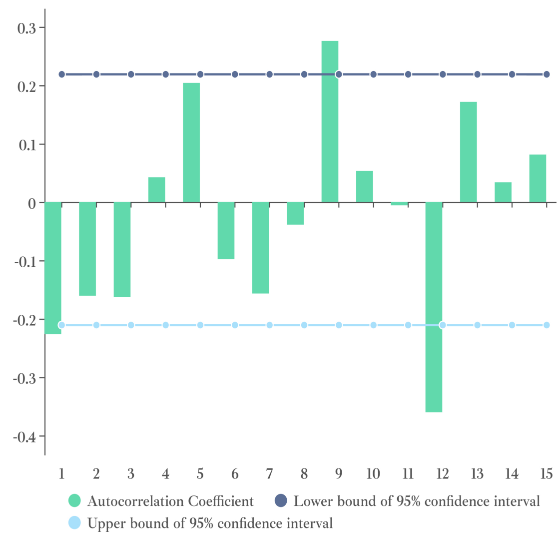



Figure 5: Autocorrelation Test

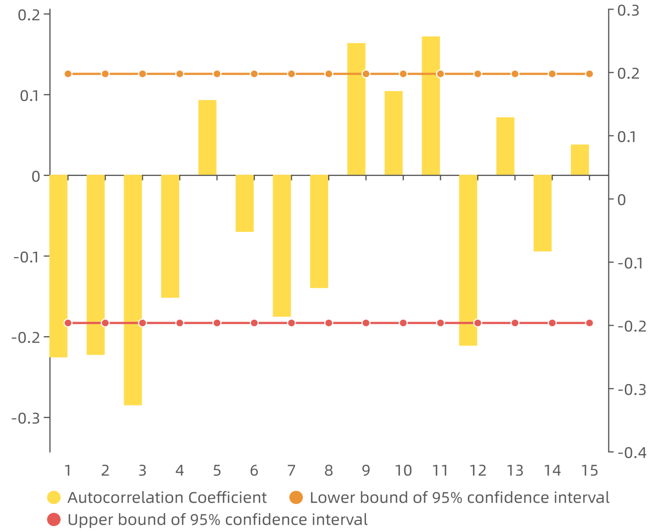



Figure 6: Skewness Autocorrelation Test

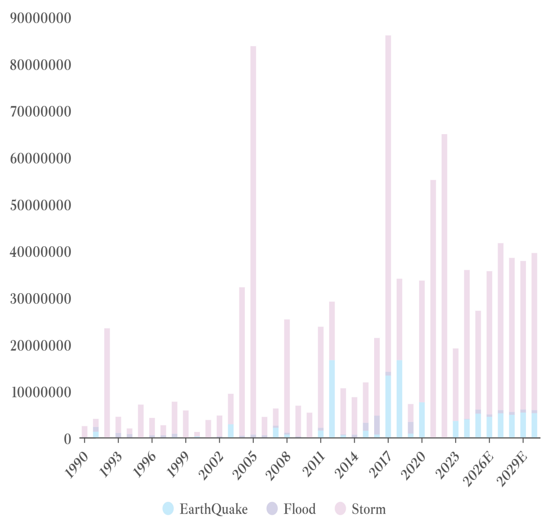



Figure 7: The insured damageof the US

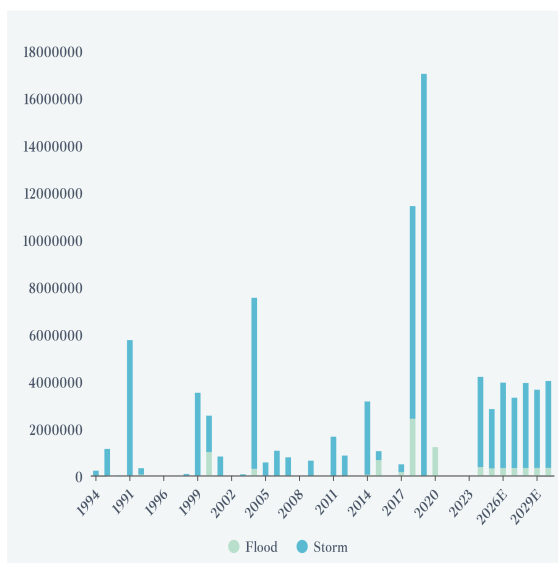
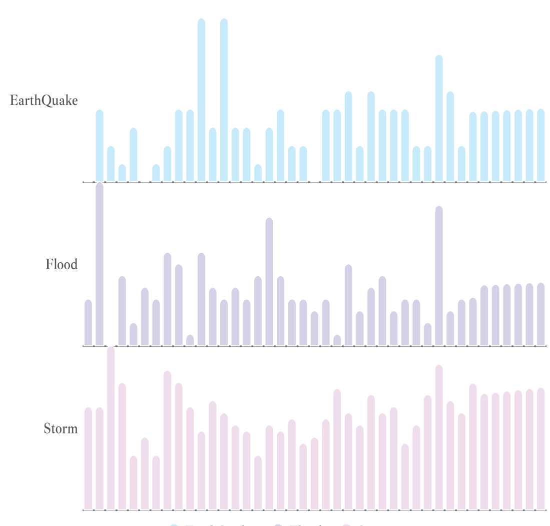
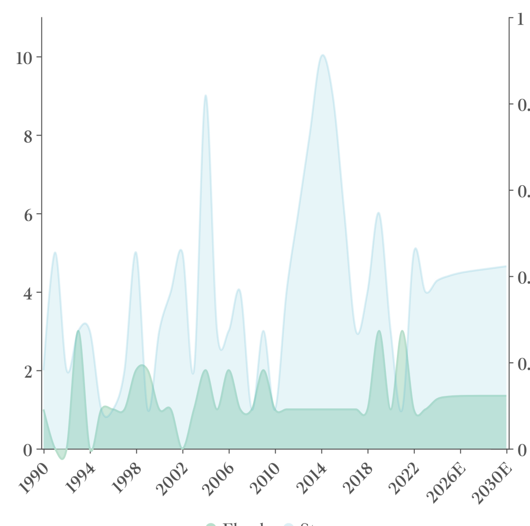



Figure 8: The insured damageof Japan



**4. Diagnosing and accepting the model:**

Based on the above steps, we forecast the frequency of common natural hazards with Insured Damage for the next seven years for the U.S. and Japan, respectively. The historical data and forecast results are shown below.

| $R^2$ | Frequancy | Insured Damage |
|---|---|---|
| **EarthQuake** | 0.791 | 0.456 |
| **Flood** | 0.665 | 0.680 |
| **Storm** | 0.634 | 0.785 |

Figure 11: R$^2 of the United States$

| $R^2$ | Frequancy | Insured Damage |
|---|---|---|
| **Flood** | 0.519 | 0.604 |
| **Storm** | 0.587 | 0.475 |

Figure 12: R$^2 of Japan$

## 2.3 Engineering Model

Then, we use $Structural\ Integrity(SI)$ to measure the sturdiness of a house. It refers to a structure's ability to support its weight and resist external forces. The load-bearing components of a building must be strong enough to bear the weight of the structure without collapsing.

By recognizing mitigation features in the modeling process, insurers can calculate discounts for homeowners who mitigate risk.

The results of $SI$ are displayed in Fig13. As the color in the legend deepens, the $SI$ values increase, indicating a lower level of damage to buildings from extreme weather disasters.

Using historical data from the Bulding Resilience Index (BSI) by the IFC as $SI$, we are able to get the indicator that measures the structural integrity in different states of the USA. And we improve the equation above by taking $SI$ into consideration.

$$\begin{aligned} Climate\_Damage &= Climate\_Risk \times (1 - SI) \\ &= \sum_{i=1}^{N} Frequency_i \times Severity_i \times (1 - SI) \end{aligned} \tag{4}$$

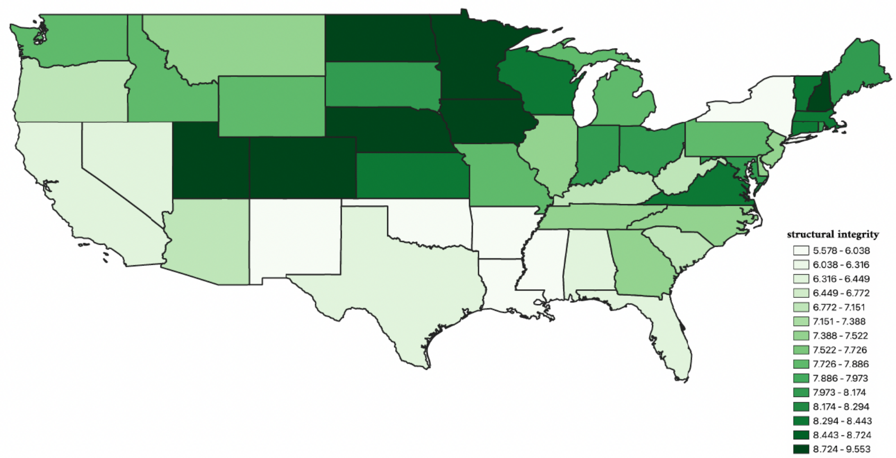



Figure 13: Structural Integrity States Distribution in USA

## 2.4 Insurance Model Based on Dynamic Programming

### 2.4.1 Dynamic Programming Model

Consider the dynamic programming model for the decision-making process of insuring local properties over the next T years $(t = 1, ...T)$in a given region:

Objective:

$$max \sum E(R_t)X_t \tag{5}$$

Subject to the constraint:

$$s.t. \sum E(C_t)X_t \leq I \tag{6}$$

The state transition equation is given by:

$$dp[t][j] = max(dp[t-1][j], dp[t-1][j - E[\hat{C[t]}] + E[\hat{R[t]}]) \tag{7}$$

$E(R_t)$ represents the expected revenue in the t-th year when choosing to undertake insurance in the region, where $X_t = \{0, 1\}$ with 1 indicating investment and 0 indicating no investment. $E(C_t)$ denotes the expected cost of undertaking insurance in the region in the $t$ year, and $I$ is the allocated budget for the insurance company to pay premiums over the next T years.

The term $dp[t][j]$ signifies the maximum income when deciding to invest or not in the $t$ year, given the remaining budget of $j$ units of currency.

Specifically, the insurance model is computed through the following steps: computing cost, revenue, and backtrack to find solutions.

### 2.4.2 Costs

The anticipated annual insurance underwriting costs are calculated based on the output equation (4) of the Engineering Model . The formula is as follows:

$$E(C_t) = Climate\_Damage \tag{8}$$

### 2.4.3 Revenue

The anticipated annual insurance underwriting revenue is calculated through a **Supply-and-Demand Equilibrium Model**, as shown in the following equation:

$$\begin{cases} Q_s = P + k_s \\ Q_d = -P + k_d \end{cases} \tag{9}$$

Where $Q_s$ represents the supply of property insurance, while $Q_d$ represents the demand for property insurance$k_d$ and $k_s$ are calculated by substituting actual data of the average insurance purchase quantity and insurance premium rates for a specific region.The solutions(10) obtained by solving the equation(9):

$$\begin{cases} P_0 = \frac{k_d - k_s}{2} \\ Q_0 = \frac{k_+ k_s}{2} \end{cases} \tag{10}$$

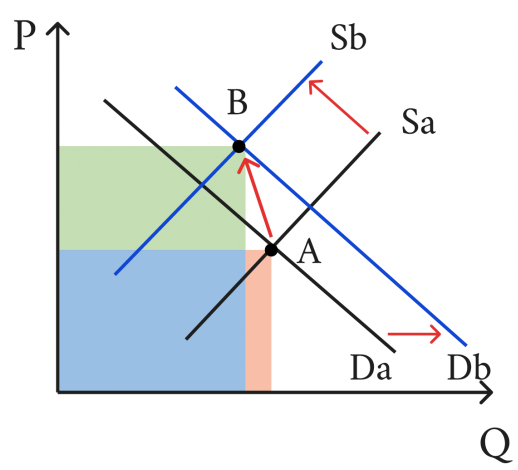



Figure 14: Supply-and-Demand Equilibrium Model

As the frequency of natural disasters increases in a region, the quantity of insurance products that insurance companies are willing to provide decreases, causing the supply curve to shift leftward. Concurrently, the demand for insurance products by local residents increases, leading to a rightward shift in the demand curve. This results in an increase in $k_s$ and $k_d$. This process can be characterized by the Fig 17 and the following equations(11):

$$\begin{cases} Q_{s,t} = Q_{s,t-1} + \Delta k_s = P + k_s + \Delta k_s \\ Q_{d,t} = Q_{d,t-1} + \Delta k_d = -P + k_d + \Delta k_d \end{cases} \tag{11}$$

Where $\Delta k_s = 0.52e^{-0.03t}k_s - 150\Delta P_t k_s$ and $\Delta k_d = 0.47e^{-0.01t}k_d + 150\Delta P_t k_d$ calculated by data collected in the Catastrophe Prediction Model, the solutions(12)(13) obtained by solving the equation(11):

$$\begin{cases} P_t = \frac{k_d+\Delta k_d - k_s - \Delta k_s}{2} = P_0 + \frac{\Delta k_d - \Delta k_s}{2} \\ Q_t = \frac{k_d+\Delta k_d + k_s + \Delta k_s}{2} = Q_0 + \frac{\Delta k_d + \Delta k_s}{2} \end{cases} \tag{12}$$

$$E(R_t) = P_t Q_t = \frac{1}{2}[(k_d + \Delta k_d)^2 - (k_s + \Delta k_s)^2] \tag{13}$$

### 2.4.4 Backtrack to Find the Solution

Now that we have specific numerical values for all the coefficients appearing in dynamic programming, we can proceed to find the optimal solution(14) using the Backtrack method with the assistance of a computer.

$$X = (x_1, x_2, ..., x_T), \qquad x_i = \{0, 1\} \tag{14}$$

## 2.5 Cases Study of Extreme Weather Events

We collected the data from Governments [1, 2]

Table 1: Data and Results from California and Fukuoka used in CRUM

| Location | Climate Risk | Climate Damage | T | I($) | X |
|---|---|---|---|---|---|
| San Francisco US | 23.17 | 10 | 42.03 | 7 | $(0,1,0,0,1,0,0,1,0,1)$ |
| Fukuoka Japan | 45.92 | 10 | 33.50 | 15 | $(0,0,0,0,0,1,0,0,0,0)$ |

# 3 Task 2: Real-Estate Decisions Model

## 3.1 Location and Disaster-Proof Measures

First, it is crucial to assess the site selection to ensure a location with lower natural disaster risks. Choosing the right site can significantly reduce the risk and impact of natural disasters. Research the area's history of natural disasters such as floods, hurricanes, earthquakes and wildfires.

Then, based on the risk assessment of the chosen area, corresponding building standards should be established. As Fig15 provided, we have summarized the strategies for constructing a residence that exhibits resilience against natural disasters.

Additionally, a cost-benefit balance is necessary to weigh the additional costs of enhancing the building's resilience against the potential savings from reducing losses and lowering insurance premiums.

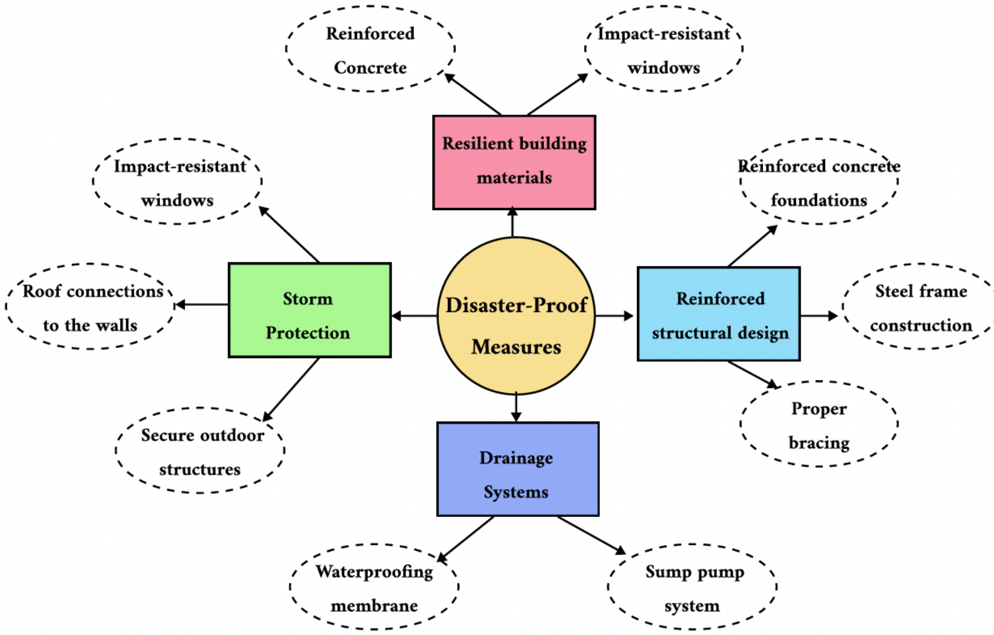



Figure 15: Disaster-Proof Measures

## 3.2 From Insurance Model to Real-Estate Decisions

Therefore, taking all the aforementioned factors into consideration, we adjusted the Climate Risk Underwriting Model (CRUM) to assess whether to build on certain sites.

The decision by developers to reinforce the construction of houses can reduce future insurance expenditures for homebuyers or mitigate risks that insurance companies may be unwilling to cover, thus attracting more people to make purchases. However, this concurrently results in increased costs.

Applying microeconomic principles, one can establish the decision criterion as follows:

$$MC = \frac{dC}{dI} = MR = \frac{dR}{dI} \tag{15}$$

Where the marginal benefit of investing one unit of money in reinforcing houses equals the marginal cost.

Simultaneously adjust the dynamic programming model(6)(5)(7) in CRUM, to make dynamic decisions for multiple locations during the same time period, as shown below.

Objective:

$$max \sum \hat{R}_i X_i, \quad X_i = 0, 1 \tag{16}$$

Subject to the constraint:

$$s.t. \sum \hat{C}_i X_i < I \tag{17}$$

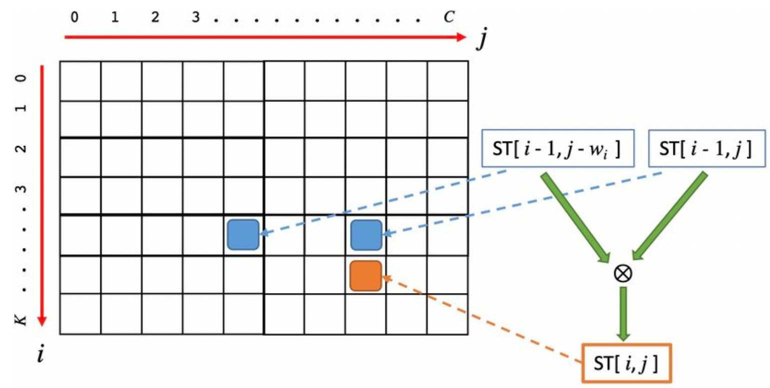



Figure 16: A two dimensional solution table for the dynamic programming solving

The state transition equation is given by:

$$dp[i][j] = max(dp[i-1][j], dp[i-1][j-C[i]] + R[i]) \tag{18}$$

$\hat{R}_i$ represents the expected revenue in the location $i$ , where $X_t = \{0, 1\}$ with 1 indicating to build and 0 indicating no to build. The cost denoted by $\hat{C}_i$ for reinforcing the house in location $i$ equals the sum of future insurance premiums, serving as an indicator of the property's resilience to disasters. And $I$ is the investment budget for building houses in location $i$.

Similar to solutions in CRUM, we can use backtrack method,as Fig16 to find the solution as well. This model enables communities and property developers to decide how and where to build and grow.

# 4 Task 3: Evaluating the conservation value of community buildings

In the previous section, we balanced cost and benefit considerations to construct an insurance company underwriting decision model in the context of climate change. In certain regions, insurance companies may opt not to underwrite current or future property insurance based on a comprehensive assessment of risk and return. In this section, we analyze how relevant departments can explore landmark building resources with significant value in areas where insurance companies do not provide coverage.

## 4.1 Value Perception of Landmark Buildings

Perception of the Value of Landmark Buildings Differing from residential and commercial structures, landmark buildings typically serve as distinctive and prominent symbols in a region. Beyond meeting the daily needs of local residents, they carry the weight of regional history, culture, and represent the spirit of the city. Firstly, landmark buildings often include museums, residences, and churches, making them preferred venues for cultural exhibitions. Secondly, these structures may represent cultural traditions from specific historical periods, witnessing significant changes in urban development. Additionally, serving as social and cultural hubs in cities, landmark buildings tend to attract a considerable number of tourists, contributing to local economic income. Finally, apart from being architectural entities, landmark buildings may host public squares, restaurants, observation decks, and provide diverse services. In summary, this paper categorizes the value of landmark buildings into cultural value (C), historical value (H), economic value (E), and social value.

## 4.2 CHES landmark building value assessment model

### 4.2.1 Criteria for the Evaluation Model

An assessment model for the value of landmark buildings in a region should meet the following criteria:

- The evaluation model should be universal, applicable to measuring any country or region.
- The model should be comprehensive, covering various aspects of landmark building value.
- Selected indicators should be representative and non-redundant.

### 4.2.2 Model Assumptions

To simplify the model and reduce the complexity of the evaluation, the following assumptions are made:

- The higher the number of exhibitions held, the higher the cultural value reflected in landmark buildings.
- The longer the age of a building, the closer its connection to historical changes in the city.
- Sample conditions in the survey can accurately reflect the overall situation.
- Profitability of various tourist attractions is the same, and popularity can reflect the appeal.

### 4.2.3 Indicator Selection

Based on the earlier analysis, we selected the number of cultural events held within a year, the construction time, the number of TripAdvisor website reviews, and the annual visits by local residents as indirect measures of the cultural, historical, economic, and social values of landmark buildings, respectively. The specific indicators are sourced as shown in the figure.

### 4.2.4 Weight Calculation

Based on the above description, we employed the Analytic Hierarchy Process (AHP) to determine the weights of various evaluation indicators. Seeking assistance from experts, we obtained comparison matrices for the main factors through the following steps:

- Two-by-two comparisons between different factors.
- Three experts voted on the importance of the four values. Cultural value  Historical value > Economic value > Social value.

- Calculation of the comparison matrix. Through the relationships established earlier, we derived the comparison matrix.

| $cIndex$ | $C$ | $H$ | $E$ | $S$ |
|---|---|---|---|---|
| $C$ | 1 | 2 | 1.7 | 3 |
| $H$ | 0.5 | 1 | 1.5 | 2 |
| $E$ | 0.588 | 0.667 | 1 | 2 |
| $S$ | 0.333 | 0.5 | 0.5 | 1 |

- Consistency Test

  We calculate the eigenvalues and eigenvectors of the comparison matrix and perform a consistency check using the largest eigenvalue.

  For the above comparison matrix, we obtained CR=0.014, indicating that the consistency check has passed.

- Weight Calculation

  After passing the consistency check, we can calculate the weights of the main factors using the eigenvector corresponding to the largest eigenvalue: Cultural Value (0.407), Historical Value (0.254), Economic Value (0.214), and Social Value (0.122).

#### 4.2.5 Establishing Topsis Evaluation Model

After determining the weights, we use the weighted Topsis model to score the value of landmark buildings.

- Selecting n landmark buildings within the region and n evaluation criteria, standardize and normalize the data to obtain matrix Z.

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \tag{19}$$

- Finding vectors composed of the maximum and minimum values in each column.

$$Z^+ = max\left\{z_{12}, z_{22}, \dots z_{n2}\right\}, max\left\{z_{12}, z_{22}, \dots z_{n2}\right\}, \dots, max\left\{z_{1m}, z_{2m}, \dots z_{nm}\right\} \tag{20}$$

$$Z^- = min\left\{z_{12}, z_{22}, \dots z_{n2}\right\}, min\left\{z_{12}, z_{22}, \dots z_{n2}\right\}, \dots, min\left\{z_{1m}, z_{2m}, \dots z_{nm}\right\} \tag{21}$$

- Defining the distance of the $i$ (i=1,2,...,n) evaluation object from the maximum value

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j (Z_j^+ - z_{ij})^2} \tag{22}$$

and the distance from the minimum value

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j (Z_j^- - z_{ij})^2} \tag{23}$$

- Calculating the score of the evaluation object.

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{24}$$

# 5 Task 4: Value Assessment and Preservation Program

Figure 17: *St. Louis Cathedral*

Being in the New Orleans area of the United States, which often experiences hurricanes, we chose *St. Louis Cathedral*, a famous historical building located in New Orleans, as a case study for question four.

## 5.1 Introduction to St. Louis Cathedral

St. Louis Cathedral is an iconic building in New Orleans, Louisiana, USA, and one of the oldest Catholic churches in the city. Its architectural style combines Gothic and Neoclassical elements, reflecting the characteristics of 18th and early 19th-century French colonial architecture. The cathedral hosts religious and cultural events such as masses, weddings, and concerts. It has witnessed important historical events in New Orleans, including the signing ceremony of the Louisiana Purchase Agreement and the coronation of Catherine D'Orléans. The cathedral symbolizes the traditional culture and religious rituals of New Orleans, attracting numerous visitors.

In recent years, with global warming, warmer sea water may provide more energy to hurricanes, making them more destructive and causing intense storm surges and rainfall. New Orleans is located in an area frequently hit by hurricanes, so the building structure and roof of St. Louis Cathedral may be affected by hurricane winds. Therefore, appropriate hurricane protection measures, such as strengthening the building structure and regular roof inspections and maintenance, are necessary.

## 5.2 Landmark Assessment

Having collected historical, cultural, and economic data about the St. Louis Cathedral, as well as historical data on extreme weather events in the area, the insurance and conservation models we developed previously were used in the near future to conduct a landmark assessment of whether or not the St. Louis Cathedral is covered by insurance and its priority for conservation.

### 5.2.1 Insurance Assessment

Based on the results of the insurance model, it was shown that insurance companies would not include the St. Louis Cathedral in the insured area.

### 5.2.2 Protection Assessment

According to the landmark building preservation value assessment model we have established, acting in the role of the New Orleans city government, we measure the preservation value of key landmark buildings in the city. St. Louis Cathedral is one such landmark, serving as a reference for preservation investment decisions.

| | D+ | D- | Score | Rankings |
|---|---|---|---|---|
| **St.Louis Cathedral** | 0.2999 | 0.9378 | 0.7577 | 1 |
| **Sazarac House** | 0.7441 | 0.3688 | 0.3313 | 2 |
| **Miltenberger Houses** | 0.8136 | 0.2890 | 0.2621 | 6 |
| **Milton H.Latter Memorial Library** | 0.8554 | 0.3527 | 0.2920 | 3 |
| **Elms Mansion** | 0.8367 | 0.2252 | 0.2121 | 7 |
| **Madame John's Legacy** | 0.9288 | 0.3493 | 0.2733 | 5 |
| **Generations Hall** | 0.8608 | 0.3280 | 0.2758 | 4 |
| **Dufour-Baldwin House** | 0.9435 | 0.2035 | 0.1775 | 8 |

Figure 18: New Orleans Landmarks Valuation Results

The model evaluation results indicate that the preservation value of St. Louis Cathedral in

New Orleans is the highest, with a score index of 0.758. It should be prioritized when making preservation decisions.

## 5.3 Comprehensive Protection Plan

Based on the previous modeling results, we developed a multi-layered conservation plan that includes conservation measures, timelines, and cost budgets, combining structural and non-structural protective measures, including building reinforcement, evacuation plans, and natural barriers. Collaboration with local government, community residents and relevant stakeholders will be required to ensure the comprehensiveness and feasibility of the plan.

### 5.3.1 Structural protection measures

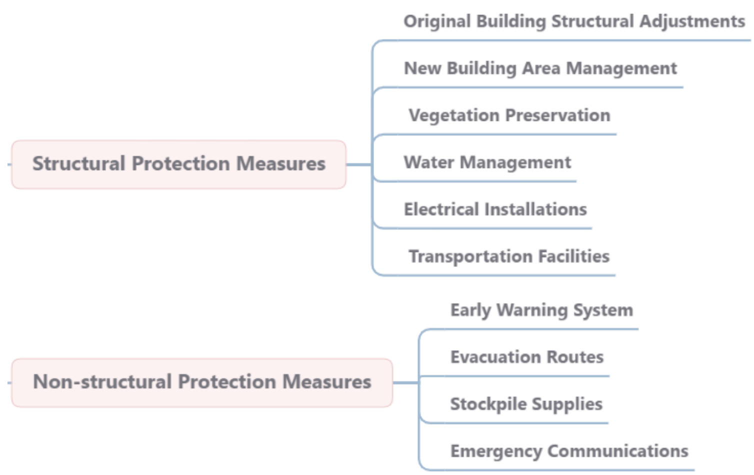



Figure 19: Protection Measures

- **Original Building Structural Adjustments:**Work with a team of architectural professionals to conduct a structural analysis of the St. Louis Cathedral building and make structural adjustments in accordance with wind-resistant design guidelines.Structural analysis to be completed within 6 months, followed by design and preparation work over the next 12 months.Improve the wind resistance of the St. Louis Cathedral building and mitigate potential damage from hurricanes.

- **New Building Area Management:**Specific Approach: Develop land planning policies to limit new construction in historic risk areas.Discussion and development of planning policies to be completed within 3 months.Reduce the number of new buildings in high-risk areas and reduce hurricane risk.

- **Vegetation Preservation:**Develop a vegetation conservation plan to ensure the health and density of surrounding vegetation.Develop and implement plan within 6 months in consultation with local landscape and environmental protection departments.Natural vegetation acts as a risk mitigation barrier to reduce hurricane risk.

- **Water Management:**Review and improve the perimeter drainage system to ensure it is open and mitigates flood risk.Assessment by specialist water engineering team followed by implementation of improvements within 12 months.Reduce the potential threat of flooding to the area around the church.

- **Electrical Installations:**Carry out a structural assessment of the electricity grid and implement reinforcement works to the electricity facilities. In consultation with the energy company, complete the assessment and reinforcement works within 12 months.Improve the stability of the electrical system and ensure that the power supply system is less susceptible to interruption during a hurricane.

- **Transportation Facilities:** Structural reinforcement of surrounding bridges and roads to ensure they can withstand hurricane risk.In consultation with the Transportation and Infrastructure Management Agency (TIMA), complete the reinforcement work within 18 months.Improve the wind resistance of transportation infrastructure and mitigate the impact of hurricanes on the transportation system.

#### 5.3.2 Non-structural protection measures

- **Early Warning System:** Deploy an advanced weather monitoring and warning system capable of notifying communities 48 hours in advance.Deployment and testing of the system to be completed within 12 months in consultation with meteorological and emergency management agencies.Improved warning time for community residents prior to hurricanes and increased response capacity.

- **Evacuation Routes:**Develop clear evacuation routes, including signage and traffic management measures.In consultation with transportation and public safety agencies, complete planning and signage for evacuation routes within 6 months.Improve the efficiency and safety of evacuating community residents.

- **Stockpile Supplies:** Establish a stockpile center for emergency supplies, including adequate food, water, and first aid supplies.Work with the community and vendors to complete the construction and stocking of the reserve supplies center within 12 months.Provide sufficient supplies to meet the basic needs of community residents during a hurricane.

- **Emergency Communications:**provide multiple means of communication, including cell phone texting, radio, and social media. When a hurricane warning is issued, ensure that evacuation plans and emergency preparedness measures are immediately activated.Work with communications companies and community organizations to complete construction and testing of communications systems within 6 months. Ensure that in the event of a hurricane, the community is able to communicate important information in a timely manner and improve the ability of residents to respond.

The implementation of all of the above specific practices will require annual reviews, periodic review and updating of risk assessments, and adjustments to land plans and conservation programs. We look forward to improving the overall level of protection for the St. Louis Cathedral and its surrounding communities in the event of a hurricane, mitigating potential risks and ensuring the safety and well-being of community residents. This is a long-term endeavor that will require the active support and participation of community residents.

#### 5.3.3 Program Costs

- **Building Design and Reinforcement:** Costs to work with a team of building professionals, including structural engineers, architects, etc., estimated at $50,000. structural analysis and design work to be completed within 6 months.
- **Infrastructure Reinforcement:** Structural improvements to electric utilities and transportation facilities, estimated at $200,000 based on appraisal. Infrastructure reinforcement work to be completed within 18 months.
- **Early Warning System Construction:** Deployment costs for the Advanced Weather Monitoring and Early Warning System (AWMS), including equipment and technical support, are estimated at $80,000. Deployment and testing of the system to be completed within 12 months.
- **Evacuation Routes:** Costs for evacuation route planning, signage, and traffic management, estimated at $30,000. Planning and implementation to be completed within 6 months.
- **Stockpile Supplies:** Procurement of emergency supplies and construction of a stockpile center, including food, water, and first aid supplies, estimated at $120,000. Procurement of supplies and construction of a stockpile center will be completed within 12 months.
- **Emergency Communications:** Construction costs for multiple means of communication, including cell phone text messaging systems, broadcast equipment, etc., estimated at $50,000. Construction and testing of communications system to be completed within 6 months.
- **Community Training and Educational Activities:** Costs to conduct community training and educational activities, including workshops, promotional materials, etc., estimated at $40,000. Phased implementation over a total of 12 months.

Overall budget estimate: 50,000 (building design) + 200,000 (infrastructure reinforcement) + 80,000 (early warning system) + 30,000 (evacuation routes) + 120,000 (stockpile of materials) + 50,000 (emergency communications) + 40,000 (community engagement) = $570,000.

This is a rough estimate and the exact cost may be adjusted due to market changes, fluctuations in material prices and project realities. During implementation, costs will need to be closely monitored and controlled to ensure effective implementation of the project.

## 5.4 Letter of Recommendation

**Dear Residents of the Communities Surrounding*St. Louis Cathedral*:**

I am writing to recommend to you an important and urgent project, the *St. Louis Cathedral* Preservation Program.

**Why is this plan needed?** *St. Louis Cathedral* is a source of pride for us, but it is also a huge responsibility. Through preliminary modeling results, we have learned of the increasing risk of hurricanes. Hurricanes could not only cause direct damage to the Cathedral, but could also threaten the lives and property of the surrounding community. Therefore, there is an urgent need to take measures to improve the overall level of hurricane protection for the Cathedral and the surrounding community.

**Structural protection measures:**

- Structural adjustments to the original building to improve the cathedral's wind resistance.
- Limit the amount of new construction in historic risk areas.
- Natural vegetation as a risk mitigation barrier to reduce hurricane risk.
- Water management, electric utilities, and transportation facilities reinforcement.

**Non-structural protection measures:**

- Deploy advanced weather monitoring and warning systems to notify communities 48 hours in advance.
- Improve the efficiency and safety of community evacuation and ensure that community residents have adequate food, water, and first aid supplies during a hurricane.
- Provide multiple means of communication to ensure that communities are able to communicate important information in a timely manner in the event of a hurricane.

**This program requires the active support and participation of the entire community. We encourage every community resident to:**

- Participate in evacuation drills: Actively participate in evacuation drills to improve evacuation efficiency.
- Comply with Land Planning Policies: Work together to reduce risk by complying with the New Building Zone Management Policy.
- Protect Vegetation: Care for and protect the surrounding vegetation and support the Vegetation Conservation Program.

This is not just a conservation program, it is our commitment to the future of our community. Through these strong measures, we hope to protect our shared cultural heritage and ensure that St. Louis Cathedral and its surrounding communities are more resilient in the event of a hurricane. This is a long and arduous endeavor, but it is only with the active support and participation of every resident in our community that we can truly achieve this goal.

Please let us work together to protect our common home and ensure that future generations will also be able to enjoy the grandeur and magnificence of St. Louis Cathedral on this land.I sincerely appreciate your understanding and support.

Sincere greetings
Olivia

# 6 Strengths and weaknesses

## 6.1 Strengths

- **Sustainable**
  Our insurance models consider risk scenarios over multiple future periods and take into account the time value of money, enabling insurers to make long-term, dynamic and sustainable decisions.

- **Replicable**
  Our insurance model uses a comprehensive revenue-cost analysis with the goal of maximizing profit and minimizing risk, and can serve as a reference for most insurance companies and real estate developers.

- **Comprehensive**
  Our building value evaluation model integrates the historical, cultural, economic and social values of buildings. It can provide an important reference for the protection of landmark buildings and the comprehensive development of urban economy and culture.

## 6.2 Weaknesses

- **Inadequate response to small-scale disasters**

  Our weather prediction model data is derived from the EM-DAT database, which contains insufficient records of small-scale disasters.

- **There is still room for improvement in the evaluation model**

  Architectural conservation is not only a scientific but also a social issue, and although we consider several aspects of the value of buildings, there is still room for expansion in the choice of influencing factors.

# References

[1] National Weather Service.2022.Data Management. https://www.weather.gov/datamgmt/

[2] Japan Meteorological Agency.2022.Global Spectral Model (GSM).https://www.wis-jma.go.jp/cms/gsm/