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Real Estate Location Optimization Model Based on Linear Programming Model Mombined with Property Insurance Pricing

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Abstract. Real estate location selection is integral to real estate decision-making. Accurate real estate site selection is of great significance to ensure profits for real estate developers, increase real estate flexibility, and improve the serviceability of the real estate industry. To accurately locate real estate, this paper takes Dallas County, which is a high-risk area, as the research object, and establishes a real estate location optimization model combined with property insurance pricing model. This model selects nine indicators that affect housing prices and uses ArcGIS software to simulate the housing price score of the area based on these nine factors. Then, three factors, including property insurance premium, disaster resistance coefficient, and regional risk level, were introduced, and a real estate location optimization model with the highest profit as the objective function was established. Based on this model, the specific values of the disaster resistance coefficient, housing prices, and low-profit housing prices are calculated to achieve optimal real estate decisions in Dallas County. This model can provide various communities and real estate developers with profitable real estate decisions under frequent extreme weather conditions.

Keywords: Property Insurance; Real Estate; Location Optimization; ArcGIS.

1. Introduction

Extreme weather events are becoming a crisis for homeowners and insurers. In recent years, the world has endured "more than $1 trillion in damage from more than 1,000 extreme weather events"[1], with losses from severe weather-related events such as floods, hurricanes, and cyclones likely to increase, and climate change is expected to drive premiums up by 40-50% by 2040, raising the cost of property insurance premiums. Property insurance is getting more expensive and more complicated to find. The change in property insurance patterns significantly impacts the location of real estate. Therefore, it is necessary to incorporate the insurance premium into the real estate location optimization model.

Accurately making the optimal decision on real estate location is of great significance to reducing investment risks, maximizing land value, saving market resources, and promoting the healthy development of the regional economy [2]. At present, the traditional real estate location selection methods mainly include the analytic hierarchy process [3], fuzzy analytic Hierarchy process [4], TOPSIS method [5], rough set theory [6], GIS method [7], BP neural network method [8], etc. However, these methods have defects respectively. This paper not only uses ArcCIS software to score regional housing prices according to nine factors affecting real estate site selection but also innovatively combines the property insurance pricing model [9] and introduces three factors, namely property insurance premium, disaster resistance coefficient, and regional risk level, to establish a real estate site selection optimization model.

2. Establishment of Real Estate Location Optimization Model

2.1. Property Insurance Pricing Model

The number of disasters (D), urban average agricultural GDP (P), urban population density (P_ρ), urban gross domestic product per unit area (V), and historical claim amount (M) were identified as regional risk factors to establish a property insurance pricing model.

Firstly, the improved principal component analysis method based on entropy weighting was used to obtain the comprehensive risk assessment evaluation value, and the division classification was carried out according to the comprehensive evaluation value [9].

$$v_i = \sum_{j=1}^{m} a_j p_{ij} (i = 1, 2, ...n) \tag{1}$$

Where, v_i is the comprehensive value of the i sample, a_j is the weight of the index of the j item, and p_{ij} is the proportion of the i sample under the index of the j item.

Then, according to the extreme weather probability index H_{is} and extreme weather loss index I_{is}, the expectation of extreme weather loss in a certain period in a region to be evaluated can be obtained as follows:

$$E_{is} = H_{is} \times I_{is} = \frac{T_s}{d_s} \times \frac{G_i}{\sum_1^i G_i} \times (\alpha P_\rho + \beta V + C) \times \frac{Q_{is}}{\sum_1^i Q_{is}} \tag{2}$$

Where, $T_s (s = 1, 2, 3, 4)$ represents the number of extreme weather events occurring in each area to be assessed; G_i (i indicates the i area to be evaluated) represents the classification of the extreme weather zoning level of the region.

We may wish to set the insurance commission as l, the insurance loss rate as l, the insurance premium as yuan, and the annual government insurance subsidy $p\%$. According to the principle of return risk, to enable insurance companies to maintain a balance between return and risk, it is concluded that:

$$g_{is} = E_{is} \times r_{is} \times (1\text{-p}\%) = \frac{T_s G_i r_{is} (1 - p\%)(\alpha P_\rho + \beta V + C)}{d_s \sum_1^i G_i \sum_1^i Q_{is}} \tag{3}$$

Thus, a property insurance pricing model for quarters of a region i to be evaluated is obtained.

2.2. The Optimal Location Housing Price Scoring Simulation Based on ArcGIS Software

According to the above property insurance pricing model, it is calculated that Dallas is a high-risk area. That is, the extreme weather events in this region have the greatest impact on property insurance, and it is also the most difficult to make real estate location decisions. If this paper establishes an effective real estate location optimization model for Dallas County, which is a high-risk area, it can also be applied to other areas. So, this paper takes Dallas, USA as an example to demonstrate. Firstly, nine indicators that affect housing prices are selected by consulting references [10]:

Slope: The more stable the slope of the target area, the better, and the more stable the slope, the lower the construction cost;

Factories: The farther the target area is from these indicators, the better, the closer the property value is higher;

Schools, Hospitals, Waters, Supermarkets, CBD, Parks, Airports: the closer the target area is to these indicators, the better, the closer the property value is.

Then, use the ArcGIS software's built-in database to search for the coordinates of facilities above Dallas and present them on each layer. Then ArcGIS software was used to calculate the nine indicators affecting housing prices:

Slope calculation: based on the digital elevation data of Dallas, slope calculation was performed by using the surface analysis-slope function of the Spatial Analyst toolbox in ArcGIS;

Facility distance calculation: based on facility coordinates, Euclidean distance is used to calculate the distance between all places in Dallas County and the target facility. The above distribution map is drawn according to the calculation results of slope and distance, and some results are shown in Figure 1-4.

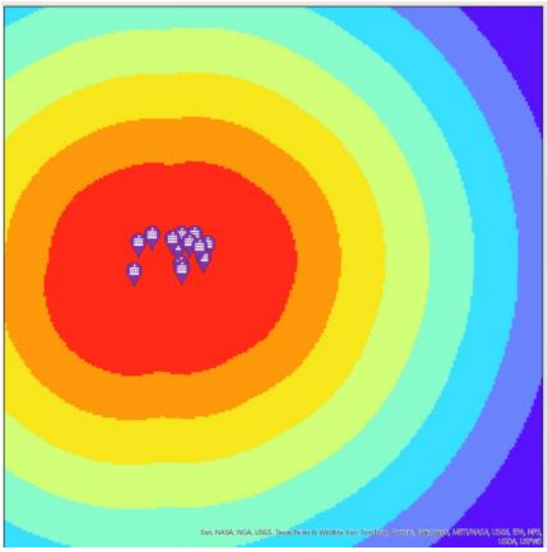

Figure 1. Map of Educational Facilities in Dallas

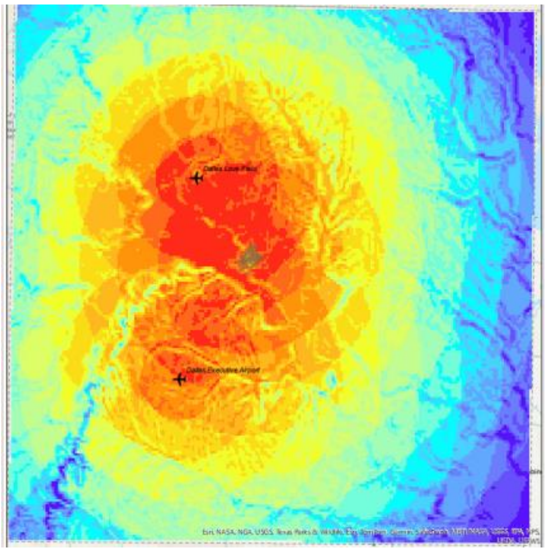

Figure 2. Map of Educational Facilities in Dallas

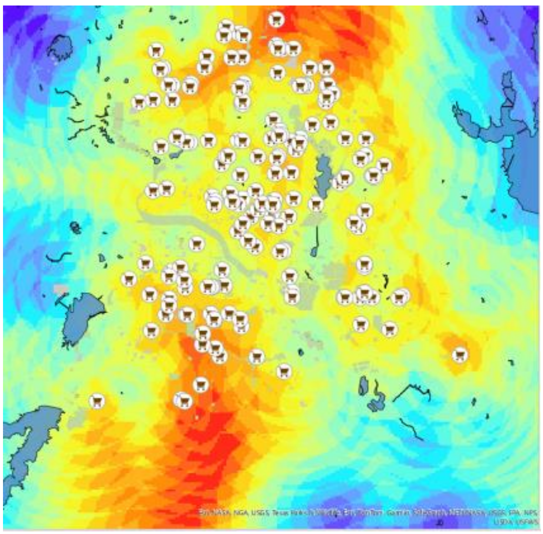

Figure 3. Map of Dallas Living and Landscape Facilities

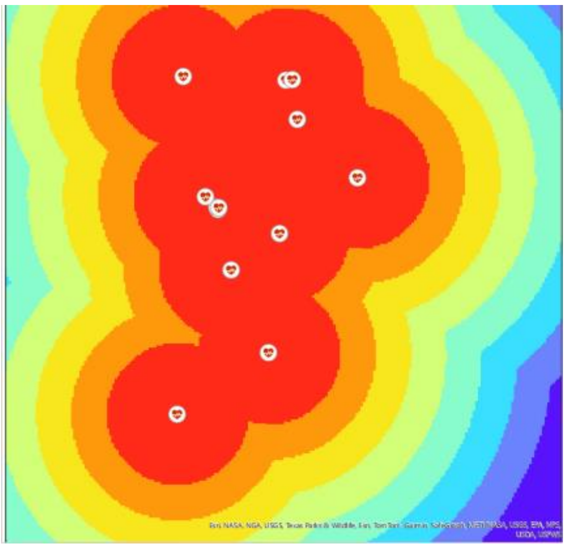

Figure 4. Map of Medical Facilities In Dallas

Among them, the warmer the color in the distribution diagram indicates the closer the distance from the target, and the colder the color suggests the farther away from the target.

Due to the different dimensions of the above nine indicators, the above data are reclassified; that is, according to the results of Euclidean distance calculation, the distance between each place and the target facility is classified into equal intervals, and these distances are divided into ten categories according to the positive and negative types of indicators. The tenth category represents the best, and the first represents the worst. Then, according to the economic situation of the United States and the living habits of residents, and concerning relevant literature [11], the empowerment of the above 9 indicators is obtained, as shown in the following Table 1.

Table 1. Dallas House Price Indicators Empowerment Data Sheet

Target Layer	Criterion Layer	Index Level	Single Weight	Total Weight
Purchase Price	Traffic Accessibility	Aerodrome	0.1	0.3
		CBD	0.1	
		Slope	0.1	
	Medical Institution	Nosocomium	0.2	0.2
	Educational Institution	School	0.2	0.2
	Landscape Life	Factory	0.075	0.3
		Waters	0.075	
		Park	0.075	
		Supermarket	0.075	

Finally, grid calculation is carried out: the weight of each index is multiplied by the category level to obtain the price score of the final region θ. The correspondence of some indicators in Dallas is shown in Figure 5. The distribution of Dallas housing price scores is shown in Figure 6.

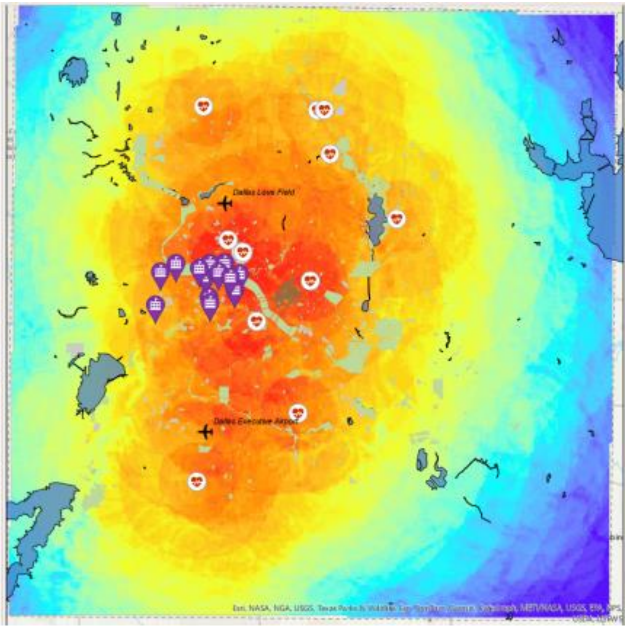

Figure 5. Dallas House Price Score Distribution Map

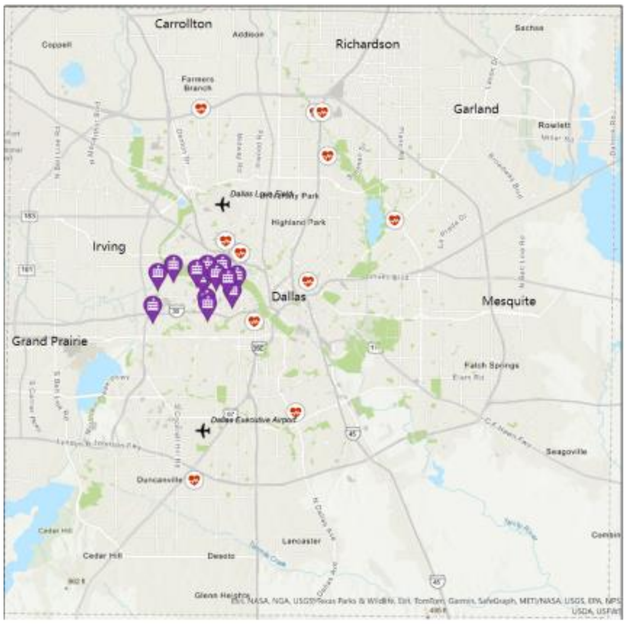

Figure 6. Dallas Partial Indicator Map

Warm colors indicate areas with high housing prices, and cool colors indicate areas with low housing prices. The warmer the color, the higher the price, and the colder the color, the lower the price.

2.3. Real Estate Location Optimization Model

First, the data is preprocessed, and the housing price scores of each region are treated with positive standardization. Then, the highest housing price in the local normal area is found, and the housing price score is multiplied by the highest housing price by percentage to obtain the reference housing price (W) of the target region:

$$W = W_{\max} \times \frac{\theta}{\theta_{\max}} \tag{4}$$

Where, $W_{\max}$ is the highest house price in the local normal area, θ is the house price score in the target area, and $\theta_{\max}$ is the highest house price score in the whole region.

The construction cost and insurance premium of the target area determine the profit of real estate developers in the target area. Therefore, the profit formula of real estate developers is as follows:

$$P = W \times S - \phi \times S - g_s \times S \tag{5}$$

Where, P is profit, S is floor area, and ϕ is construction cost.

By analyzing the collected data set, the higher the construction cost of a region, the better the construction quality of the area to a certain extent; that is, the higher the resistance of the buildings in the area to disasters. Therefore, we set the disaster resistance factor (0.5-1) to calculate the construction cost. Thus, the construction cost ϕ is:

$$\phi = \xi \times v \tag{6}$$

Where, v is the highest actual construction cost in the target area.

When choosing a site for construction, real estate developers should consider the size of the building area of the target area, and the construction area should be smaller than the local available land area, that is

$$S^* - S > 0 \tag{7}$$

Where, S^* is the available land area of the target area.

More importantly, real estate developers in an area build the strength of the building to be able to maximize the resistance to natural disasters in the area, that is

$$8 * (\xi - 0.5) > s - 1 \tag{8}$$

Where, s is the risk level obtained using the first question's model (s is 1,2,3,4).

According to the financial statements of the real estate company, it is set that when the profit exceeds the total cost (20%), the real estate developer can achieve profit, that is

$$P - (\phi * S + \gamma * S) \times 20\% > 0 \tag{9}$$

To sum up, we get a real estate location optimization model that can calculate the profits of real estate developers in target areas:

$$\max P = W \times S - \phi \times S - g_s \times S$$
$$\begin{cases} S^* - S > 0 \\ 8*(\xi - 0.5) > s - 1 \\ P - (\phi * S + \gamma * S) \times 20\% > 0 \end{cases} \tag{10}$$

3. Results

3.1. Analysis of Experimental Results

Based on available land area data in Dallas County, a 50,000-square-foot home will be built within Dallas County. According to the American Real Estate Monthly Report, the highest construction cost in the area is $155 per square foot, the highest standard house price is $200, and the premiums are roughly estimated to be $7 per square foot. Since the risk level of Dallas is the highest level 4 after assessment, it can be calculated from the above formula that the disaster resistance factor of the construction here must be greater than or equal to 0.875 to ensure sufficient safety.

Finally, through the proposed 20% profit margin, it is calculated that to be profitable in Dallas, the property price must be at least $170.4 per square foot; to be profitable, the real estate developer must build in Dallas County home price score above 7.242.

4. Conclusion

This paper takes Dallas County as the research object, and establishes the real estate location optimization model combined with the property insurance pricing model. The model selects nine indicators that affect the housing price to make the location problem more concrete and intuitive. Then, based on these nine factors, ArcGIS software was used to simulate the housing price score of the region. Then, three factors, including insurance premium, disaster resistance coefficient, and regional risk level, are introduced, and finally, the optimization model of real estate location is established. The model calculates that to achieve optimal real estate decisions in Dallas County, where the lowest profitable home price is $170.4 per square meter, communities and real estate developers must locate in areas with a disaster resistance coefficient higher than 0.875 and a home price score higher than 7.242.

The experimental results show that the real estate location optimization model has good predictability and robustness and has specific practical application value. This model can provide various communities and real estate developers with profitable real estate decisions under frequent extreme weather conditions.

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