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ISSN 2959-6157

Urban Regeneration Potential Land Evaluation Based on GIS and MCDA: A Case Study of London

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Abstract:
In the context of housing shortages, a fragile transportation system, stagnant productivity growth, and unequal community development, the spatial optimization of urban renewal in London faces unprecedented pressure. This study constructs a potential evaluation model based on GIS spatial analysis and Multi-Criteria Decision Analysis (MCDA), using natural, economic, and social dimensions as the criterion layer, and six factors including elevation, slope, environment (forests and water sources), building density, transportation, and infrastructure (education and healthcare) as the indicator layer. The final weights of each factor are determined through the Analytic Hierarchy Process (AHP) and the entropy weight method. The results evaluate the potential land for urban renewal in London. The evaluation is divided into five levels, among which high-potential areas account for approximately 5.75 percent of the total urban area and show a fragmented spatial distribution, providing important references for the spatial layout and site selection of future urban renewal in London.

Keywords: MCDA; GIS Spatial analysis; Urban renewal; Potential evaluation.

1. Introduction

With the continuous acceleration of global urbanization, land resources have increasingly become scarce and valuable assets. Many cities face multiple challenges including blind expansion of construction land, inefficient use of existing land stock, and continuous pressure on ecological spaces. How to accurately identify and scientifically plan urban land with renewal potential to promote the transformation from "incremental expansion" to "stock optimization" has become a core issue in achieving sustainable urban development. The process of urban renewal is continuous. According to the urban renewal processes in some developed countries, this process mainly exhibits the following patterns: ① From direct demolition and reconstruction to renovation combining usage approaches, and then to small-scale, phased, gradual organic renewal; ② From government-led only to multi-stakeholder participation in urban renewal;

③ From renewal focused solely on economy to renewal emphasizing social and environmental benefits, and then to multi-objective urban renewal.

In this context, GIS spatial analysis models, with their powerful geographic data processing and visualization capabilities, provide rapid and effective technical means for systematically assessing urban land potential. The development of this model can integrate and quantitatively analyze multiple spatial elements such as natural, economic, social, and environmental factors, and suggest suitable urban renewal potential land. Saaty first developed the Analytic Hierarchy Process (AHP), also known as Multi-Criteria Decision Analysis (MCDA), in his book [1]. This technique provides a method for decomposing criteria into sub-criteria that can be hierarchically ranked on a numerical scale. Compared to simple weighted averaging techniques, MCDA technology integrated with GIS provides both qualitative and quantitative results [2].

2. Study Area and Background

The London Plan 2021 mentions that London's population continues to grow, making it a high-density city, with intensified land competition and rising rents, requiring more effective land use [3]. The plan includes establishing 47 opportunity development areas and developing public sector and underutilized land in suburban areas, emphasizing the development of small vacant plots. Generally speaking, land value pressure is most intense in central London. Over the past 20 years, London has released nearly 6 million square meters of industrial land, accounting for approximately 23% of total industrial space (including converted space), and London's industrial land vacancy rate has also dramatically decreased. In addition, the surge in industrial land demand has led to sharp and rapid increases in rents and land values. In some areas, industrial land value growth has far exceeded expectations: in 2024, according to data from Rightmove, the UK's number one property website, the average house price at Vicarage Gate in west London was as high as £6,332,000. However, to limit unrestricted urban expansion, the government has also adopted some green space protection measures.

3. Research Data and Methods

3.1 Data Overview

The data for this study includes London's boundary range in 2020, DEM (100 m×100 m), forest and water distribution areas, building areas, hospitals, schools, bus stops, subway stations, train stations, airports, highways, main roads, pedestrian paths, and other data. Data sources mainly include Geofabrik's OpenStreetMap, Ordnance Survey Data Hub, Global Human Settlement, Geospatial Data Cloud, etc. All vector or raster data mentioned above need to be converted into 10m×10m raster data in ArcGIS 10.8.

3.2 Research Methods

Urban renewal potential land assessment is constrained by multiple factors including natural ecological environment, economic development, and society. These categories of factors also include multiple influencing factors. MCDA can help researchers weigh and analyze multiple criteria or objectives and make choices. This method is very suitable for complex decision-making situations involving multiple objectives, criteria, or attributes. This method mainly structures complex decision-making problems by constructing a hierarchical framework containing multiple key evaluation criteria. GIS can help process data and finally complete the evaluation in combination with MCDA. Therefore, this study adopts GIS-MCDA to evaluate urban renewal potential land in London. First, combined with the future planning outlook of The London Plan 2021 and London's urban characteristics, potential evaluation criteria and evaluation factors are identified; then, through a combined weighting method that integrates subjective and objective approaches to determine weights, expert scores on urban renewal from various parties are collected, and the Analytic Hierarchy Process (AHP) is used to determine the weight of each factor, and then the entropy weight method is used to determine the weight of each factor; finally, Weighted Linear Combination (WLC) is adopted to integrate weights obtained from both subjective and objective analysis, and GIS raster calculation is used to ultimately obtain urban renewal potential land evaluation results, providing reference for subsequent development site selection in London [3,4].

4. Urban Renewal Potential Land Evaluation

4.1 Research Methods

The selection of factors in this study is mainly based on two aspects. First, The London Plan 2021 identifies six major categories of planning indicators for Greater London: housing and public services, economy, ecological environment, transportation, historical and cultural heritage, and others. Second, some scholars argue that urban regeneration should be grounded in an assessment of existing conditions, incorporating elements such as transportation accessibility, industrial structure, building quality, and

ISSN 2959-6157

supporting facilities. It should also comprehensively consider district-level development and residents' willingness to participate in renewal projects in order to scientifically and rationally determine the potential for land redevelopment [3,5].

Accordingly, this paper focuses on six key factors: building density, transportation, topography (elevation and slope), infrastructure (education and healthcare), and environment (forests and water sources) [6]. In studying land use, this research integrates economic, social, and ecological dimensions to construct a potential evaluation model. The model is organized into a criterion layer comprising natural, economic, and social aspects, and an indicator layer comprising six factors such as elevation, slope, building density, and transportation, as shown in Fig. 1.

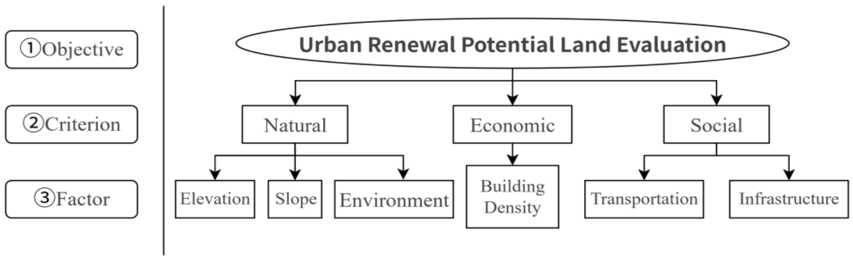

Fig. 1 Urban Renewal Potential Land Evaluation System for London (Picture credit: Original)

4.2 Data Processing

The entire spatial area of London is divided into 10 m×10 m grid cells, with each cell assigned a total score of 5 points. After converting each factor into raster data, GIS's natural breaks method is used to reclassify all data. The more suitable each factor is for urban land use, the higher the indicator score. Indicators are divided into 5 levels: very suitable (5 points), relatively suitable (4 points), general (3 points), not very suitable (2 points), and basically unsuitable (1 point). The evaluation factor indicators are shown in Table 1.

Table 1. London Urban Renewal Potential Land Evaluation Indicators

Criteria Layer	Factor Layer	Indicator Value Description
Natural	Elevation	Divided into 5 levels, lower elevation yields higher indicator
	Slope	Divided into 5 levels, lower slope yields higher indicator
	Environment (forests and water sources)	Divided into 5 levels, closer proximity to forests and water sources yields higher indicator
Economic	Building Density	Divided into 5 levels, lower building density yields higher indicator
Social	Transportation (stations and roads)	Divided into 5 levels, closer proximity to bus, subway, train, airport stations and highways, main roads, pedestrian paths yields higher indicator
	Infrastructure (education and healthcare)	Divided into 4 levels, lower buildings yield higher indicator

4.3 Combined Weighting Method to Determine Indicator Weights

Since the AHP method has certain subjectivity and uncertainty in evaluation, while the entropy weight method is scientific and reasonable in evaluation, this study adopts a combined weighting method that integrates both methods for weight calculation [7].

4.3.1 Analytic Hierarchy Process

AHP is mostly used to solve complex multi-objective decision-making problems and determine evaluation indicator weights [8,9]. AHP can determine the relative importance of three factors for urban renewal potential land through pairwise comparison by constructing a judgment matrix, converting expert and planning book subjective judgments into quantitative weights. AHP uses a 9-level numerical scale to assess the importance intensity of criteria, where 1 represents equal importance, 5 represents high importance, and 9 represents an extremely important relationship [10]. This study also adopts this method to assign relative weights to the three major criteria and conducts consistency testing. If the test result ≤0.1, the judgment matrix has consistency. Experts generally believe that social factors (transportation convenience and infrastructure) are the first criterion, followed by economic and natural factors, with weights of 0.462, 0.308, and 0.231, respectively, and a consistency ratio <0.1.

4.3.2 Entropy Weight Method and Linear Weighted Method

Information entropy reflects the chaos or disorder of a system. According to the definition of information entropy, the entropy value can judge the degree of dispersion of indicators, determining weights entirely from the data itself. The greater the dispersion of evaluation indicators, the greater the amount of information and weight; conversely, the smaller the dispersion of evaluation indicators, the smaller the amount of information and weight [11]. For the indicators under each criterion layer, entropy weights are calculated separately. The above six factor data were standardized to 1-5, and then each indicator data is normalized to the [0, 1] interval to eliminate dimensional effects, and then the proportion of each value in its indicator is calculated. Finally, the entropy formula is used to calculate the entropy value, thereby calculating the weight of each factor. The linear weighting method is used to combine subjective and objective weights. This study sets subjective and objective weights at 50% each, with final results shown in Table 2.

Table 2. London Urban Renewal Potential Land Evaluation Indicator Weights

Criteria Layer	Weight	Factor Layer	Entropy Weight Method Weight	Comprehensive Weight
Natural	0.231	Elevation	0.249	0.067
		Slope	0.228	0.065
		Environment (forests and water sources)	0.523	0.099
Economic	0.308	Building Density	1.000	0.308
Social	0.462	Transportation (stations and roads)	0.248	0.173
		Infrastructure (education and healthcare)	0.752	0.289

4.4 GIS Calculation

In GIS, the raster calculator is used to combine the raster data of six factors with their weights to obtain the urban potential land evaluation results. Rivers, green spaces, and other non-developable land are added to obtain the final urban potential land evaluation results, as shown in Fig. 2.

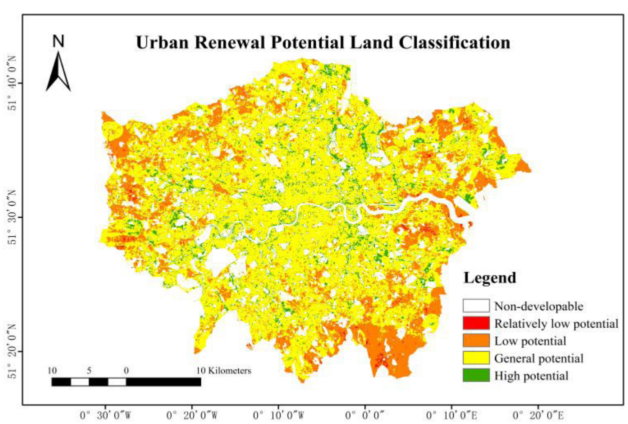

Fig. 2 Urban Renewal Potential Land Classification
Picture credit: Original

4.5 Evaluation Results and Analysis

The potential index is divided into five levels: non-developable, relatively low potential, low potential, general potential, and high potential. The urban renewal potential land evaluation results for the study area are shown in Table 3. The overall distribution of high-potential areas across the city is relatively fragmented. Through observation, it is found that larger-scale high-potential areas are mainly distributed near green spaces and rivers, accounting for only 5.75% of the city's total area. After screening

ISSN 2959-6157

by other influencing factors, this type of area can serve as a basis for urban renewal site selection; general potential areas account for 56.07% of the city's total area. This type of area mainly extends from the center outward, occupying the vast majority of the region. This type of area can undergo small-scale urban renewal after subsequent screening; low potential and relatively low potential areas account for 0.38% and 19.89% of the city's total area, respectively. These two types of areas are not suitable as sites for urban renewal. The distribution of low potential and relatively low potential spaces in Hillingdon and Bromley is most dense; non-developable green spaces, rivers, and other areas account for 17.91% of the city's total area, reflecting the London government's restrictions on unlimited urban expansion and environmental protection.

Table 3. London Urban Renewal Potential Land Index Levels

Level	Score	Proportion (%)
Non-developable	0	17.91%
Relatively low potential	1-2	0.38%
Low potential	2-3	19.89%
General potential	3-4	56.07%
High potential	4-5	5.75%

5. Urban Renewal Potential Land Evaluation

Taking the global city of London as an example, this study combines the standard specification requirements for emergency shelter construction and London's urban characteristics, constructs an urban renewal potential land evaluation model from three perspectives: natural, economic, and social-based on the GIS-MCDA method, adopts a combined weighting method that integrates AHP and entropy weight method, calculates weights through weighted linear combination, and finally obtains the distribution characteristics of urban renewal potential land in London. The method is simple, systematic, and practical, providing important reference for future urban renewal site selection and having a positive impact on optimizing urban spatial utilization and layout. This study still has certain limitations, roughness, and subjectivity. The data has certain deficiencies in time span, and the potential evaluation model can be further optimized and improved.

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