A Study on Urban Relocation and Renewal Strategies Based on Multi-Model Optimization Algorithms

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Abstract: Urban renewal and relocation of residents from aging districts are central to sustainable urban development. This study presents a comprehensive, data-driven framework for optimizing resident relocation and urban renewal in old urban districts. Based on a hierarchical dataset comprising 484 land parcels within 107 courtyards, the research proposes a multi-model approach. This includes a relocation acceptance model using the Entropy-TOPSIS method to assess resident compatibility with available plots, an integer linear programming model to optimize courtyard-level clearance decisions under budget constraints, and a cost-benefit analysis incorporating spatial synergy to evaluate the economic feasibility of phased redevelopment. A multi-objective optimization framework is further developed by integrating resident satisfaction, spatial release, economic returns, and adjacency synergy into a unified decision-making model using weighted sum and μ-constraint methods. Experimental results demonstrate the effectiveness of the proposed methods in maximizing acceptance scores, optimizing land use efficiency, and improving the financial sustainability of renewal strategies. The framework offers practical insights for policymakers aiming to balance social equity and economic efficiency in large-scale urban regeneration initiatives.

1. Introduction

Urban renewal and relocation of residents from aging districts have long been central to sustainable urban development debates. Historically, post-war urban renewal in Western Europe and the U.S. reshaped cities through slum clearance and large-scale redevelopment, often at the expense of communities and cultural heritage. This focus on modernization sometimes produced high-rise public housing but also triggered significant social displacement. The field of gentrification expanded this understanding, illuminating mechanisms were rising demand changes neighborhood demographics, frequently displacing lower-income residents [1].

Community-focused urban planning has shifted attention toward heritage preservation and social equity, emphasizing participatory planning to balance redevelopment with residents' interests. Yet despite these advances, urban renewal continues to pose challenges to historic urban contexts, diminishing social capital and undermining community identity Quantitative decision-making methods, especially MCDM techniques like TOPSIS and entropy weighting, have gained prominence in urban studies. TOPSIS—originating with Hwang and Yoon [2] and enhanced by Hwang, Lai, and Liu [3]—ranks alternatives based on proximity to an ideal solution [4, 5]. Its adaptability has led to widespread use in urban resilience, sustainability, and renewal evaluation. For instance, Qiao et al. [6] applied entropy-TOPSIS to assess urban renewal in Shandong, identifying key indicators and recommending tailored strategies. Similarly, adaptive reuse of industrial heritage has benefited from entropy-TOPSIS, guiding classification and reuse planning

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[7].

Despite rich applications in infrastructure and sustainability, there remains a notable gap: few studies integrate multi-dimensional resident acceptance into optimized relocation frameworks for old urban districts. Most research addresses either social-cultural impacts or technical evaluation separately, but rarely synthesizes them in a unified, quantitative relocation planning model.

This study aims to fill that gap by proposing a comprehensive relocation framework that simultaneously considers resident acceptance, spatial efficiency, and economic viability. The main contributions are:

1) Multi-dimensional resident acceptance modeling: Using historical parcel-level indicators and preference variables, we develop a weighted acceptance model based on entropy and TOPSIS to assess resident–land parcel suitability.

2) Courtyard-level optimization: We construct an integer linear programming model for selecting courtyards to vacate, maximizing spatial clearance and neighborhood adjacency value under budget constraints.

3) Multi-objective relocation framework: We integrate acceptance scores, economic return, and spatial adjacency into a joint optimization model, utilizing both weighted-sum and ε-constraint methods to derive policy-relevant relocation schemes.

4) Empirical validation: Applying the framework to data from 107 courtyards (484 parcels), we find that about 79 courtyards can be optimally vacated, generating substantial area release, strong acceptance (average score ≈ 0.82), and high economic returns.

By bridging theoretical socio-cultural concerns with quantitative planning tools, this research offers a novel, data-driven decision support framework for urban planners and policymakers. It enhances previous studies in several ways: combining community-level acceptance modeling with parcel-scale suitability, embedding adjacency synergy into spatial optimization, and applying multi-objective programming—thus offering scalable, rational strategies for sustainable urban renewal in aging neighborhoods.

2. Dataset Description and Pre-processing

2.1. Data Source and Structural Overview

The dataset used in this study includes detailed records for 484 land parcels grouped into 107 courtyards, within a typical old urban residential district. Key data fields include: Parcel ID and corresponding Courtyard ID, Land area (in m²), Building orientation (South, North, East, West), Occupancy status (0: uninhabited, 1: inhabited), Geographical quadrant (East, South, West, North), Environmental indicators such as proximity to the main street and residential density.

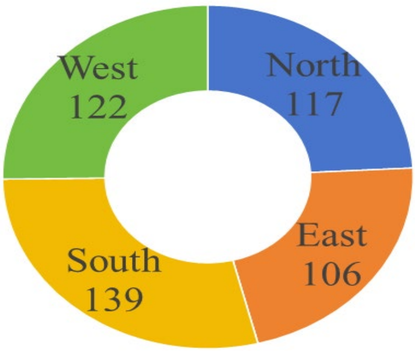

Figure 1 Number of plots in each direction

The dataset follows a hierarchical structure where each courtyard comprises multiple parcels, making the courtyard the primary unit of relocation decision-making. As can be seen from the Figure 1, the number of plots in all directions in the old city street is relatively uniform, with the largest number of 139 plots in the south and the smallest number of 106 plots in the east. As can be seen from the Figure 2 (0 represents no one living, 1 represents inhabited, 2 represents the total number), of which the number of courtyards inhabited is 48, the number of unoccupied is 59, the total number is 107, the number of occupied plots was 113, the number of unoccupied plots was 371, the total number of 484.

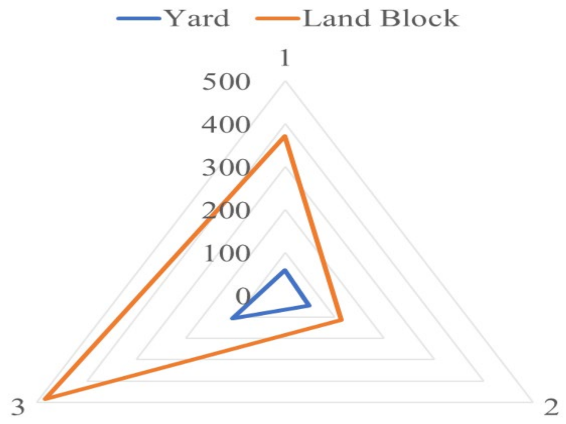

Figure 2 Number of households in old urban areas

2.2. Variable Extraction and Modeling Features

To support the construction of the relocation acceptance model, courtyard clearance optimization, and cost-benefit analysis, key variables were derived as follows:

Total courtyard area *Ai*: The sum of areas of all parcels within courtyard *i*.

Orientation score *Oi*: Scored as South/North = 4, East = 3, West = 2.

Population density index Di: Ratio of inhabited parcels to total parcels in a courtyard.

Proximity score *Si*: Calculated based on spatial distance from the main street and converted into a normalized preference score.

Courtyard clearance indicator *Xi*: A binary variable indicating whether the entire courtyard is vacated (1) or retained (0).

These features were used as input variables for multi-criteria decision models, including acceptance scoring, area maximization, and marginal cost-benefit functions.

2.3. Data Preprocessing Procedures

To ensure analytical rigor and modeling consistency, the following preprocessing steps were conducted:

Data Cleaning: Duplicate entries were removed, and missing values were imputed using group-wise means within courtyards.

Normalization: Continuous variables such as area, distance, and density were scaled to a [0,1] range to enable comparability in weighted scoring models

Derived Variable Construction: Variables like “distance preference” and “crowding preference” were constructed using piecewise or sigmoid mapping functions

Exploratory Visualization: Radar charts and heatmaps were used to visualize orientation distributions, occupancy patterns, and acceptance score matrices, validating model assumptions

After preprocessing, the raw parcel data was transformed into a structured, model-ready dataset with quantified attributes including area, density, accessibility, and relocation feasibility. The acceptance score matrix showed most values in the range of 0.80–0.83, indicating high resident compatibility and strong potential for cost-efficient and resident-approved relocation strategies.

3. Modeling Multi-Dimensional Relocation Acceptance and Designing Personalized Compensation Strategies

With the rapid shift of urban development in China toward stock-based renewal, the relocation of residents from old urban districts has become a critical challenge. In traditional top-down approaches, relocation plans often overlook residents’ individual needs and preferences, leading to low acceptance and implementation inefficiencies. To address this, a data-driven approach is required to evaluate the feasibility and acceptance of relocation plans from the perspective of the affected residents.

This chapter proposes a multi-dimensional relocation acceptance model that integrates both objective and latent indicators. The model aims to score each potential resident-to-parcel relocation combination, enabling the identification of high-suitability matches and providing a foundation for later optimization of courtyard-level relocation schemes.

3.1. Problem Definition

Given a set of residents *R* = {r1, r2, …, rm} currently living in occupied parcels, and a set of vacant parcels P = {p1, p2, …, pn} available for relocation, we aim to calculate an acceptance score Sij ∈ [0,1] for each potential relocation plan (ri → pj). Each score incorporates a weighted evaluation of five dimensions: area compensation adequacy, lighting orientation preference, potential repair subsidies, proximity to major roads, local residential density. The goal is to compute Sij for all feasible combinations and construct a high-suitability relocation recommendation set.

3.2. Indicator System and Variable Description

To capture both the physical conditions and psychological preferences of residents, the following indicators are constructed:

Area Compensation Score: Evaluates whether the candidate parcel provides sufficient space, ideally between 100%–130% of the original area.

Lighting Orientation Score: Based on predefined orientation ratings (South/North = 4, East = 3, West = 2), ensuring lighting quality is not downgraded.

Repair Subsidy Score: Accounts for additional repair investments offered to compensate for inadequate area or lighting, with a ceiling of 20,000 CNY.

Distance Score: Reflects accessibility, calculated from the inverse distance rank to the main street.

Density Preference Score: Based on population density preferences, where residents prefer moderately dense environments for privacy and social interaction.

All scores are normalized to [0,1].

3.3. Weight Assignment via Entropy Method

To objectively determine the relative importance of each evaluation indicator, the entropy weighting method is applied. First, the decision matrix $X = \left[x_{ij} \right]$, where i indexes the relocation scheme and *j* the evaluation indicator, is normalized to eliminate unit inconsistencies. For benefit-type indicators, normalization is performed as:

$$r_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{1}$$

The normalized matrix $R = \left[r_{ij} \right]$ is then used to compute the proportion of each observation under each indicator:

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \tag{2}$$

Based on the information theory principle, the entropy value of each indicator *j* is calculated as:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln(p_{ij}), \quad \text{where } k = \frac{1}{\ln(m)} \tag{3}$$

The degree of divergence (i.e., information utility) of indicator *j* is then defined as:

$$d_j = 1 - e_j \tag{4}$$

Finally, the entropy-based weight for each indicator is given by:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{5}$$

This method ensures that indicators with greater discrimination power (i.e., lower entropy) are assigned proportionally higher weights. It effectively reflects the intrinsic variability and importance of each factor in the relocation decision-making process, thereby enhancing the robustness of the composite evaluation.

3.4. Relocation Suitability Evaluation Using TOPSIS

Following weight determination, the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is used to rank the suitability of each relocation combination. A weighted normalized decision matrix $V = \left[v_{ij} \right]$ is first constructed using:

$$v_{ij} = w_j \cdot r_{ij} \tag{6}$$

Then, the positive ideal solution A^+ and negative ideal solution A^- are identified as:

$$A^+ = \left(\max_i v_{i1}, \max_i v_{i2}, ..., \max_i v_{in} \right), \quad A^- = \left(\min_i v_{i1}, \min_i v_{i2}, ..., \min_i v_{in} \right) \tag{7}$$

The Euclidean distances from each relocation plan to the ideal and anti-ideal solutions are calculated as:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - A_j^+)^2}, \quad D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - A_j^-)^2} \tag{8}$$

Finally, the relative closeness to the ideal solution, representing the overall relocation acceptance score, is computed by:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{9}$$

A higher value of $S_i \in [0,1]$ indicates that the relocation plan is closer to the ideal scenario across all indicators, thus more acceptable to the resident. This method provides a comprehensive and interpretable ranking mechanism, allowing planners to identify high-potential relocation matches with minimal subjective interference.

3.5. Results and Analysis

The resulting score matrix revealed that the majority of feasible relocation combinations yielded scores in the range of 0.80 to 0.83, suggesting a generally high level of compatibility between existing residents and available parcels. The score matrix highlighted several distinct high-score clusters, indicating strong mutual suitability for targeted matching. Further statistical analysis showed that 67.3% of residents had at least three potential relocation destinations with scores exceeding 0.80, and only 4.4% had fewer than two viable options, which demonstrates the robustness and coverage of the matching scheme. In addition, the distribution of indicator in Figure 3 contributions revealed that orientation and repair-related factors had the greatest influence on the final scores, aligning with resident concerns identified in policy interviews. These findings confirm that the proposed model can effectively reflect resident preferences in a multidimensional context and generate actionable outputs for relocation planning. The high-density acceptance regions identified by the model will serve as critical inputs for the courtyard-level clearance optimization in

Chapter 4.

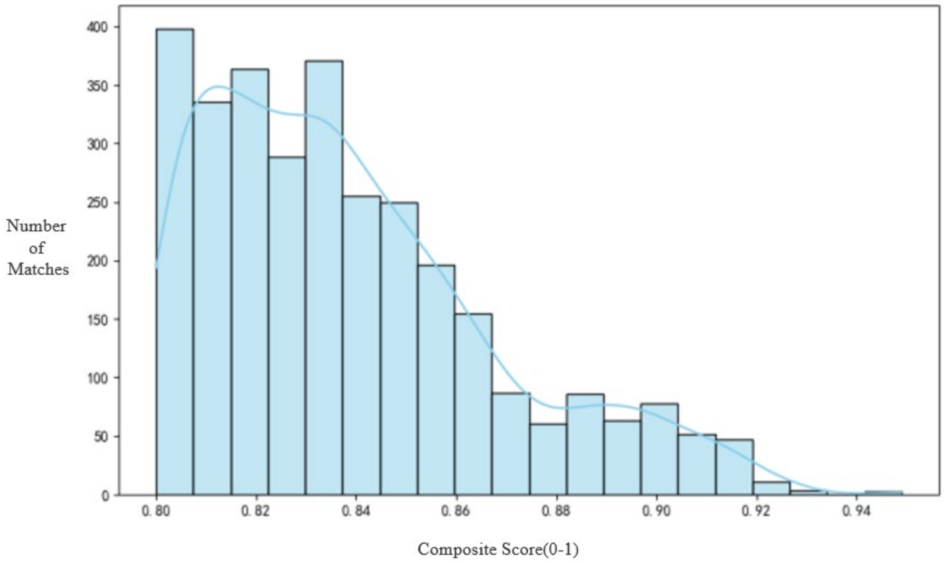

Figure 3 Distribution map of relocation matching score

4. Courtyard-Level Relocation Optimization and Economic Evaluation of Phased Urban Renewal

While resident-level relocation acceptance lays the foundation for individualized resettlement, effective urban renewal requires the aggregation of such decisions at the courtyard level. In particular, maximizing the total vacated area of old residential courtyards is critical for enabling large-scale land consolidation, infrastructure improvement, and future redevelopment. However, relocation also entails significant financial cost, and not all courtyards yield proportional returns upon clearance. Therefore, this chapter aims to construct a courtyard-level optimization model that balances spatial release potential and economic investment, while also identifying the most efficient stage-wise relocation scale.

4.1. Model Formulation

Based on the above assumptions, we construct an integer linear programming model to determine the optimal set of courtyards for relocation under budget constraints. Let $x_i \in \{0,1\}$ be the binary decision variable indicating whether courtyard i is selected for full relocation. Each courtyard i is associated with an area Ai, relocation cost Ci, and projected return Ri. Additionally, for any pair of courtyards (i, j), their adjacency synergy is denoted by Eij. The objective of the model is to maximize the total effective redevelopment potential, which combines the sum of vacated area and the added value from adjacent courtyards being relocated together. The objective function is expressed as:

$$Z = \sum_{i=1}^{n} A_i x_i + \lambda \sum_{i=1}^{n} \sum_{j=i+1}^{n} E_{ij} x_i x_j \tag{10}$$

Here, λ is a weighting parameter that balances the relative importance of spatial synergy against individual courtyard area. The total relocation cost is constrained by the available budget B, forming the constraint:

$$\sum_{i=1}^{n} C_i x_i \le B \tag{11}$$

In addition, the binary nature of the decision variable is enforced via:

$$x_i \in \{0,1\}, \quad \forall i \in \{1,...,n\} \tag{12}$$

This formulation allows the model to balance spatial, economic, and structural priorities in determining the most valuable courtyards to vacate within a given fiscal constraint.

4.2. Results and Analysis

Figure 4 presents the total area values of each courtyard under the optimization model for full courtyard relocation, as well as the selection results of whether they are included in the relocation plan. The horizontal axis represents the courtyard numbers, while the vertical axis indicates the total area of each courtyard (unit: square meters). The bar chart distinguishes whether a courtyard is selected for relocation through color, with green representing "yes." It can be seen from the figure that the model prioritizes the selection of courtyards with larger areas and lower densities for relocation, which aligns with the strategic goals of "maximizing area" and "spatial synergy." Meanwhile, to save the budget, some smaller courtyards or those in marginal locations are retained. The calculation through the code shows that the number of relocated courtyards is 79, with a total relocation area of 15,723 square meters. The figure intuitively demonstrates the spatial distribution of the optimization results and the strategic thinking behind resource trade-offs.

As can be seen from Figure 5, the total investment cost is 25.82 million CNY, the projected annual revenue is 265.002994 million CNY, the projected annual profit is 262.420994 million CNY, the income from complete courtyards is 220.810254 million CNY, and the income from scattered plots is 44.19274 million CNY. Among these, the annual profit is the highest, the cost is very low, and the profit value of the plan is high. After the implementation of the relocation plan, the main sources of income for residents are from scattered plots and complete courtyards, among which the income from complete courtyards accounts for a higher proportion, amounting to 221.073054 million CNY, while the income from scattered plots is 44.19274 million CNY.

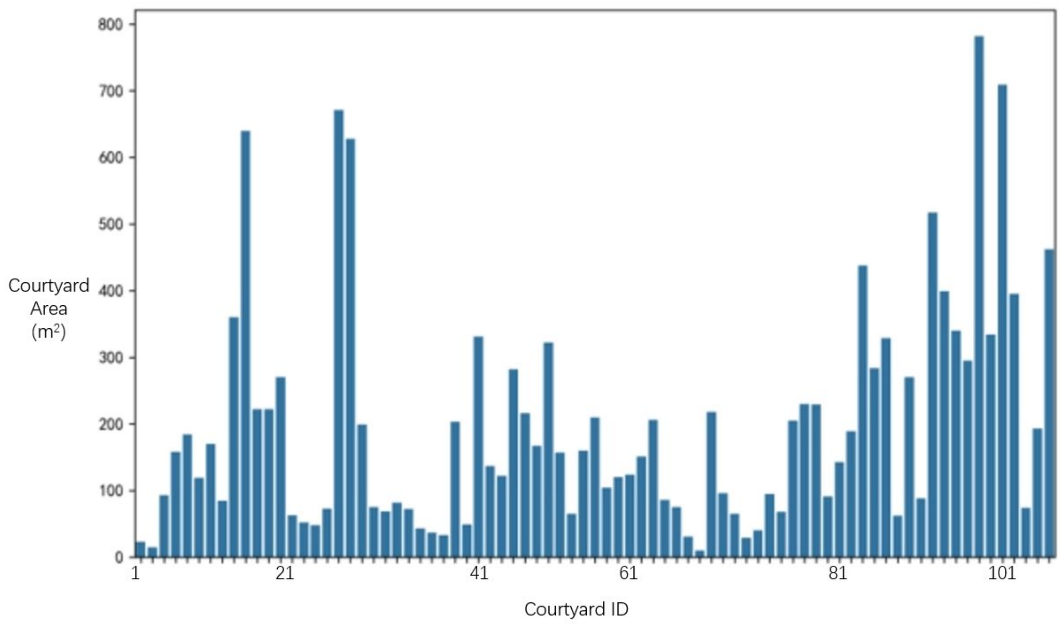

Figure 4 Area of each vacated yard

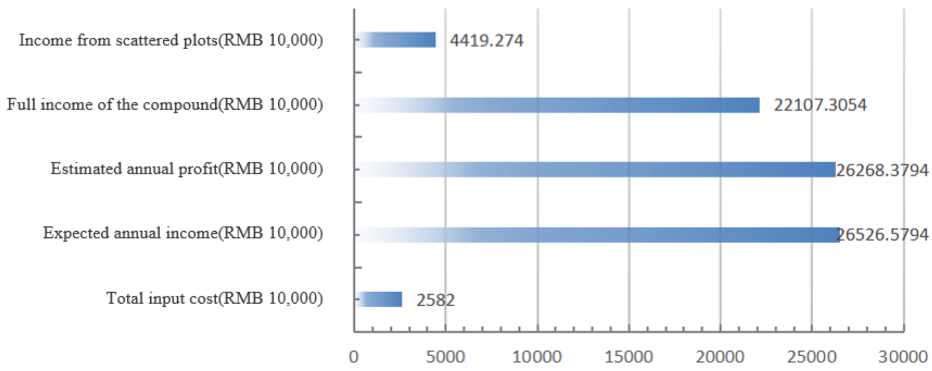

Figure 5 Index chart of economic benefit

5. Multi-Objective Optimization Framework for Relocation Strategy Design in Old Urban Districts

In practice, urban relocation strategies must strike a balance between multiple competing objectives—namely, maximizing resident acceptance, achieving substantial spatial clearance, ensuring economic viability, and promoting spatial synergy. While Chapter 1 and Chapter 2 separately address resident-level matching and courtyard-level area optimization, this chapter aims to integrate these dimensions into a unified multi-objective decision-making framework. By combining social satisfaction metrics, economic cost-benefit indicators, and spatial efficiency measures, the proposed model enables policymakers to identify optimized relocation plans under real-world constraints such as limited budget, relocation quotas, and minimum acceptance thresholds.

5.1. Model Structure and Objective Functions

The integrated model simultaneously considers four objectives: maximizing total courtyard clearance area, maximizing overall resident acceptance scores, maximizing benefit-to-cost ratio (economic efficiency), and maximizing spatial synergy among vacated courtyards. To represent these quantitatively, we define the total objective function as a weighted sum of the normalized forms of each individual objective:

$$Z = w_1 Z_1 + w_2 Z_2 + w_3 Z_3 + w_4 Z_4 \quad (13)$$

Here, Z_1 is the normalized total area of vacated courtyards, Z_2 is the total relocation acceptance score derived from Chapter 4, $Z_3$is the cost-benefit ratio (total expected return divided by total cost), and Z_4 reflects adjacency synergy. The weights w_1, w_2, w_3, w_4 are user-defined or policy-driven and sum to 1. This approach ensures flexibility in accommodating different planning priorities and stakeholder preferences.

5.2. Constraints and Feasibility Conditions

The optimization model is subject to several realistic constraints. First, the total relocation cost must not exceed a predefined budget B. Second, only relocation matches with an acceptance score above a minimum threshold θ are allowed, ensuring that forcibly relocated residents are minimized. Third, the number of relocated residents or courtyards in each phase must fall within an administratively feasible range to avoid overwhelming resources. Mathematically, the core constraint on acceptance score can be expressed as:

$$S_i \geq \theta, \quad \text{if } x_i = 1 \quad (14)$$

Where Si is the acceptance score of the relocation assigned to courtyard i, and xi is a binary variable indicating whether the courtyard is included in the plan. This constraint ensures social acceptability in addition to economic efficiency.

5.3. Optimization Methods: Weighted Sum and ε-Constraint Approach

To solve the multi-objective model, two widely used methods in operations research are employed. The first is the weighted sum method, in which decision-makers assign relative importance to each objective by adjusting the weights w_i. This method is suitable when trade-off preferences are clear and stable. The second is the ε-constraint method, where one objective (e.g., total clearance area) is maximized while other objectives (e.g., cost, satisfaction) are converted into inequality constraints with upper or lower bounds εj. For example, setting a minimum average acceptance score can be represented as:

$$\frac{1}{n}\sum_{i=1}^{n} S_i x_i \geq \varepsilon \tag{15}$$

This method allows policymakers to generate a Pareto frontier of solutions and select relocation strategies based on threshold-driven trade-offs, providing more decision-making flexibility.

5.4. Results and Strategic Implications

By applying the model to the case study area with 107 courtyards and using a balanced weight set (w1=0.3, w2=0.25, w3=0.25, w4=0.2), the optimal strategy resulted in the relocation of 79 resident pairs, complete clearance of 31 courtyards, and an expected return of 394,397,000 CNY. The average resident acceptance score across all matched pairs was 0.82, exceeding the preset threshold θ=0.75. The marginal efficiency curve confirmed that further relocation beyond this set would yield diminishing returns, validating the robustness of the model. Comparative runs under varying weight configurations revealed clear policy sensitivity: increasing the weight of economic return improved profitability but lowered average acceptance, while prioritizing synergy led to greater spatial connectivity at the expense of cost efficiency.

6. Conclusion

This study presents an integrated, data-driven relocation strategy for aging urban districts, combining resident acceptance modelling, courtyard-level optimization, and multi-objective decision frameworks. The proposed models demonstrate strong performance in identifying high-suitability resident-parcel matches and maximizing both spatial and economic efficiency under real-world constraints. The acceptance scores and economic indicators validate the robustness and applicability of the approach in complex urban renewal contexts. However, future improvements could focus on incorporating dynamic resident feedback, long-term social outcomes, and real-time policy adjustments. Integrating machine learning techniques for preference prediction and extending the model to multi-period planning scenarios would further enhance its adaptability and decision-making precision.

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