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Evaluation of the Criteria for Designating Maintenance Districts in Low-Rise Residential Areas: Urban Renewal Projects in Seoul

Woongkyoo Bae, UnHyo Kim and Jeongwoo Lee *

Department of Urban Design and Studies, Chung-Ang University, Seoul 06974, Korea; baegogh@cau.ac.kr (W.B.); freddie3944@gmail.com (U.K.)

* Correspondence: jeongwoo@cau.ac.kr; Tel.: +82-2-820-5321

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Abstract: Since the 1970s, the South Korean government has been redeveloping blighted residential environments and adopting large-scale redevelopment policies to solve urban housing-related problems. However, it is difficult to designate areas for redevelopment and identify areas where redevelopment is currently unfeasible. This study establishes a framework to support decision-making in a selection of housing renewal districts. The proposed Residential Environment Maintenance Index (REMI) overcomes the limitations of existing indicators, which are often biased toward physical requirements. Using this, we rationalize the designation of maintenance areas by considering both physical and social requirements and outline the renewal district designation procedure. To derive REMI, we used an analytic hierarchy process analysis and estimated the index's reliability by clarifying the relative importance and priority of the indicators based on surveys of 300 subject matter experts. We analyzed various simulations by applying REMI at sites where maintenance is currently planned or discharged in Seoul. These reveal that the total number of urban renewal projects can be adjusted by adjusting the number of renewal district designations through the proposed REMI according to the economic situation. The results have implications for understanding REMI's possible application and flexible management at the administrative level to pursue long-term sustainable development.

Keywords: site evaluation indicator; low-rise residential area; urban renewal; analytic hierarchy process; simulation

1. Introduction

To solve the housing provision–related problems that arose during the processes of urbanization and rapid industrial and economic growth, the South Korean government has been providing housing by physically improving the blighted residential environment and consistently adopting large-scale redevelopment policies [1]. Specifically, over the years, the development of new large-scale cities or removal of old housing areas in the city center through demolition has become the most feasible method for solving the housing problems caused by urbanization in South Korea [2]. However, the quantitative growth-oriented development policy, which does not consider the unique characteristics of a neighborhood, has in some places destroyed the community; further, it has several undesirable side effects, such as the overdevelopment of a city's periphery [3]. In addition, the maintenance method based on demolition does not guarantee the residential stability of indigenous people and tenants and often causes conflicts among social classes by promoting residential planning that does not correspond with the residents' will [4–6].

Since the 1970s, which was a period of rapid industrialization and urbanization, the large-scale supply of housing units has created a number of problems because of the following factors: Uniformity

of housing types [7], deletion of existing urban tissue [8], low resettlement rate of indigenous people [5], and destruction of communities' unique characteristics [9]. To systematically and efficiently manage and maintain the residential areas that have deteriorated and need improving, various projects have been implemented under the government's initiative [7]. Accordingly, the "Act on the Improvement of Urban Areas and Residential Environments" (hereinafter, the IUARE Act) [10], which encompasses a systematic management plan for improving deteriorated residential areas, was enforced in 2002. The IUARE Act contributes to the improvement of urban environments and the quality of residential life by integrating housing development projects and housing reconstruction projects, regenerating declining infrastructure, and renewing deteriorated housing infrastructure. The IUARE Act details four steps to implement an urban renewal project (Figure 1). The first step is to develop a master plan for a housing redevelopment or reconstruction project. In the second step, the maintenance area is designated. Maintenance of an area must form a part of any urban renewal project. In other words, areas that are intended to be redeveloped to improve the residential environment should first be designated as maintenance areas. In the second step, approval is obtained to form the Promotion Committee, and the establishment of a renewal association is authorized with the consent of at least 75% of the landowners. The third step involves issuing an urban renewal project plan. For the process to proceed, a Management Disposal Plan must be approved, which involves obtaining approval for the actions necessary to demolish buildings and install buildings and infrastructure in the project area. Therefore, even after the designation of a maintenance area, the project may not proceed until the ward office issues a permit to implement the project's Management Disposal Plan.

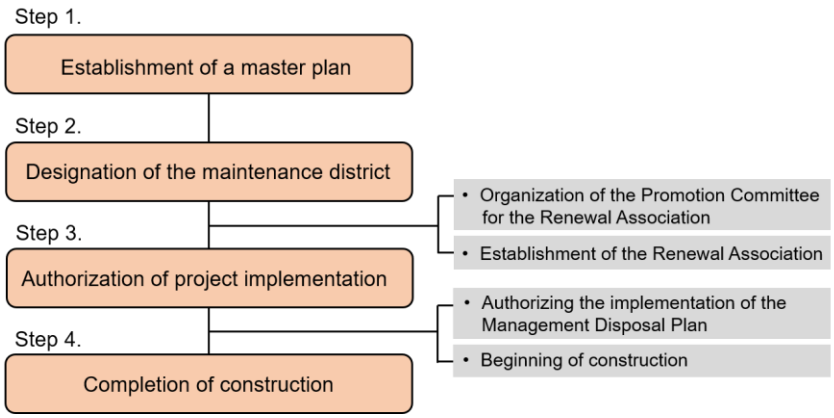

Figure 1. Four steps of the urban renewal project. Source: The Act on the Improvement of Urban Areas and Residential Environments [10].

However, the designation of urban renewal districts has some limitations. The designation of housing redevelopment and reconstruction districts encouraged expectations regarding increases in land property prices, which impeded the project's progress [11]. In some cases, although the relevant areas were designated as a redevelopment district for housing redevelopment or reconstruction, the Promotion Committee and the community failed to implement the renewal plan or the implementation took a long time. Typically, projects are completed almost 10 years after the maintenance area is designated. Further, changes in real estate value can occur over short periods, causing considerable difficulties in the course of a business. Such a possibility raised doubts regarding the feasibility of project execution in certain areas where the progress of execution was slow and poor. Moreover, several urban renewal projects experienced financial difficulties due to various factors, including a slowdown in economic growth [12].

Over the years, local governments have been attempting to improve the residential environment and restore urban functions by designating maintenance districts for urban renewal projects. However, during the renewal project's basic planning stage, each municipality designated too many maintenance areas, and the areas with low project execution feasibility among the planned maintenance districts

remained long-term non-implementation areas [7]. According to Table 1, 302 areas were designated for housing redevelopment projects under the IUARE Act, among which only 113 projects have been completed to date. Further, the completion of 189 projects was hindered; this number includes the 55 discharged areas and 134 uncompleted projects recorded as of 2019, of which 85 projects have remained incomplete for more than 10 years. This indicates that the effectiveness of urban renewal district designation is less than 40%. Therefore, a systematic procedure to designate maintenance districts and establish an index to implement these designations should be established.

Table 1. Status of the housing redevelopment project.

Type Division	Total Designation of the Maintenance Area under the Act [1]	Discharged Area (Master Plan Area)	Processing Area		Project Completion
			More than 10 Years	Less than 10 Years	
Number of districts	302	55	85	49	113
Proportion (%)	100%	18.2%	28.2%	16.2%	37.4%

Note: [1] The Act on the Improvement of Urban Areas and Residential Environments [10]. Source: Statistical data of Seoul's urban renewal project.

The purpose of this study is to create a comprehensive analysis framework to evaluate candidates for the maintenance district based on the indicators that diagnose decline. Accordingly, we develop the Residential Environment Maintenance Index (REMI) to support decision-making processes for selecting housing renewal districts in Seoul. Further, we analyze various simulations that apply the REMI in currently operational maintenance-planned and discharged areas. The results have implications for clarifying the possibility of applying the REMI in individual cases and implementing a flexible management plan at the administrative level.

The next section provides an overview of the literature reviewing international housing evaluation indicators and the literature on the criteria for residential environment evaluation by addressing cases of urban renewal approaches both in South Korea and around the world. This is followed by a description of the research methodology used to accomplish the study objectives. The next section presents the results and discussion. The paper ends with the conclusion section summarizing the findings and limitations of the study.

2. Literature Review

2.1. Concepts and Indicators of Residential Environment Quality

The value of the residential environment refers to the value of the living environment, including the economic, social, and psychological environment, which extends from the daily life of the family unit to that of the entire human settlement. The residential environment refers to the built surroundings of dwelling units that provide the setting for human activities, and it encompasses a range of built environments, from immediate neighbors to large-scale civic environments.

To develop a REMI based on the global criterion to evaluate the value of the residential environment, we reviewed relevant international standards based on the concept of sustainable development in terms of environmental, social, and economic aspects. The World Health Organization (WHO), Organization for Economic Co-operation and Development (OECD), United Nations Human Settlements Programme (UN-Habitat), and Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan, among other international organizations, have implemented many measures to improve urban living conditions.

The WHO [13] drafted guidelines for the basic living requirements of human beings by identifying four dimensions of the residential environment: Safety, health, convenience, and amenity. Further, the WHO suggested that these dimensions are important to the promotion of public hygiene and health. The OECD [14] broadened the concept of quality of life by considering the residential environment's social impact. Apart from emphasizing quantifiable physical dimensions, the OECD stressed the importance of subjective elements such as "social network support" and "life-satisfaction" in assessing the quality of life and, therefore, included indicators such as happiness, health, social connections, civic engagement and governance, and subjective well-being. Further, UN-Habitat [15] presented urban indicators to monitor urban issues and the progress of individual cities in improving the living conditions of low-income populations. The indicators measure poverty eradication, economic development, diversity, and urban governance in cities as sources of the development problems faced by these cities in terms of economic and social conditions. Similarly, the United Kingdom's Index of Multiple Deprivation is a governmental assessment tool that monitors the housing environment using indicators related to deprivation levels in terms of income, employment, education, skills, health, and living environment, as well as barriers to the accessibility to housing and services [16].

Whereas the aforementioned international indicators emphasize basic quality of life and the eradication of poverty at the national or city level, some international organizations indicate that macro-economic indices do not adequately reflect individuals' quality of life; further, they emphasize neighborhood-level sustainability as an evaluation factor for the judgment criteria of the residential environment. For instance, the United States' Vital Signs introduced an index focusing on not only housing development but also community activities [17]. Similarly, the Japanese MLIT added the indicators of safety, convenience, comfort, and sustainability to the neighborhood environmental index, which typically assesses microeconomic impacts, with particular emphasis on increasing the community's sustainability and reducing the load on the environment. The MLIT's early "housing construction five-year program" [18], which was based on the mass housing supply plan, focused on improving the residential infrastructure and physical maintenance by considering the indicators of housing quality, including the number of houses available for rent, number of housing units, and spatial size of a house. Over the years, the MLIT [19] has evolved to include qualitative indices of residential stability, such as a living environment level that reflects the different needs and lifestyles of residents.

Overall, these indicators, which were developed by international organizations, are globally applicable, and they focus on residential welfare to maintain public health and on physical and non-physical neighborhood and housing conditions. The indicators are strongly related to the four concepts of the residential environment: (1) The safety of the residential environment, (2) convenience of the residential service, (3) comfort of living, and (4) sense of community (Table 2). Most discussions of the residential environment highlight safety (such as safety from natural disasters and criminal activities) not only as one of the most important aspects of residential satisfaction, but also as a particularly crucial aspect of policies for the management of healthy built environments. Further, greater convenience implies improvements in the accessibility of basic facilities necessary for living or the satisfaction of people's minimum economic needs, whereas comfort refers to the provision of aesthetic and leisure quality beyond minimum living conditions. The sense of community is a social value that brings together the members of a social system. The higher the sense of community, the stronger the tendency of people to settle in one place.

Table 2. Selection of detailed items of the Residential Environment Maintenance Index [a].

Category		Indicators	International Housing Evaluation Criteria				REMI Criteria	
			Safety	Convenience	Comfort	Sense of Community	Quantitative Evaluation Criteria	Qualitative Evaluation Criteria
Physical environment	Regulation factors	Area of the district	○	-	-	-	Y	-
		Land use plan	○	-	○	-	Y	-
	Infrastructure	Urban planning facility and infrastructure	○	○	-	-	Y	-
		Road length ratio	-	○	-	-	Y	-
	Building and land use	District status (use, landowner, size, whether government owned)	-	○	-	-	-	Y
		Undersized parcel ratio	○	-	-	-	Y	-
		Building deterioration	○	-	-	-	Y	-
		Building status (use, structure)	○	-	-	-	-	Y
		Other status of building (residential/non-residential unauthorized)	○	-	-	○	-	Y
		Housing density	○	-	○	-	Y	-
		New building ratio	-	○	-	-	Y	-
		Building status by size	○	-	○	-	-	Y
	Residence status	Residence status by building type and scale	-	-	○	○	-	Y
Economic environment	Neighborhood environment	Natural environment	○	-	-	-	-	Y
		Traffic conditions	-	○	-	-	-	Y
		Educational facility status	-	○	-	○	-	Y
	Resident Standard of living	Substandard household of minimum housing standard	○	-	-	○	-	Y
		Applicants for apartment sale	-	-	-	○	-	Y
		Applicants for rental housing	-	-	-	○	-	Y
Social environment	Population distribution	Population density/household density	-	-	○	○	-	Y
		Household composition	-	-	-	○	-	Y
		Duration of residence	-	-	-	○	-	Y
	Community participation	Resident's opinion	-	-	-	○	-	Y
		Resident's satisfaction	-	-	○	○	-	Y
		Resident's resettlement countermeasure	-	-	-	○	-	Y
		Resident's consent rate (landowner)	-	-	-	○	-	Y
	Cultural characteristic	Cultural assets	-	-	○	○	-	Y
		Other regional characteristics	-	-	-	○	-	Y

Notes: [a] REMI, Residential Environment Maintenance Index; ○, applicable; -, not applicable; Y, selected. Source: Composed of the indicators commonly mentioned in international organization standards such as WHO, OECD, UN-Habitat.

2.2. Review of Studies on Indicators Evaluating Sustainable Urban Renewal

Because of the increasing importance of applying the concept of sustainability in urban spaces, "sustainable urban renewal", which refers to efforts aiming to solve the problem of urban decline comprehensively from economic, environmental, and social perspectives, has become a major theme of urban policy. In this context, the literature proposes that the indicators of urban renewal projects should be improved to consider specific local characteristics [20,21]. Moreover, there is a need to develop measurable indicators that assess whether urban renewal is being conducted in a sustainable manner [22–24]. Therefore, recent studies have discussed impacts at the local level by clarifying the sustainability of urban renewal projects from economic, physical environmental, and social perspectives [25,26].

First, from an economic perspective, urban renewal is considered an opportunity to improve the effective use of land resources and housing stock at the site. In general, urban renewal increases the value of the land and improves the quality of the residential environment [27–29]. Hence, many studies have evaluated the efficacy of urban renewal policies by using indicators pertaining to local economic activities, building and land value, land use diversity, public space, and public transport quality [30,31]. They applied this indicator-based approach to several urban renewal case studies, performed quantitative assessments, and engaged in qualitative discussion. In addition, they presented indicators related to the economy, buildings, and land use and mobility and indicated

that these indicators improve the quality of life by assessing the sustainability objectives associated with renewal sites.

Second, many studies have focused on aspects of the physical environment that define urban redevelopment as a method to repair aging buildings, prevent urban decline, and improve the quality of the built environment. Accordingly, they suggested structural safety and conditions, building deterioration, block size, parcel accessibility, land adjacent to roads, the ratio of new buildings, land use mix, density level, the ratio of open spaces, and occupancy levels as indicators to clarify the degree of deterioration of the sites and improve the quality of the site's amenities [24,31–34].

A relatively smaller number of studies examine the social impact of urban renewal projects. To encourage stakeholder participation and enrich a community's unique characteristics, the studies developed indicators reflecting the opinions of various stakeholders, such as landlords, tenants, and households [35]; the owner's tendency to sell the property [36]; and the management of the participation process [37–39]. In addition, in recent years, many have expressed critical perspectives on the demolition-type development taking place in East Asia [33,40] and considered indicators such as the preservation of the local environment and community [29,41,42].

Most earlier studies on the topic have evaluated the performance of completed urban renewal projects, and very few have applied future-based approaches to evaluate urban renewal. Further, no study has considered future scenarios in detail. However, the consideration of future scenarios will probably enable policymakers to investigate existing and potential plans thoroughly and provide useful decision-making insights on sustainable urban renewal [25].

2.3. Importance of Evaluation Indicators in Sustainable Urban Renewal in South Korea

Urban renewal is regarded as a useful tool for improving physical environment conditions and the living standards of the public. However, the existing literature [7,43,44] indicates that the government-led physical plan focusing on economic growth did not effectively control the problems of urban decay and did not satisfy affected stakeholders. Further, urban renewal has increased gentrification and come into conflict with the goals of sustainable development in North America, Europe, and Asia.

This issue has also become pressing in China, which has experienced drastic urban development over the past 30 years. Since the 1990s, urban renewal projects have been implemented in the form of large-scale demolition [45]. Hong Kong, which has a high urban density, has adopted a market-led urban renewal approach to emphasize achieving economic goals [46]. These renewal approaches often meet economic goals, but overlook the environmental and social needs of the community and cause various problems such as environmental pollution, latent social contradictions, and loss of community. Therefore, there is a tendency to introduce more comprehensive and community-driven urban renewal projects in the region [47,48].

In some Western countries, the urban renewal approach has shifted from government-led massive construction to governance-led, participatory, and sustainable development [45]. Many urban renewal projects encourage the revitalization of city centers with mixed-use developments employing strategies to encourage city centers actively [49,50]. However, many renewal sites in the United States and England are experiencing gentrification, where urban renewal projects create areas for more profitable residential and commercial development, and such development primarily benefits the middle class rather than low-income groups [51].

South Korea, like other countries, has a long history of urban renewal and has therefore experienced the evolution and challenges associated with major urban renewal projects [52]. South Korea has undergone rapid urbanization over the past 50 years. During this period, it has been implementing urban renewal projects focusing on the development of new cities and towns and improvement of the physical environment. This has resulted in many social problems, such as the physical decline of existing cities, environmental pollution, the weakening of the urban economy, and the loss of the community's identity. However, since the 2000s, social consensus has been achieved on the need for

sustainable urban renewal. Accordingly, many South Korean municipalities are attempting to ensure sustainable development in urban renewal projects. To increase the effectiveness of these projects, the active utilization of the unique historical and cultural resources of existing cities is necessary. In addition, long-term policy and management plans should be established, and various actors, such as the government, residents, and the real estate industry, should cooperate to achieve sustainable urban renewal. Moreover, policy and institutional rehabilitation measures should be promoted to maintain the efficiency of urban renewal projects.

Most of the studies on improving the designation criteria for urban renewal projects in South Korea analyzed trends of improvement of the criteria for designating districts for the implementation of urban renewal projects among all the areas of the residential environment requiring maintenance. These studies recognized the necessity of improving the criteria for a maintenance district and proposed improvement plans. In particular, some studies argued that the district selection criteria differ in importance and, therefore, that a relative weight should be assigned to each criterion [26,53].

Moreover, some studies indicated that urban renewal projects in South Korea focused on physical characteristics alone when designating districts [25]. In addition, the existing standard for designating a maintenance district is not clear and does not sufficiently reflect the district's socioeconomic characteristics [54]. Therefore, the studies proposed the addition of social conditions, such as the residents' consent rate and the local government's willingness to implement renewal plans, to the list of indicators for designating a maintenance district [5,55]. Some other studies discussed the problem that the urban renewal of many areas designated as districts once they satisfy the minimum criteria is not subsequently pursued [56], along with the problem of slumming occurring after the designation of the maintenance district caused by prolonged real estate recession [54].

Further, most of the existing certification schemes and evaluation systems adopt a post-assessment approach to assess the results of an urban renewal project after its completion. Every year, smarter cities in the United States and livable cities in South Korea are selected and presented as sustainable cities, which can be considered ex-post evaluation bases on the statistical data that are published and aggregated in existing cities. At the planning stage, it is very difficult to predict a city's appearance at the completion of its redevelopment. However, it is more efficient to consider all efforts to secure environmental and economic sustainability in earlier stages of project implementation than after the project's completion. Therefore, it is necessary to devise a plan that ensures maximum sustainability in the planning process. In this respect, indicators designating maintenance districts for urban renewal projects are important factors in establishing the criteria for selecting a renewal district having certain conditions for maintenance and reorganization [57].

To address the research gaps in the literature, the current study builds a REMI that can be used at the evaluation stage of the residential maintenance district designation to ensure maximum sustainability in the urban renewal project planning process. To the authors' knowledge, this is the first study to devise and validate a comprehensive framework to ensure the sustainability of urban renewal area designation.

3. Methods

Figure 2 depicts the research process: First, following a literature review, we discovered several criteria for residential environment evaluation and categorized them by conducting expert opinion surveys. Second, based on universally applicable indicators, we selected the indicators that can reflect the environmental, social, and economic characteristics of residential areas. Third, we evaluated the relative importance (weight) of each individual criterion through expert opinion surveys and the analytic hierarchy process (AHP). Fourth, we carried out a simulation to determine the basic score, which is the sum of all the evaluation indicators derived from the AHP, and to predict the number of maintenance districts that change according to the basic score. The simulation's scope of analysis for the REMI's practical application was examined in the scheduled maintenance area and discharged area, excluding the maintenance area where the project had already been carried out, in the city of Seoul.

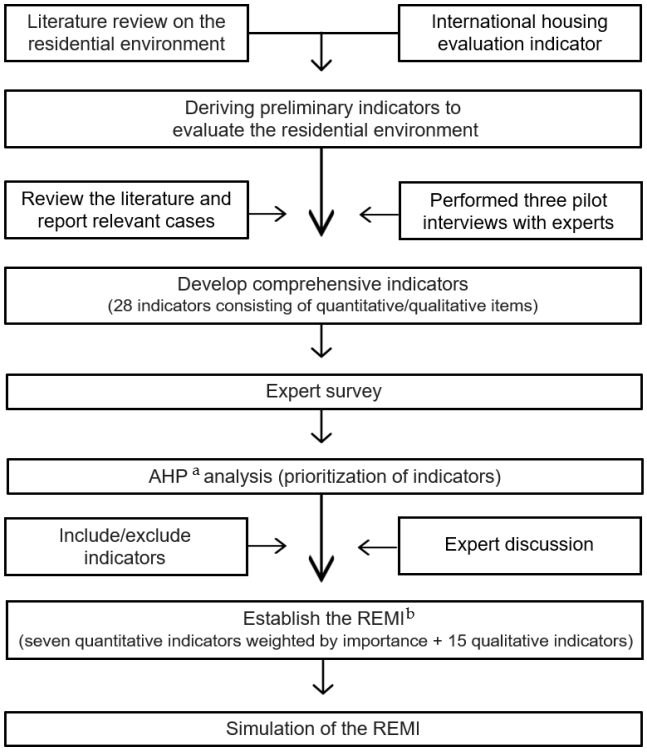

Figure 2. Flowchart of the research process. Notes: [a] AHP, analytic hierarchy process; [b] REMI, Residential Environment Maintenance Index. Source: Authors' work.

The indicators are divided into several major categories, such as physical environment, social environment, and economic environment factors, which are depicted in Table 2. The physical environmental sector is composed of comprehensive indicators of the decline of physical facilities and direct and indirect conditions of the living environment. The economic sector comprises comprehensive indicators of human infrastructure, provision of affordable housing, and residents' living standard, whereas the social sector consists of comprehensive indicators of the population and community, and the site's social conditions. The specific indicators of the maintenance index were divided into 28 indicators selected from the three pilot studies that were conducted to review the indicators that should be excluded from or included in the REMI.

While selecting and collectively evaluating indicators, one should consider the indicators' relative importance, which can be determined using various methods, including surveys of residents and of experts. To construct the REMI, we surveyed experts and implemented the AHP to identify the importance of the indicators. We distributed two questionnaires among 300 people, including 148 public officials, 52 professors and researchers, and 103 practitioners, who were professionals with more than 10 years of experience in implementing urban renewal projects. The data collected from the questionnaire survey were analyzed on an 11-point Likert scale (ranging from 1, meaning strongly insignificant, to 11, meaning strongly significant) to compare the importance of the criteria. Therefore, the proposed REMI is conceived as a system that gives a differential score according to the conditional criteria indicators corresponding to district designation requirements to meet legal standards.

4. Results and Discussion

4.1. Examination of the Priority Weights of Criteria Using the Analytic Hierarchy Process

In this study, we used an AHP to compare the adequacy and importance of the REMI's indicators to analyze the type of standards that should be considered while selecting a maintenance area for an urban renewal project. The AHP is frequently used to assist decision-making in situations requiring

the simultaneous consideration of multiple criteria. This technique is based on the assumption that evaluators can make more precise and clear decisions by performing pairwise comparisons, rather than simultaneously considering complex selection criteria.

Based on the questionnaire response results for six indicators using the AHP analysis function, the pairwise comparison matrix yielded the result shown in Table 3. The consistency index (CI) was 0.0115 and the consistency ratio (CR) was 0.0097. In other words, the CI was less than 0.1 and the CR (CI/1.24) was significantly less than 0.2, indicating the high reliability of the analysis results.

Table 3. Comparison matrix of criteria obtained from analytic hierarchy process analysis.

	Residents' Consent	Building Deterioration	Housing Density	Undersized Parcel	Road Length	New Building
Residents' consent	1	1.5	3.1	3.4	3.3	2.8
Building deterioration	0.6666667	1	2.7	3.1	3.1	2.5
Housing density	0.3225806	0.3703704	1	1.4	1.2	1.3
Undersized parcel	0.2941176	0.3225806	0.7142857	1	1.5	1.3
Road length	0.3030303	0.3225806	0.8333333	0.6666667	1	1
New building	0.3571429	0.4	0.7692308	0.7692308	1	1

Source: Authors' computations.

The residents' consent indicator was 1.5 times more important than the building deterioration indicator. Compared to the other four indicators (housing density, ratio of undersized parcel, ratio of road extension, and ratio of new buildings), the residents' consent indicator was more than three times as significant.

Table 4 depicts the weights of the indicators that were fixed according to the importance of the evaluation index. The importance of each factor in the designation of the urban renewal project area decreased in the following order: Residents' consent, 0.330; building deterioration, 0.270; and housing density, 0.115. In addition, the difference in importance of the undersized parcel ratio, new building ratio, and road length ratio was insignificant. These results reveal that the experts recognized the importance of the residents' consent rate and physical deterioration level in the progress of the urban renewal project. To ensure the detailed point adjustment of each indicator, points were set by analyzing the weight of each indicator by conducting a survey of experts in a related field. In the results, the total basic score of 100 consisted of the residents' consent ratio (37.5 points), building deterioration (30 points), housing density (12.5 points), the undersized parcel ratio (10 points), and the road extension ratio (10 points). As an additional point, the indicators of the new building ratio were set to 5 points.

Table 4. Final weights of the Maintenance District Criteria.

	Residents' Consent	Building Deterioration	Housing Density	Undersized Parcel	Road Length	New Building
AHP [a] weights	0.330	0.270	0.115	0.103	0.088	0.095
Points adjustment	37.5	30	12.5	10	10	(5)

Notes: [a] AHP, analytic hierarchy process. Source: Authors' computations.

Areas having scores of 60–70 or higher on a 100-point scale should be suited to maintenance district designation and maintenance plans for urban renewal projects. This helps encourage the flexible implementation of urban renewal projects and enables the control of housing demand based on policy decisions. In other words, when the housing demand in the market is high, demand and supply can be increased by setting the basic score as low as 60 points. On the other hand, when it is necessary to regulate unreasonable district designation, the district designation can be rapidly and efficiently controlled by decreasing the housing supply by setting a basic score as high as 70 points.

4.2. Working Principle of the Residential Environment Maintenance Index

This study proposed the REMI, which can be used at the evaluation stage of maintenance district designation in low-rise residential areas for urban renewal projects. The index provides differential scores based on the conditional criteria assessments that satisfy district designation requirements. Further, the REMI utilizes both quantitative and qualitative indicators (Table 5).

Table 5. Definitions of indicators and evaluation concepts.

	Indicator	Measure
First stage **Legal criteria**	**Minimum legal standards**	
	• Residents' consent ratio	- Based on the consent of more than 50% of the landowners in the maintenance district and the ratio of the land area occupied by them to the total area
	Area of the district [1]	- Based on a land area of 10,000 m^2 or more
	Aging housing stock [1]	- Based on the number of aging housing units, which account for more than 60% of the total number of housing units, or the area of aging housing, which covers more than two-thirds of the total housing area
Second stage **Conditional criteria** (quantitative indicators)	**Physical standards**	
	• Residents' consent ratio	- Points for residents' consent rate above the minimum legal standard
	• Level of building deterioration	- Points for the number and floor area ratio of deteriorated buildings above the minimum legal standard
	• Rate of undersized parcels [2]	- Percentage of the number of undersized parcels (90 m^2 or less) to the total number of parcels
	• Rate of road length	- Percentage of road lengths more than 6 m wide to total road length
	• Housing density [2]	- Number of housing units per hectare
	• Rate of new buildings	- Deduction points for the percentage of new buildings less than 10 years old
	Resident survey	
	• Rate of survey respondents	- Additional points for more than 60% of residents responding to the survey
Third stage **Review by committee** (qualitative indicators)	**Local characteristics**	
	• Local environment status	- Existing condition of building use, urban planning, topography (elevation, slope), population, and industries in the district
	• Land use status	- Existing condition of zoning and land use of the district
	• Infrastructure status	- Existing condition of urban planning facilities and infrastructure
	• Traffic condition status	- Existing condition of public transportation system facilities
	• Status of educational facilities	- Existing condition of elementary, middle, and high schools within 200 m, 1 km from the site
	• Building status	- Existing condition of residential/non-residential buildings, number of authorized/non-authorized buildings
	• Residence status	- Residence status by type of housing (detached housing, multifamily housing); residence status by type of ownership (landowner, tenant)
	• Residence status by size of housing	- Residence status by type and size of housing (residential/non-residential) (under 60 m^2, 60–85 m^2, over 85 m^2)
	• Status of household composition	- Household composition by type (age, gender, number of members)
	Residents' intention	
	• Tendency for duration of residence	- Residents' tendency to settle in the neighborhood
	• Residents' opinion	- Residents' (landowners, tenants) opinion about maintenance district designation
	• Residents' satisfaction	- Resident satisfaction survey on indicators evaluating the residential environment
	• Applicant status for housing sale	- Household's ability to pay for new housing
	• Consent status for designation	- Stakeholders'/landowners' agreement on maintenance district designation
	• Applicant status for rental housing	- Tenants' intention to live in a rental housing unit

Source: [1] The Act on the Improvement of Urban Areas and Residential Environments [8]; [2] Seoul Special Metropolitan City Ordinance on the Maintenance and Improvement of Urban Areas and Dwelling Conditions for Residents [58].

There are seven quantitative indicators, including the six physical indicators analyzed by the AHP and the response rate of the resident survey as an additional indicator. The indicator of residents'

consent rate is calculated by accounting for both the ratio of the number of landowners agreeing to urban renewal project promotion to the total number of landowners in the maintenance district and the ratio of the land area occupied by the landowners to the total area. The indicator of building deterioration represents the level of physical deterioration of buildings in the maintenance district. The level of deterioration is calculated by considering both the ratio of the number of deteriorated buildings at least 20 years old to the total number of deteriorated buildings in the district and the ratio of the aged building floor area to the total building floor area in the district. The undersized parcel ratio is an indicator that reflects both the ratio of the number of undersized parcels (less than 90 m^2) to the total number of undersized parcels and the ratio of the undersized-parcel area to the total area of the maintenance district. The indicator of road length ratio is the length of a road 6 m wide or more divided by the total road length in the district. All of the road lengths were measured from the road centerline. Further, the indicator of housing density refers to the number of housing units per 1 ha area. The new building indicator is calculated using the ratio of the number of buildings aged less than 10 years to the total number of buildings in the maintenance district. Finally, the survey response rate is an indicator that scales the percentage of residents who responded to the surveys, and this indicator identifies the status and characteristics of the residents.

Qualitative indicators include the City Planning Council's deliberation scores for the data submitted for the consideration of urban renewal project designation and indices pertaining to the residents' intention to participate in the project and site's local characteristics. Indicators on residents' intention include residence status by type and size of housing, residents' opinion on the maintenance district designation, residents' satisfaction with the residential environment, and residents' ability to pay for new housing. Local characteristics include general characteristics related to the site's environment, such as tangible and intangible assets, as well as site characteristics, including the surrounding environment.

The working principle of our proposed REMI involves three steps (Figure 3). The first step involves satisfying the legal standards for the designation of maintenance districts for a blighted residential area in accordance with the requirements of the IUARE Act. For an area to be designated as a maintenance district for the implementation of an urban renewal project, the land area must be at least 10,000 m^2 and the residents' consent rate for the area designation must be at least 50%. Further, the percentage of aging housing stock in the area should be at least 60%. Although the definition of aging housing varies depending on the regulations of the city and province, in general, aging housing refers to housing units older than 20 years.

In the second stage, the districts that pass the first stage of legal criteria are scored and evaluated. In this stage, conditional criteria are evaluated on the basis of seven quantitative indices. The evaluation of indices such as residents' consent, building deterioration criteria, undersized parcel ratio, road length, and housing density is based on a total of 100 points. Additional points are awarded once a high rate of survey respondents is identified, and points are deducted according to the increase in the proportion of new buildings. In total, an area with more than 60–70 points can proceed with the request for maintenance district designation. Areas with conditional scores of 60–70 or more are required to develop a maintenance plan and request processing deliberation from the City Planning Council.

In the third stage, the City Planning Council is required to examine 15 qualitative indices pertaining to the local characteristics and residents' intentions. Since qualitative indices cannot be measured by numerical values, the City Planning Council uses these indices to judge whether the designation for an urban renewal project is appropriate. Finally, the maintenance district planner submits a self-assessment report of the comprehensive opinion on the data submitted for deliberation.

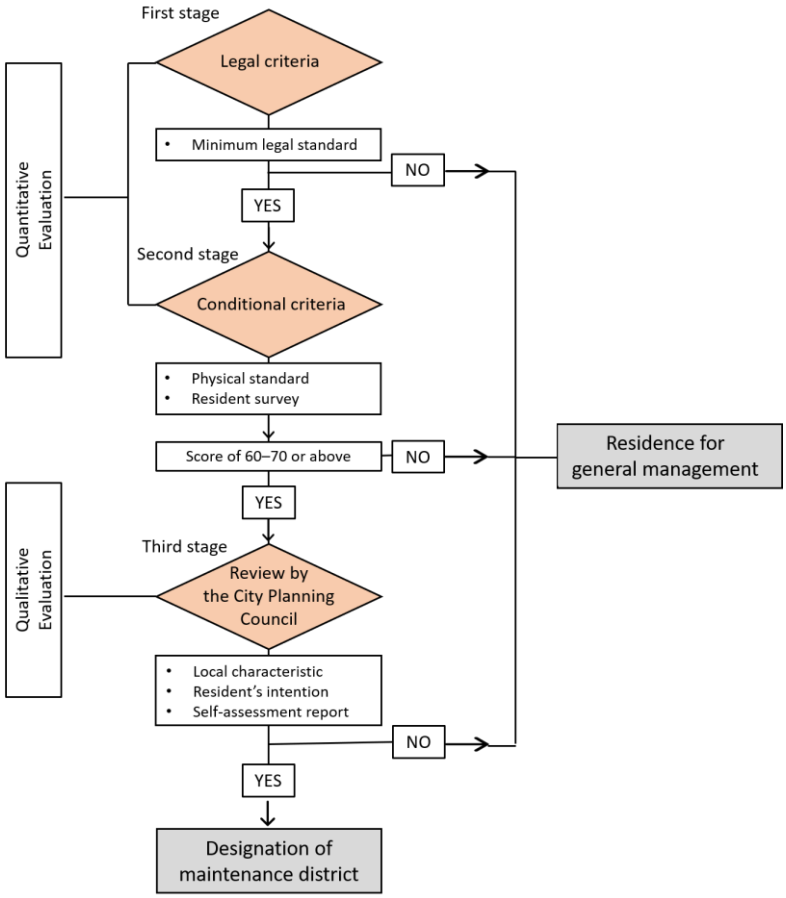

Figure 3. Flowchart depicting the working process of the proposed REMI. Source: Authors' work.

4.3. Simulation of the Residential Environment Maintenance Index

We performed a simulation analysis to enable the REMI's practical application. To ensure the realistic application of the REMI, we analyzed the areas where maintenance districts could be designated until 2030 based on the samples from 189 regeneration sites in Seoul, including 134 scheduled maintenance districts and 55 released districts. Our simulation targeted these samples of old low-rise residential areas. Further, these are the sites of urban renewal projects, including housing redevelopment or reconstruction projects, that are undergoing maintenance projects in the form of complete demolition.

The simulation was divided into two stages. In the first stage, we analyzed how the estimated number of maintenance areas and housing units changed when the basic score was simulated to 60, 65, and 70 points (Figure 4). The basic score was the sum of the indicator's distribution points based on the weights attributed through the AHP, which were set between 60 and 70 points. The minimum basic score was fixed at 60 points based on expert evaluation to prevent indiscriminate zoning in the absence of minimum standards. The basic scores could be flexibly changed to activate or control the maintenance project according to the progress of the annual maintenance business. In case of housing supply shortages, the basic score was set to 60 points to increase the number of maintenance districts. On the other hand, when the housing supply exceeded the demand, the supply was adjusted by setting the basic score to 70 points.

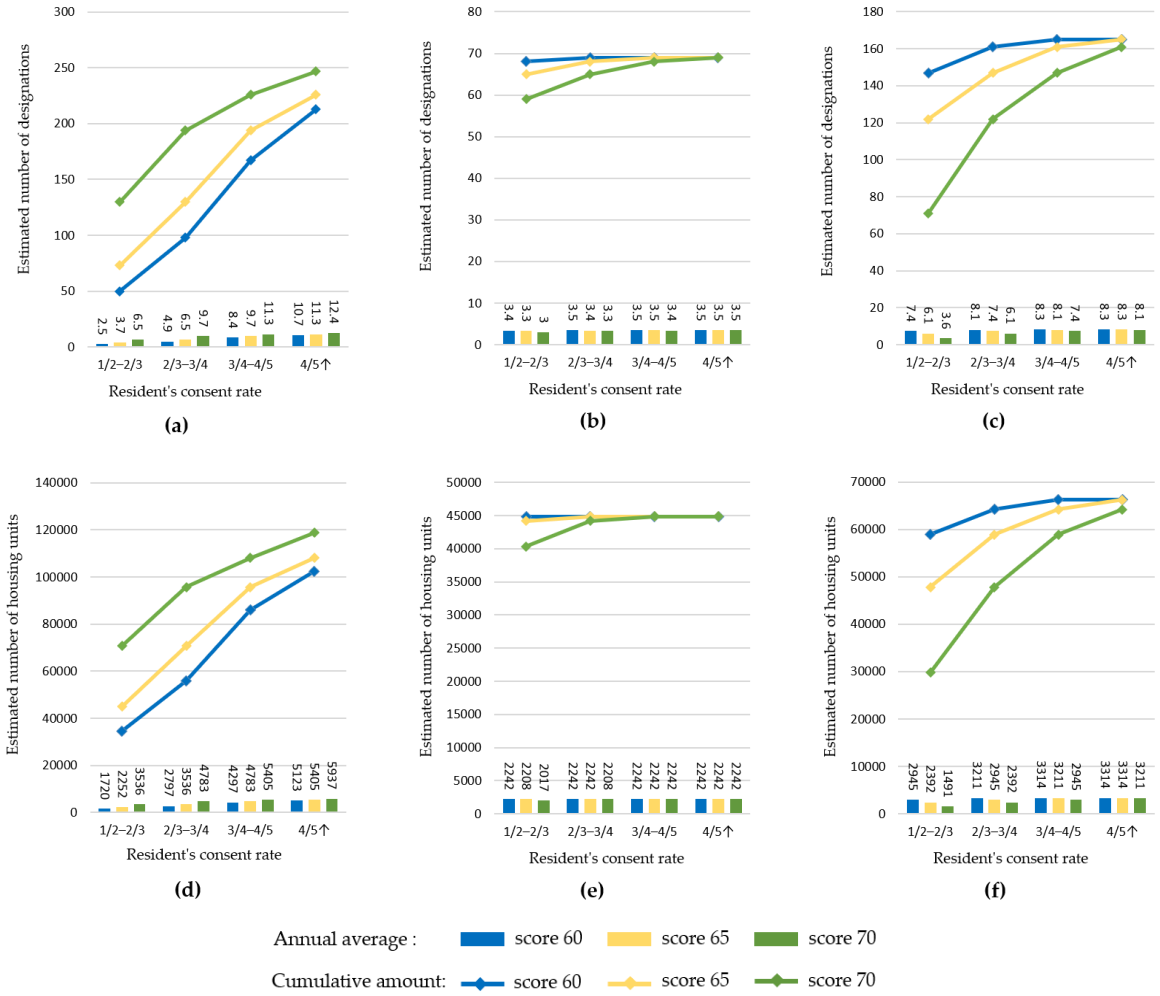

Figure 4. Comparison of variations in simulation results according to the adjustment of the basic score: Designated maintenance districts and estimated housing units. (**a**) Total number of designations; (**b**) number of designations in the redevelopment area; (**c**) number of designations in the reconstruction area; (**d**) total number of housing units; (**e**) number of housing units in the redevelopment area; and (**f**) number of housing units in the reconstruction area. Source: Statistical data of Seoul's urban renewal project.

In the second stage, the simulations (Figure 5) reveal the annual average of the estimated number of designations and housing units and its cumulative trends when the City Planning Council's deliberation scores are expected to be 1.5, 4.5, and 7.5 points. For the districts satisfying the basic score, the City Planning Council's deliberation scores should be submitted. The deliberation scores include qualitative evaluation factors such as residents' intention and local characteristics, which were excluded from the previous method of maintenance district designation. The City Planning Council's evaluation process assigns a sufficiently high score to designate a maintenance district. This score is the sum of 15 indicators that belong to the category of residents' intention and local characteristics and for each of which a minimum score of 0.1 and a maximum score of 0.5 are assigned. If the 15 indicators are assigned the lowest score of 0.1, the total score is 1.5; however, if each indicator is rated using the highest score of 0.5, the total score is 7.5.

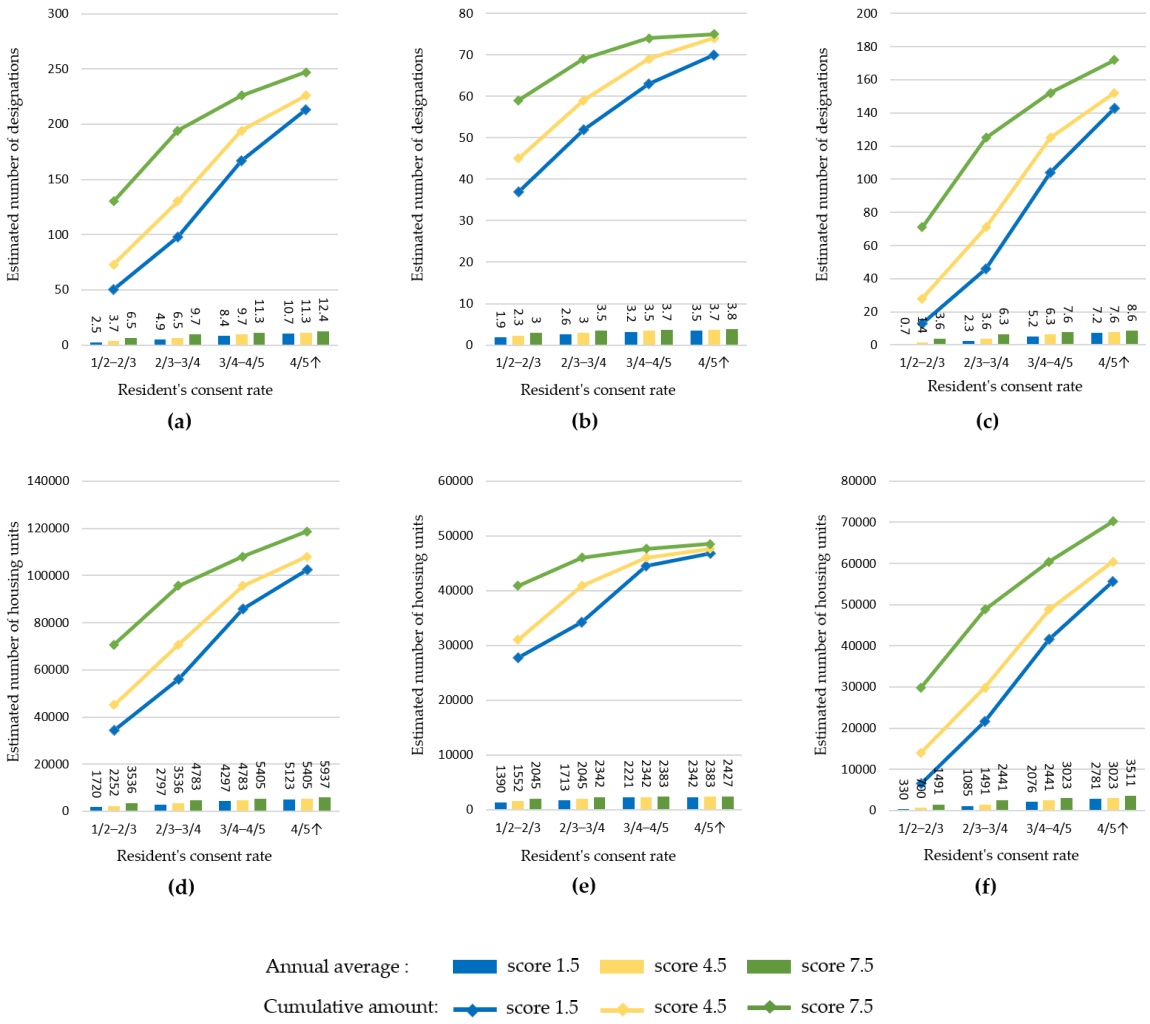

Figure 5. Comparison of the variations in simulation results according to the adjustment of the City Planning Council's deliberation score: Designated maintenance zones and estimated housing units. (**a**) Total number of designations; (**b**) number of designations in the redevelopment area; (**c**) number of designations in the reconstruction area; (**d**) total number of housing units; (**e**) number of housing units in the redevelopment area; and (**f**) number of housing units in the reconstruction area. Source: Statistical data of Seoul's urban renewal project.

It is considered that systematic and comprehensive management will become possible by quantifying the requirements for maintenance district designation so that only those areas requiring maintenance work are designated as maintenance districts. From a management perspective, basic score adjustments are expected to control the number of designated maintenance districts and the number of housing units constructed by renewal projects by strengthening or mitigating conditional criteria.

Further, changes in the number of designated areas and housing units according to the residents' consent rate can be identified using the cumulative amount and annual average value. The cumulative amount refers to the total number of districts and housing units that are designated by 2030, and the annual average is the total number of districts and housing units divided by the number of years remaining till 2030.

Table 6 depicts the results of the simulation analysis and reveals how the estimated numbers of housing units and designated maintenance areas vary according to the basic score. The lower the basic score, the higher the numbers of housing units and designated maintenance districts, which implies that the screening power decreased according to the residents' consent rate. On the other hand, the higher the basic score, the lower the number of maintenance districts.

Table 6. Results of the simulation predicting the number of maintenance district designations for the urban renewal project.

Basic Score	Rate of Residents' Consent	Total		Redevelopment Site		Reconstruction Site	
		Number of Designations (until 2030)	Annual Average Number of Designations	Number of Designations (until 2030)	Annual Average Number of designations	Number of Designations (until 2030)	Annual Average Number of Designations
60	1/2–2/3	233 (86%)	12.3	72 (95%)	3.8	161 (83%)	8.5
	2/3–3/4	245 (90%)	12.9	72 (95%)	3.8	173 (89%)	9.1
	3/4–4/5	246 (91%)	12.9	72 (95%)	3.8	174 (89%)	9.2
	4/5 or more	246 (91%)	12.9	72 (95%)	3.8	174 (89%)	9.2
65	1/2–2/3	205 (76%)	10.8	68 (89%)	3.6	137 (70%)	7.2
	2/3–3/4	233 (86%)	12.3	72 (95%)	3.8	161 (83%)	8.5
	3/4–4/5	245 (90%)	12.9	72 (95%)	3.8	173 (89%)	9.1
	4/5 or more	246 (91%)	12.9	72 (95%)	3.8	174 (89%)	9.2
70	1/2–2/3	157 (58%)	8.3	64 (84%)	3.4	93 (48%)	4.9
	2/3–3/4	205 (76%)	10.8	68 (89%)	3.6	137 (70%)	7.2
	3/4–4/5	233 (86%)	12.3	72 (98%)	3.8	161 (83%)	8.5
	4/5 or more	245 (90%)	12.9	72 (95%)	3.8	173 (89%)	9.1

Source: Statistical data of Seoul's urban renewal project.

According to the AHP analysis, the most important variable in our simulation was the residents' consent rate, which was classified as 1/2–2/3, 2/3–3/4, 3/4–4/5, and 4/5 or more. The number of designated maintenance districts sensitively varied according to the residents' consent rate, as evidenced by the case where the consent rate is less than 3/4. Further, such trends are particularly more prominent in housing reconstruction sites than in housing redevelopment sites.

Figure 4 compares the cases of housing redevelopment and housing reconstruction to reveal how the number of designated areas varies when the basic score is simulated from 60 to 70. In Figure 4a, when the basic score is set to 60 and the consent rate is 1/2–2/3, the number of designated maintenance districts is 215. However, when the basic score is set to 70, the number of designated districts is significantly reduced, to 130. On the other hand, if the consent rate is 4/5 or more, the number of designations does not show any major difference even when the basic score is changed. The reason is that when the consent rate is 1/2–2/3, the percentage of residents' consent score is relatively less reflected in the total score. However, when the consent rate is 3/4 or more, it is relatively strongly reflected in the total score, which weakens the influence of other indicator scores.

In addition, the districts for housing redevelopment and housing reconstruction differ in terms of simulation results. In the case of redevelopment sites, slight changes were observed according to the difference in basic scores, as well as differences in the residents' consent rate. However, for reconstruction sites, the number of designations significantly varied according to changes in the basic score. Specifically, when the residents' consent rate is 1/2–2/3, there are apparent changes in the number of designations according to the different basic scores. When the basic score is 70 points, the number of designations increases rapidly with an increase in the residents' consent rate. In other words, the REMI's screening power is higher at a basic score of 70 points than at 60 points.

The number of designated districts increases at a constant rate with the increase in residents' consent rate for the City Planning Council's deliberation scores of 1.5, 4.5, and 7.5. For example, the total annual average number of designated districts increases from 2.5 (residents' consent rate pertaining to the 1/2–2/3 section) to 10.7 (residents' consent rate pertaining to the 4/5 or more section) when the deliberation score is 1.5 (Figure 5a).

However, for the same residents' consent rate, the number of designated maintenance districts differs according to the deliberation score evaluated by the City Planning Council. In Figure 5a, for the section with 1/2–2/3 residents' consent, the number of designated districts is 50 when the deliberation score is 1.5; however, the number increases to 130 when the deliberation score is 7.5. Although the residents' consent rate remains the same, there is a clear difference in the number of districts according to the deliberation score. However, the difference in the number of districts according to the score decreases with an increase in the residents' consent rate. Compared to the case of the residents' consent rate pertaining to 1/2–2/3, the change in the number of designated districts according to the deliberation score is very small when the residents' consent rate is 3/4 or more. In other words, when the residents' consent rate is low, such as 1/2–2/3, there is an obvious difference in the number of district designations in accordance with the deliberation score; however, the screening power of the deliberation score decreases with an increase in the residents' consent rate.

The trend of change in the number of designations according to the deliberation score varies depending on the project type. For the redevelopment project (Figure 5b), the change in the number of designations according to the residents' consent rate is relatively small. However, for reconstruction projects, the number of designations tends to increase significantly with an increase in the residents' consent rate (Figure 5c). On comparing the annual average values according to project type, we found that, when the deliberation score is 1.5, the number of designations of the redevelopment area (Figure 5b) increased less than twice from 1.9 to 3.5, whereas the reconstruction area increased by more than 10 times from 0.7 (1/2–2/3) to 7.2 (4/5 or more).

The results show that the residents' consent rate has relatively little influence on the designation of redevelopment sites but considerable influence on the designation of reconstruction sites. In addition, for redevelopment project sites, the difference based on the deliberation score is not large in the same residents' consent rate section (Figure 5b); however, for reconstruction project sites, there is a large difference based on different deliberation scores (Figure 5c). This indicates that the deliberation scores have relatively weak screening power in housing redevelopment sites but much greater screening power in housing reconstruction sites. Since the deliberation score comprises qualitative indicators, including local characteristics and residents' intentions, the deliberation from the City Planning Council's qualitative evaluation appears to have more impact on the designation of maintenance districts in reconstruction sites than on the designation of redevelopment sites.

5. Conclusions

Existing legal requirements consisting of simple deterioration diagnoses of residential environments have been used as the selection criteria of maintenance districts and have created conflicts among social classes by promoting residential planning that does not correspond with the residents' will. To implement sustainable urban renewal projects, the types of declining areas in cities should be accurately identified, and different urban renewal projects that suit various types of areas should be implemented. Accordingly, this study explored both the quantitative and qualitative evaluation criteria of the physical, economic, and social aspects of the residential environment to enable its sustainable development.

In this study, we proposed the REMI as a framework to support the decision-making processes of maintenance district designation to implement urban renewal projects in low-rise residential areas in Seoul. The study examined the validity and relative weight of the evaluation index by conducting an expert survey and the AHP. In addition, the REMI specified the qualitative indicators to be assessed by the City Planning Council as part of its deliberation, which is the final stage of decision-making for maintenance district designation.

By combining experts' opinions on the evaluation index, a total of 22 final evaluation indicators, including 7 quantitative and 15 qualitative indicators, were selected after evaluating their importance and practical applicability. The REMI is a comprehensive management tool that reflects both physical and social factors. Moreover, it has the advantage that it can be flexibly applied in accordance with the

housing policy that helps the project proceed in conformance with the residents' intention and controls housing supply and demand.

The results of this study have the following implications: First, previous studies recognized the importance of the indicators for the designation of urban renewal sites through expert or community surveys, but they seldom presented the indicators with specific criteria, so it was hard to apply those indicators to actual cases [21]. In contrast, the REMI is designed to assess sustainability performance based on certain criteria and can be used to select a reasonable site for maintenance area designation for an urban renewal project. The results contribute to increasing the probability of success of urban renewal projects and provide directions for the effective management of housing redevelopment and reconstruction projects. Second, the study suggests that the intentions of residents and local characteristics of target sites should be considered as indicators while selecting maintenance areas to enable the smooth functioning of urban renewal projects. The findings of this study support the idea that community-driven projects based on increasing residents' willingness to join the projects and sustaining existing social and cultural structures can be successful strategies for improving a sense of community, as well as the social sustainability of urban renewal projects [41,59]. Further, although existing legal requirements consider basic physical conditions, willingness of residents, and disaster risks, the study suggests that these legal requirements are ineffective, since they do not consider the efficiency of project promotion and the social and economic characteristics of a target site [21]. Third, it is necessary to consider the relative weights of indicators when selecting priority project areas. Although some indicators should be considered more important than others in the selection of priority project areas, the current standards do not reflect these priority levels. Therefore, we suggest the establishment of a system of criteria for the selection of priority projects that reflects the relative weights of indicators. The study found that the following indicators were more important than others: Residents' consent, building deterioration, housing density, and undersized parcel. These are the mandatory indicators that should be considered when selecting priority projects. The weight of the indicators is not only a criterion for the selection of maintenance district by the projects, but also a criterion reflecting expert opinion on the concept of residential renewal projects [60]. Fourth, this study contributes to an improvement of the academic understanding on residential environment maintenance projects. The results of the expert survey conducted by this study are meaningful since they represent the opinions of experts on the concept of the project, as well as the indicators' selection process. Finally, few studies analyzed the future situation of renewal projects in depth, although the future-based approach has the potential to provide valuable insight for policy decision-making from a holistic perspective [25]. This study has implications for clarifying the possibility of using the REMI as a preplanning strategy to promote sustainable urban renewal projects in the future.

The study has some limitations as well. One limitation in terms of spatial scope is that this study focused on the city of Seoul alone. Hence, future research should expand the scope of this study to include the entire country and compare the results when different data are obtained for each region. In addition, the criteria for judging the maintenance district designation that determines the areas where renewal projects will primarily be implemented may differ depending on the municipality. Further, this study highlights the importance of considering the relative weights of indicators, since all indicators are not equally important. However, in general, since the relative importance of indicators depicted in this study is dependent on the unique characteristics of a municipality, some indicators probably need not be applied in some municipalities.

Despite the limitations of the study, the REMI attempts to reflect the social, economic, and physical aspects of residential environments from the sustainable development perspective and classify the steps of the renewal district designation procedure. Further, simulations predicting the number of maintenance area designations, which reflects the intentions of residents and local characteristics of target sites, and are hence an important factor affecting housing supply, can act as a useful reference for policymakers in the formulation of housing policy.

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