

## Integration of AHP and MOORA for Determining Beneficiaries of Uninhabitable Housing Assistance

Beki Subaeki<sup>1</sup>, Yanyan Gunawan<sup>2</sup>, Khairul Manaf<sup>3</sup>, Erna Sianturi<sup>4</sup>, Olif Prasetyo<sup>5</sup>

<sup>1,2,3,4,5</sup>Department of Information System, Faculty of Engineering, Universitas Sangga Buana, Bandung, Indonesia

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### ABSTRACT

Housing is a basic need that plays an essential role in human life. According to Law No. 1 of 2011, adequate housing must meet safety, health, and comfort standards. However, many people still live in uninhabitable houses due to economic limitations. The government, through the Social Rehabilitation of Uninhabitable Houses program, provides financial assistance to help low-income communities improve their homes. Nevertheless, the selection process for beneficiaries often suffers from inaccuracies in targeting because it is still conducted manually and subjectively.

To address this issue, a decision support system (DSS) is developed to assist in selecting beneficiaries more objectively. This study implements a DSS that combines the Analytical Hierarchy Process (AHP) and Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) methods. The results of system testing show that all stages, from entering criteria and assigning weights to ranking alternatives, operate in accordance with the applied methods, and the system can display the final ranking of beneficiaries accurately and efficiently.

A comparison between manual calculations and the system's output demonstrates that the system produces identical results for the criteria weighting and alternative ranking processes. Testing was conducted using 10 criteria and 110 alternatives, with selected alternatives presented in the calculation section as representative examples to illustrate the method's stages. The AHP Consistency Ratio of 0.0278 indicates that the pairwise comparison matrix is consistent and acceptable. Furthermore, the system identified 64 eligible aid recipients based on the final MOORA ranking results and the applied eligibility rules. These results demonstrate that integrating the AHP and MOORA methods can enhance the objectivity, accuracy, and effectiveness of the aid recipient selection process.

### Corresponding Author:

Beki Subaeki

Department of Information System, Faculty of Engineering, Sangga Buana University, Bandung

Jl. Phh. Mustofa No.68, Cikutra, Kec. Cibeunying Kidul, Kota Bandung, Jawa Barat 40124

Email: [beki.subaeki@usbypkp.ac.id](mailto:beki.subaeki@usbypkp.ac.id)

## 1. INTRODUCTION

Housing is a fundamental need for every individual and family, functioning not only as a place of shelter but also as a determinant of overall well-being, as stated in Law No. 1 of 2011 on Housing and Settlement Areas [1]. However, not all communities have access to adequate housing [2]. Data from the Ministry of Public Works

and Housing (PUPR) in 2020 indicate that approximately 2.5 million families in Indonesia still live in Uninhabitable Houses [3]. National e-RTLH data further show that the number of uninhabitable houses reaches approximately 3,829,973 units distributed across various provinces in Indonesia. Provinces with particularly high numbers of RTLH include Central Java with around 613,632 units, East Java with 194,613 units, and West Java with approximately 144,258 units. In Bali, about 53,996 RTLH units are recorded, while other regions such as Sumatra, Sulawesi, and Kalimantan also show substantial figures, each with hundreds of thousands of RTLH units. This situation reflects the limited coverage of existing housing rehabilitation assistance programs [4].

To address this condition, the government launched the Social Rehabilitation Program for Uninhabitable Houses, which provides stimulus assistance to low-income communities [4]. However, the selection process for beneficiaries is still carried out manually, making it vulnerable to subjectivity and inaccurate targeting. Therefore, a more structured and data-driven selection mechanism is required [5].

The proposed solution is the development of a computer-based Decision Support System (DSS) capable of supporting the determination of eligible beneficiaries through systematic data analysis [6][7]. This study employs two main methods within the DSS, namely the Analytical Hierarchy Process (AHP) and Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA).

The AHP method, developed by Saaty in the 1970s, is used to determine hierarchical criteria weights through pairwise comparisons and consistency testing [8]. AHP is suitable for the context of beneficiary selection because it accommodates multiple criteria with different levels of importance [9]. Meanwhile, the MOORA method, as described in [10], is used to perform efficient and objective multi-criteria calculations by optimizing ratio-based comparisons among criteria. The combination of these two methods enhances the accuracy and transparency of decision-making [10].

Based on the research hypothesis, applying the AHP–MOORA approach can increase the accuracy of RTLH beneficiary selection up to 90%, compared with manual methods, which achieve only around 70%. This improvement is attributed to the capability of AHP to generate consistent and precise criteria weights and the ability of MOORA to optimize multi-criteria decisions.

This study aims to develop an AHP–MOORA-based DSS to improve the accuracy and objectivity of RTLH beneficiary selection and to evaluate the effectiveness of the proposed methods. The research approach includes literature review, system requirements analysis, system development, and system testing.

Previous studies show that methods such as SMART [11], MAUT [12], WP [13], SAW [14], and TOPSIS [15] have been applied in determining RTLH beneficiaries. However, these studies still exhibit several limitations, including small testing datasets, limited incorporation of physical housing conditions, and the absence of comparisons with manual calculation results. Therefore, the integration of AHP and MOORA in the context of RTLH beneficiary determination represents the novelty of this research.

Theoretically, this study is grounded in the concept of Decision Support Systems [16][17][7], which are defined as interactive systems designed to assist decision-makers in solving semi-structured problems. Furthermore, the concept of uninhabitable housing refers to Ministry of Public Works and Housing Regulation No. 07/PRT/M/2018, which states that uninhabitable houses are those that do not meet requirements of safety, health, and adequate living space.

In this study, ten criteria are used to assess the eligibility of RTLH beneficiaries, namely: type of floor, wall condition, roof condition, level of housing damage, availability of sanitation facilities (MCK), lighting, ventilation, room area per family member, DTKS status, and income level [18].

Through the application of an AHP–MOORA-based DSS, the process of selecting RTLH beneficiaries becomes more objective, efficient, transparent, and accountable. The implementation of this system is expected to help the government distribute housing assistance more accurately and optimally to communities that truly need it.

## 2. METHOD

The research method used in this study is a software development method with a prototyping approach (Figure 1), as it can provide an initial representation of the system to be developed and allows users to conduct evaluations from the early stages [19][20]. This approach produces a system that is more aligned with user needs because the development process is carried out iteratively until an optimal result is achieved. In general, the prototyping model consists of five interrelated stages, namely:

1. Communication, which is an intensive communication process between developers and users to elicit detailed system requirements.
2. Quick Plan, which is a simple planning stage that serves as the initial framework of the system.
3. Modeling Quick Design, which involves creating a rapid design that represents the basic structure of the system.
4. Construction of Prototype, which is the development of the initial software model.
5. Evaluation, which refers to the testing and assessment of the developed prototype.

In this study, all stages of the prototyping model were applied, ranging from communication, quick planning, and quick design modeling to prototype construction and evaluation. The communication stage was conducted to identify user requirements and key issues in the aid recipient selection process. The quick planning stage was used to define the system scope, data requirements, assessment criteria, and user roles. The quick design modeling stage produced the initial system design, including input forms, calculation workflows, and output in the form of ranking results. The prototype construction stage involved implementing AHP and MOORA calculation processes into the decision support system. Finally, the evaluation stage was carried out by comparing manual calculation results with system outputs and conducting functional testing to ensure that every feature operated according to its intended function.

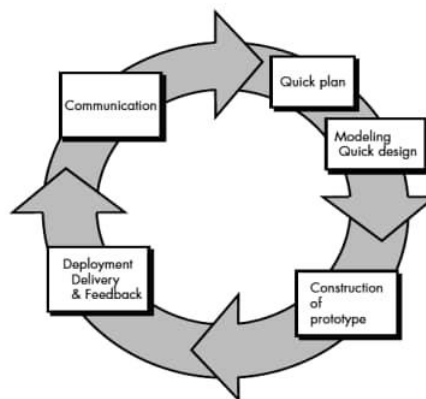


Figure 1. Prototype Method Stages[21]

### 3. RESULT AND DISCUSSION

This section presents the results of the system implementation and evaluates its performance in processing criteria weights and ranking alternatives. The findings are further analyzed to explain their implications for improving the accuracy and objectivity of beneficiary selection.

#### 3.1. AHP Method

The criteria used in this study include several indicators related to housing conditions, such as the level of structural damage, type of wall, availability of sanitation facilities, type of roof, type of floor, lighting, ventilation, and adequacy of room space per family member, as well as economic criteria such as income level and inclusion in the Social Welfare Integrated Data (DTKS).

##### (1). House Damage

The house damage criterion, as presented in Table 1, is assessed based on the severity of structural damage experienced by the prospective beneficiaries.

Table 1. House Damage Criteria[22]

No	House Damage	Value
1	Severe Damage	4
2	Moderate Damage	3
3	Minor Damage	2
4	No Damage	1

##### (2). Type of Wall

The wall type criterion, as presented in Table 2, is assessed based on the material and quality of the walls used in the prospective beneficiaries' houses.

Table 2. Wall Type Criteria

No	Wall Type	Value
1	Plywood	5
2	Bamboo Weave	4
3	Glassfibre Reinforced Concrete (GRC)	3
4	Wood	2
5	Red Brick	1

(3). Availability of Sanitation Facilities

The sanitation facility (MCK) criterion, as shown in Table 3, is assessed based on the presence or absence of bathing, washing, and toilet facilities in the prospective beneficiary's house.

Table 3. Availability of Sanitation

No	Availability of Sanitation	Value
1	Not Available	2
2	Available	1

(4). Type of Roof

The roof type criterion, as presented in Table 4, is assessed based on the strength and type of roofing material used in the prospective beneficiary's house.

Table 4. Roof Type Criteria

No	Roof Type	Value
1	Zinc Sheet	3
2	Asbestos	2
3	Roof Tile	1

(5). Type of Floor

The floor type criterion, as presented in Table 5, is assessed based on the strength and type of flooring material used in the prospective beneficiary's house.

Table 5. Floor Type Criteria

No	Floor Type	Value
1	Earthen Floor	4
2	Wood	3
3	Plur	2
4	Ceramic	1

(6). Lighting (Minimum 10% of Building Area)

The lighting criterion, as presented in Table 6, is assessed based on the adequacy of natural lighting in the prospective beneficiary's house.

Table 6. Lighting Criteria

No	Lighting (minimum 10% of building area)	Value
1	Not Adequate	2
2	Adequate	1

## (7). Ventilation (Minimum 5% of Building Area)

The ventilation criterion, as presented in Table 7, is assessed based on whether air circulation in the prospective beneficiary's house is adequate.

Table 7. Ventilation Criteria

No	Ventilation (minimum 5% of building area)	Value
1	Not Adequate	2
2	Adequate	1

(8). Space Adequacy (Minimum 9 m<sup>2</sup> per Person)

The space adequacy criterion, as presented in Table 8, is assessed based on whether the available living space per family member in the prospective beneficiary's house is sufficient.

Table 8. Space Adequacy Criteria

No	Space Adequacy (minimum 9 m <sup>2</sup> per person)	Value
1	Not Sufficient	2
2	Sufficient	1

## (9). Monthly Income

The income criterion, as presented in Table 9, is assessed based on the total monthly income of the prospective beneficiary.

Table 9. Monthly Income Criteria

No	Monthly Income	Value
1	Rp.1.000.001 – Rp.1.500.000	3
2	Rp.500.001 – Rp.1.000.000	2
3	Rp.0 – Rp.500.000	1

## (10). Inclusion in the Social Welfare Integrated Data (DTKS)

The Social Welfare Integrated Data (DTKS) status criterion, as presented in Table 10, is assessed based on whether the prospective beneficiary is registered in the DTKS database.

Table 10. Criteria for Entry into the Integrated Social Welfare Data (DTKS)

No	Inclusion in DTKS	Value
1	Yes	3
2	No	2

**3.2. AHP Weighting**

In the next stage, weighting is carried out using the Analytical Hierarchy Process (AHP) method.

## (1). Pairwise Comparison Matrix

At this stage, as presented in Table 11, a pairwise comparison matrix is constructed between each criterion and the others to determine the relative importance of each criterion.

Table 11. Pairwise Comparison Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	3	5	5	5	7	7	7	9	9
C2	0.3333	1	3	3	3	5	5	5	7	7
C3	0,2	0.3333	1	1	1	3	3	3	5	5

C4	0,2	0.3333	1	1	1	3	3	3	5	5
C5	0,2	0.3333	1	1	1	3	3	3	5	5
C6	0.1429	0.2	0.3333	0.3333	0.3333	1	1	1	3	3
C7	0.1429	0.2	0.3333	0.3333	0.3333	1	1	1	3	3
C8	0.1429	0.2	0.3333	0.3333	0.3333	1	1	1	3	3
C9	0.1111	0.1429	0.2	0.2	0.2	0.3333	0.3333	0.3333	1	1
C10	0.1111	0.1429	0.2	0.2	0.2	0.3333	0.3333	0.3333	1	1
SUM	2.5842	5.8857	12.3999	12.3999	12.3999	24.6666	24.6666	24.6666	42	42

The comparison value at row C5, column C10 was adjusted from 3 to 5 to ensure consistency with the comparison pattern for criteria C3 and C4. This adjustment also aligns with the reciprocal value of 0.2 at row C10, column C5, as well as the final weight results, where criteria C3, C4, and C5 all received an identical weight of 0.0979. Consequently, the AHP weight calculation results remain consistent and suitable for use in the MOORA calculation stage.

(2). Matrix Normalization

Each column is first summed, and then each element  $a_{ij}$  is divided by the total value of its column ( $s_j$ ) in order to normalize the matrix. This procedure produces values that represent the relative comparison of the elements within each column. Subsequently, as shown in Table 12, the average value of each row represents the priority weight ( $W$ ) for each criterion. These weights reflect the relative importance of each criterion and are used in the subsequent calculation stages. However, before being applied, the weights must be tested for consistency to ensure that the judgments made are logical and mutually consistent.

Table 12. Matrix Normalization

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	AVE (W)
C1	0.387	0.5097	0.4032	0.4032	0.4032	0.2838	0.2838	0.2838	0.2143	0.2143	0.3386
C2	0.129	0.17	0.2419	0.2419	0.2419	0.2027	0.2027	0.2027	0.1667	0.1667	0.1966
C3	0.0774	0.0566	0.0806	0.0806	0.0806	0.1216	0.1216	0.1216	0.119	0.119	0.0979
C4	0.0774	0.0566	0.0806	0.0806	0.0806	0.1216	0.1216	0.1216	0.119	0.119	0.0979
C5	0.0774	0.0566	0.0806	0.0806	0.0806	0.1216	0.1216	0.1216	0.119	0.119	0.0979
C6	0.0553	0.034	0.0269	0.0269	0.0269	0.0405	0.0405	0.0405	0.0714	0.0714	0.0434
C7	0.0553	0.034	0.0269	0.0269	0.0269	0.0405	0.0405	0.0405	0.0714	0.0714	0.0434
C8	0.0553	0.034	0.0269	0.0269	0.0269	0.0405	0.0405	0.0405	0.0714	0.0714	0.0434
C9	0.043	0.0243	0.0161	0.0161	0.0161	0.0135	0.0135	0.0135	0.0238	0.0238	0.0204
C10	0.043	0.0243	0.0161	0.0161	0.0161	0.0135	0.0135	0.0135	0.0238	0.0238	0.0204
SUM	1.0001	1.0001	0.9999	0.9999	0.9999	0.9998	0.9998	0.9998	1	1	1

(3). Weighted Sum Vector (WSV)

To calculate the Weighted Sum Vector (WSV), an equation is applied in which each column of matrix  $A$  is multiplied by the weight vector  $W$ . This calculation process produces the WSV values, which represent the weighted combination of all criteria based on the previously determined weights.

$$WSV = AW \dots \dots \dots (1)$$

$$(WSV)_1 = (1 \times 0.3383) + (3 \times 0.1966) + (5 \times 0.0979) + (5 \times 0.0979) + (5 \times 0.0979) + (7 \times 0.0434) + (7 \times 0.0434) + (7 \times 0.0434) + (9 \times 0.0204) + (9 \times 0.0204)$$

$$\begin{aligned}
&= 0.3383 + 0.5883 + 0.4875 + 0.4875 + 0.4875 + 0.3031 + 0.3031 + 0.3031 + 0.2232 + 0.1683 \\
&= 3.6899 \\
(\text{WSV})_2 &= (0.3333 \times 0.3383) + (1 \times 0.1966) + (3 \times 0.0979) + (3 \times 0.0979) + (3 \times 0.0979) + (5 \times 0.0434) + (5 \times 0.0434) + (5 \times 0.0434) + (7 \times 0.0204) + (7 \times 0.0204) \\
&= 0.1129 + 0.1966 + 0.2937 + 0.2937 + 0.2937 + 0.2170 + 0.2170 + 0.2170 + 0.1428 + 0.1428 \\
&= 2.1272 \\
(\text{WSV})_3 &= (0.2 \times 0.3383) + (0.3333 \times 0.1966) + (1 \times 0.0979) + (1 \times 0.0979) + (1 \times 0.0979) + (3 \times 0.0434) + (3 \times 0.0434) + (3 \times 0.0434) + (5 \times 0.0204) + (5 \times 0.0204) \\
&= 0.0677 + 0.0655 + 0.0979 + 0.0979 + 0.0979 + 0.1302 + 0.1302 + 0.1302 + 0.1020 + 0.1020 \\
&= 1.0215 \\
(\text{WSV})_4 &= (0.2 \times 0.3383) + 0.3333 \times 0.1966 + (1 \times 0.0979) + (1 \times 0.0979) + (1 \times 0.0979) + (3 \times 0.0434) + (3 \times 0.0434) + (3 \times 0.0434) + (5 \times 0.0204) + (5 \times 0.0204) \\
&= 0.0677 + 0.0655 + 0.0979 + 0.0979 + 0.0979 + 0.1302 + 0.1302 + 0.1302 + 0.1020 + 0.1020 \\
&= 1.0215 \\
(\text{WSV})_5 &= (0.2 \times 0.3383) + (0.3333 \times 0.1966) + (1 \times 0.0979) + (1 \times 0.0979) + (1 \times 0.0979) + (3 \times 0.0434) + (3 \times 0.0434) + (3 \times 0.0434) + (5 \times 0.0204) + (5 \times 0.0204) \\
&= 0.0677 + 0.0655 + 0.0979 + 0.0979 + 0.0979 + 0.1302 + 0.1302 + 0.1302 + 0.1020 + 0.1020 \\
&= 1.0215 \\
(\text{WSV})_6 &= (0.1429 \times 0.3383) + (0.2 \times 0.1966) + (0.3333 \times 0.0979) + (0.3333 \times 0.0979) + (0.3333 \times 0.0979) + (1 \times 0.0434) + (1 \times 0.0434) + (1 \times 0.0434) + (3 \times 0.0204) + (3 \times 0.0204) \\
&= 0.0484 + 0.0393 + 0.0326 + 0.0326 + 0.0326 + 0.0434 + 0.0434 + 0.0434 + 0.0612 + 0.0612 \\
&= 0.4381 \\
(\text{WSV})_7 &= (0.1429 \times 0.3383) + (0.2 \times 0.1966) + (0.3333 \times 0.0979) + (0.3333 \times 0.0979) + (0.3333 \times 0.0979) + (1 \times 0.0434) + (1 \times 0.0434) + (1 \times 0.0434) + (3 \times 0.0204) + (3 \times 0.0204) \\
&= 0.0484 + 0.0393 + 0.0326 + 0.0326 + 0.0326 + 0.0434 + 0.0434 + 0.0434 + 0.0612 + 0.0612 \\
&= 0.4381 \\
(\text{WSV})_8 &= (0.1429 \times 0.3383) + (0.2 \times 0.1966) + (0.3333 \times 0.0979) + (0.3333 \times 0.0979) + (0.3333 \times 0.0979) + (1 \times 0.0434) + (1 \times 0.0434) + (1 \times 0.0434) + (3 \times 0.0204) + (3 \times 0.0204) \\
&= 0.0484 + 0.0393 + 0.0326 + 0.0326 + 0.0326 + 0.0434 + 0.0434 + 0.0434 + 0.0612 + 0.0612 \\
&= 0.4381 \\
(\text{WSV})_9 &= (0.1111 \times 0.3383) + (0.1429 \times 0.1966) + (0.2 \times 0.0979) + (0.2 \times 0.0979) + (0.2 \times 0.0979) + (0.3333 \times 0.0434) + (0.3333 \times 0.0434) + (0.3333 \times 0.0434) + (1 \times 0.0204) + (1 \times 0.0204) \\
&= 0.0376 + 0.0281 + 0.0196 + 0.0196 + 0.0196 + 0.0145 + 0.0145 + 0.0145 + 0.0204 + 0.0204 \\
&= 0.2088 \\
(\text{WSV})_{10} &= (0.1111 \times 0.3383) + (0.1429 \times 0.1966) + (0.2 \times 0.0979) + (0.2 \times 0.0979) + (0.2 \times 0.0979) + (0.3333 \times 0.0434) + (0.3333 \times 0.0434) + (0.3333 \times 0.0434) + (1 \times 0.0204) + (1 \times 0.0204) \\
&= 0.0376 + 0.0281 + 0.0196 + 0.0196 + 0.0196 + 0.0145 + 0.0145 + 0.0145 + 0.0204 + 0.0204 \\
&= 0.2088
\end{aligned}$$

#### (4). Maximum Eigenvalue ( $\Lambda$ Max)

To calculate the maximum eigenvalue, the Weighted Sum Vector (WSV) is divided by the weight vector  $W$ . The resulting values are then summed, and the total is divided again by 10.

$$\begin{aligned}
(\text{WSV})_1/W_1 &= 3.6755 / 0.3386 \\
&= 10.8550 \\
(\text{WSV})_2/W_2 &= 2.1272 / 0.1966 \\
&= 10.8199 \\
(\text{WSV})_3/W_3 &= 1.0215 / 0.0979 \\
&= 10.4341 \\
(\text{WSV})_4/W_4 &= 1.0215 / 0.0979 \\
&= 10.4341 \\
(\text{WSV})_5 / W_5 &= 1.0215 / 0.0979 \\
&= 10.4341
\end{aligned}$$

$$\begin{aligned}
 (WSV)_6/W_6 &= 0.4381 / 0.0434 \\
 &= 10.0945 \\
 (WSV)_7/W_7 &= 0.4381 / 0.0434 \\
 &= 10.0945 \\
 (WSV)_8/W_8 &= 0.4381 / 0.0434 \\
 &= 10.0945 \\
 (WSV)_9/W_9 &= 0.2088 / 0.0204 \\
 &= 10.2353 \\
 (WSV)_{10}/W_{10} &= 0.2088 / 0.0204 \\
 &= 10.2353 \\
 \lambda_{max} &= (10.8550 + 10.8199 + 10.4341 + 10.4341 + 10.4341 + 10.0945 + 10.0945 + 10.0945 \\
 &\quad + 10.2353 + 10.2353) / 10 \\
 \lambda_{max} &= 103.7313 / 10 \\
 \lambda_{max} &= 10.3731
 \end{aligned}$$

(5). Consistency Index (CI)

To calculate the Consistency Index (CI), the following formula is used:

$$CI = \frac{\lambda_{max} - n}{n - 1} \dots\dots\dots (2)$$

where  $n$  the order of the pairwise comparison matrix (i.e., the number of criteria).

$$\begin{aligned}
 CI &= (\lambda_{max} - n) / (n - 1) \\
 &= (10.3731 - 10) / (10 - 1) \\
 &= 0.3731 / 9 \\
 &= 0.0415
 \end{aligned}$$

(6). Consistency Ratio (CR)

To calculate the Consistency Ratio (CR), the following formula is applied:

$$CR = \frac{CI}{IR} \dots\dots\dots (3)$$

where IR is the Random Consistency Index, determined by the size of the matrix (number of criteria). For  $n = 10$ , the IR value is 1.49.

$$\begin{aligned}
 CR &= CI / IR \\
 &= 0.0415 / 1.49 \\
 &= 0.0278
 \end{aligned}$$

Since the obtained value  $CR = 0.0278 \leq 0.1$ , the pairwise comparison matrix is considered consistent, and the resulting weights are valid for further calculations. Conversely, if  $CR > 0.1$ , the matrix must be revised to achieve consistency.

Table 13. Criteria Weight

Criteria	Type	Weight
House Damage	Benefit	0.3386
Type of Wall (C2)	Benefit	0.1966
Availability of Sanitation Facilities (C3)	Benefit	0.0979
Type of Roof (C4)	Benefit	0.0979
Type of Floor (C5)	Benefit	0.0979
Lighting (Minimum 10% of Building Area) (C6)	Benefit	0.0434
Ventilation (Minimum 5% of Building Area) (C7)	Benefit	0.0434

Criteria	Type	Weight
Space Adequacy (Minimum 9 m <sup>2</sup> per Person)(C8)	Benefit	0.0434
Monthly Income (C9)	Cost	0.0204
Inclusion in the Social Welfare Integrated Data (DTKS) (C10)	Benefit	0.0204

As shown in Table 13, the results of the Analytical Hierarchy Process (AHP) weighting indicate that the house damage criterion has the highest weight, at 0.3386, while the inclusion in DTKS criterion has the lowest weight, at 0.0204.

### 3.3. MOORA Weighting

At this stage, the ranking process is carried out using the Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) method, with the following steps:

(1). Decision Matrix

The MOORA calculations in this section present five alternatives as representative examples to clearly illustrate the calculation steps. However, the overall system testing was conducted using a complete dataset comprising 110 alternatives. Thus, the alternatives shown in the following table serve only to demonstrate the calculation process, while the final evaluation and accuracy testing were performed on the entire set of alternatives.

Table 14. Decision Matrix

Alternative	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	2	4	2	1	4	2	1	1	2	2
A2	2	3	2	1	3	2	2	1	2	2
A3	3	4	2	1	3	2	2	2	2	2
A4	2	4	2	1	3	2	2	1	2	2
A5	2	4	2	1	3	2	2	1	2	2

In Table 14, the values shown are taken from five existing alternatives as examples for the calculation, and the values are based on the criteria that have been explained.

(2). Decision Matrix Normalization

To normalize the decision matrix, the calculation uses the formula described in the theoretical framework:

$$X_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^m x_{ij}^2}}$$

After the square-root value for each criterion is obtained, each alternative value is divided by the corresponding square-root result based on its criterion number.

Table 15. Normalization Matrix

Alternative	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0.4	0.4681	0.4472	0.4472	0.5547	0.4472	0.2425	0.3536	0.4472	0.4472
A2	0.4	0.3511	0.4472	0.4472	0.416	0.4472	0.4851	0.3536	0.4472	0.4472
A3	0.6	0.4681	0.4472	0.4472	0.416	0.4472	0.4851	0.7071	0.4472	0.4472
A4	0.4	0.4681	0.4472	0.4472	0.416	0.4472	0.4851	0.3536	0.4472	0.4472
A5	0.4	0.4681	0.4472	0.4472	0.416	0.4472	0.4851	0.3536	0.4472	0.4472

Table 15 shows that the calculation results are stored in the normalized matrix. Because weighting has been carried out using the Analytical Hierarchy Process (AHP) method, the next step is to multiply the normalized matrix by the obtained weight vector (W).

Table 16. Weighted Normalized Matrix

Alternative	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0.1354	0.092	0.0438	0.0438	0.0543	0.0194	0.0105	0.0153	0.0091	0.0091
A2	0.1354	0.069	0.0438	0.0438	0.0407	0.0194	0.021	0.0153	0.0091	0.0091
A3	0.2032	0.092	0.0438	0.0438	0.0407	0.0194	0.021	0.0307	0.0091	0.0091
A4	0.1354	0.092	0.0438	0.0438	0.0407	0.0194	0.021	0.0153	0.0091	0.0091
A5	0.1354	0.092	0.0438	0.0438	0.0407	0.0194	0.021	0.0153	0.0091	0.0091

Table 16 presents the values for each alternative according to its criteria. Next, the total score for each alternative is calculated.

### (3). Calculating the Optimization Value ( $Y_i$ )

At this stage, the weighted scores of the alternatives are calculated by summing the benefit criteria and subtracting the cost criteria.

**Benefit criteria:** C1, C2, C3, C4, C5, C6, C7, C8, C10

**Cost criteria:** C9

$$Y_1 = (0.1354 + 0.0920 + 0.0438 + 0.0438 + 0.0543 + 0.0194 + 0.0105 + 0.0153 + 0.0091) - 0.0091 = 0.4236 - 0.0091 = 0.4145$$

$$Y_2 = (0.1354 + 0.0690 + 0.0438 + 0.0438 + 0.0407 + 0.0194 + 0.0210 + 0.0153 + 0.0091) - 0.0091 = 0.3975 - 0.0091 = 0.3884$$

$$Y_3 = (0.2032 + 0.0920 + 0.0438 + 0.0438 + 0.0407 + 0.0194 + 0.0210 + 0.0307 + 0.0091) - 0.0091 = 0.5037 - 0.0091 = 0.4946$$

$$Y_4 = (0.1354 + 0.0920 + 0.0438 + 0.0438 + 0.0407 + 0.0194 + 0.0210 + 0.0153 + 0.0091) - 0.0091 = 0.4205 - 0.0091 = 0.4114$$

$$Y_5 = (0.1354 + 0.0920 + 0.0438 + 0.0438 + 0.0407 + 0.0194 + 0.0210 + 0.0153 + 0.0091) - 0.0091 = 0.4205 - 0.0091 = 0.4114$$

### (4). Ranking

At this stage, the alternatives are ranked from the highest score to the lowest.

Table 17 Ranking Results of Alternatives Based on  $Y_i$  Scores

Alternative	Score ( $Y_i$ )	Rank
A3	0.4946	1
A1	0.4145	2
A4	0.4114	3
A5	0.4114	3
A2	0.3884	5

Table 17 shows that the alternative with the highest value is Alternative 3 with a score of 0.4946, while the lowest is Alternative 2 with a score of 0.3884. Alternatives 4 and 5 have the same rank because they have identical data. If the available assistance quota is only 3, then the final decision is delegated to the highest decision-maker or an expert in the relevant institution.

If two or more alternatives yield the same final MOORA score, additional prioritization rules are applied. Priority is first given to the alternative with a higher degree of housing damage, followed by lower monthly income, DTKS status, and field verification results. These rules ensure that alternatives with identical final scores can still be prioritized based on the most urgent social conditions and physical state of the house.

#### 4. CONCLUSION

Based on the implementation and testing results, it can be concluded that the Decision Support System (DSS) for determining recipients of Uninhabitable Housing Assistance (RTLH) has been successfully implemented by integrating the Analytical Hierarchy Process (AHP) and Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) methods.

##### **Key Findings**

- (1). The system is able to execute the full calculation workflow in accordance with the stages of both methods, starting from data input and ending with an accurately and efficiently generated ranked list of assistance recipients.
- (2). The testing results indicate 100% accuracy between manual calculations and the system's outputs for both the weighting and ranking processes, using 10 criteria and 110 alternatives.
- (3). A Consistency Ratio (CR) value of 0.0278 indicates that the weighting results are consistent.
- (4). The system feasibility outcome reached 100%, with 64 out of 64 prospective assistance recipients classified as eligible.

##### **Overall Implication**

The research findings confirm the hypothesis that integrating the AHP and MOORA methods enhances the accuracy, objectivity, and transparency of the selection process for RTLH aid recipients compared to the previous manual approach. The AHP method yields consistent criteria weights—evidenced by a Consistency Ratio of 0.0278—while the MOORA method facilitates the ranking of alternatives based on benefit and cost criteria. Consequently, the developed decision support system assists decision-makers in identifying potential aid recipients more systematically and efficiently. Future research could further develop the system by integrating field verification data, government databases, and Geographic Information System (GIS) features, as well as by conducting broader testing using datasets from diverse regions.

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