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Recognition and Ranking of Factors Influencing Flood Occurrence in Baghlan Markazi District Using AHP and SAW Methods

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ABSTRACT

Floods are among the most significant natural hazards globally, resulting in substantial annual economic damage and loss of life. They account for approximately 20% of global disaster-related fatalities and 33% of total economic losses. Afghanistan, as a developing country, has yet to implement a comprehensive flood management strategy, primarily due to broader structural and developmental challenges. Baghlan Province, a key industrial and agricultural region, is particularly vulnerable to flooding due to its topographical characteristics. In the spring of 2024, Baghlan Markazi District experienced significant human and financial losses due to severe flooding. This study examines the factors contributing to flooding in the Sheikh Jalal, Darwaza Kan, Laqiha, and Shahrak Mohajerin areas. Through field observations, four key factors and twenty specific criteria were identified. A questionnaire, developed within the framework of the Analytical Hierarchy Process (AHP), was used to collect data from residents, experts, and government officials. The Simple Additive Weighting (SAW) method was subsequently applied for ranking the criteria. The findings revealed that environmental factors had the highest weight (0.261), while economic factors had the lowest (0.224).

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INTRODUCTION

Flooding is one of the most frequent and devastating natural hazards encountered globally, causing greater damage and destruction than any other hydro-climatic event(Kundzewicz et al., 2014) . Floods result in the loss of thousands of lives and cause billions of dollars in property damage. Compared to other natural disasters, flood risks account for approximately 20% of global fatalities and 33% of economic losses(Ranger et al., 2011) .On the other hand, a natural phenomenon becomes a hazard when human societies are vulnerable to its impacts(Karamouz & Nazif, 2013). Recent studies suggest that climate change is expected to intensify the variability of the hydrological cycle, thereby increasing the frequency of extreme weather events, including droughts and floods(Wang & Liu, 2023).

Furthermore, the expansion of urban structures, along with an increase in impermeable surfaces, changes in natural land use, and alterations in water flow paths, has contributed to the recent rise in flooding events(Blessing et al., 2017). Meanwhile, changes in natural environments, the proliferation of various structures, and the absence of adequate regulations to safeguard these environments are creating conditions conducive to flooding, thereby increasing the vulnerability of communities to such events(Wheater & Evans, 2009) . Flood vulnerability is a complex and dynamic phenomenon. In this context, the vulnerability coefficient of regions varies according to various parameters, highlighting that multiple factors influence vulnerability, differ across regions, and are a function of both spatial and temporal conditions. Currently, more than 25 distinct definitions and methods exist within the field of vulnerability(Birkmann, 2006) . Among these, one of the most widely recognized definitions was proposed by the United Nations within the framework of the International Strategy for Disaster Reduction. According to this definition, vulnerability is a condition determined by physical, social, economic, and environmental factors or processes, reflecting the level of preparedness of societies to withstand the impacts and consequences of disasters(Asl, 2024).

The collection and disposal of debris from rainfall in the river are essentially considered measures of safety, health, and welfare (Ibrahim et al., 2024). Studies and management experiences from various countries demonstrate that the initial step in mitigating the detrimental effects of floods is identifying flood-prone and vulnerable areas. These areas should be zoned according to flood risk, allowing for the prevention of flood-related harm through integrated management and comprehensive planning based on the results obtained(Siam et al., 2022). Due to the complexity of watersheds, addressing all components of watershed vulnerability is a challenging task. Therefore, decision-making at the watershed scale has become one of the most critical issues in contemporary management(Azhoni et al., 2018). In such cases, decision-makers are presented with various options under multiple criteria, influenced by both the internal and external environments of the system. Therefore, multi-criteria decision-making (MCDM) appears to be an appropriate and effective tool for informed decision-making. In this context, Ghahrudi et al. (2017) evaluated the vulnerability of water and wastewater facilities in the first region of the Tehran Water Authority using the FUZZY-AHP method for indicator weighting and the TOPSIS model for prioritization. The results of the studies indicated that the density indices of hazard centers (such as gas stations and power transmission lines), degraded urban texture, slope, relative population density, and the condition of facilities (in terms of installation diameter and depth) all contribute to increased vulnerability(Du et al., 2022). Fadil et al. (2020) investigated the flood vulnerability of the Maros Regency basin using the Spatial Multi-Criteria Evaluation (SMCE) method. To this end, they performed a spatial analysis within a GIS environment, considering six physical factors: rainfall intensity, slope, elevation, distance from rivers, land use, and soil type(Fadhil et al., 2020). The results of this study revealed that the areas within the Camba subdivisions are highly vulnerable. Of the total area, 436 hectares (84%) are classified as highly vulnerable, while 168.6 hectares (11.8%) are considered very highly vulnerable(Fadhil et al., 2020).

According to both domestic and international studies, although limited research has been conducted on the precise identification of economic, social, infrastructural, and geomorphological indicators related to flood vulnerability at the watershed scale within the country, extensive studies have been conducted on the vulnerability of urban ecosystems and human structures. These studies indicate that the most significant factors influencing flood vulnerability include the density of hazard centers, deteriorated urban fabric, slope, relative population density, condition of facilities, changes in land use, and increases in impervious surfaces, among others. Therefore, the present study aims to investigate and identify relevant environmental, economic, social, and infrastructural criteria that influence flood vulnerability in the Sheikh Jalal area of Baghlan Markazi, at the watershed scale. The areas of Sheikh Jalal, Darwaza-e-Kan, Qaryeh-e-Kandahariha, and Shahrak-e-Mohajirin are situated in the eastern part of the Baghlan Jadid, which is characterized by high mountains, flat hills, and an expansive floodplain. High mountains and flat hills with larger water catchment areas converge in a small valley, forming a strong channel for flood flows in their lower sections, extending from Mohajerin and Kandahari in Baghlan Jadid. This research was conducted to investigate the factors influencing flood occurrence in the areas of Sheikh Jalal, Darwaza Kan, Laqiha, Mohajerin Town, Kandahariha, and the eastern parts of Baghlan Jadid. During this study, four key factors were identified as influential, and twenty criteria were selected as effective indicators. Multi-criteria decision-making methods were employed for high-precision statistical calculations(Salehy et al., 2024). The AHP method is one of the multi-criteria decision-making techniques used to determine the weights of the criteria. In contrast, the SAW method is employed to rank the influential factors.

This study aims to identify the key factors contributing to flood occurrences in Baghlan Markazi District, intending to enhance awareness among residents and relevant disaster management authorities. To achieve this, the influencing factors were first identified and subsequently ranked based on their assigned weights.

MATERIALS AND METHODS

Study Area

This research focuses on a specific area that experienced significant financial and human losses due to flooding in the year 2024. The magnitude of these losses is detailed in Table 1. The study area encompasses the regions of Sheikh Jalal, Darwaza Kan, Mohajerin Township, Kandahari, Laqiha, and the eastern parts of the Baghlan Jadid. The Sheikh Jalal region is a predominantly mountainous area characterized by earthen hills with minimal vegetation. It consists of several watersheds that originate from the surrounding mountains and low earthen hills, which ultimately converge and flow into a narrow basin. This narrow valley, through which the Baghlan–Nahrin district roads also pass, is characterized by limited depth and width and cannot absorb large volumes of water. As a result, the road infrastructure has been severely damaged by flooding. For further clarification, the topography and cross-sections of the Sheikh Jalal area were extracted using Google Earth software and are presented in Figs 1, 2, and 3.

Fig 1. *Sheikh Jalal Topography*

Fig 2. *Cross-Section 1-1*

Fig 3. *Cross-Section 2-2*

The Darwaza Kan area is an extension of the Sheikh Jalal Valley, located in the lower part of the region. Similar to the Sheikh Jalal area, it consists of sub-valleys and a central valley that simultaneously discharges a large volume of floodwater. These floodwaters converge with the flows originating from Sheikh Jalal, collectively forming an extensive floodplain. For further clarification, the topography and cross-sections of the Darwaza Kan area are presented in Figs 4, 5, and 6.

Fig 4. *Darwaza Kan Topography*

Fig 5. *Cross-Section 1-1*

Fig 6. *Cross-Section 2-2*

The Laqiha and Mohajerin areas are located in the lower part of the Darwaza Kan Valley, forming the southern side of the Baghlan–Nahrin road. These areas are highly vulnerable to flooding due to their extensive catchment area, which consists of multiple valleys surrounded by mountains and flat hills. However, due to the construction of a government facility (military base), the vulnerability of residential houses in the area has been reduced. At the same time, the floodwater flow has been redirected and concentrated toward the northern side of the Baghlan–Nahrin road, particularly the Kandahari area. For further clarification, the topography and cross-sections of the Laqiha area and the Mohajerin settlement are presented in Figures 7, 8, and 9.

Fig 7. *Laqiha and Mohajerin Topography*

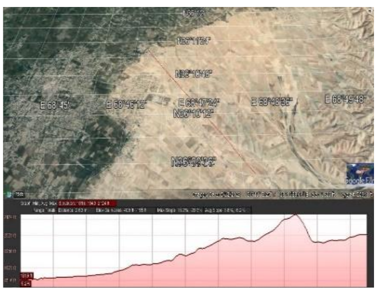

Fig 8. *Cross-Section 1-1*

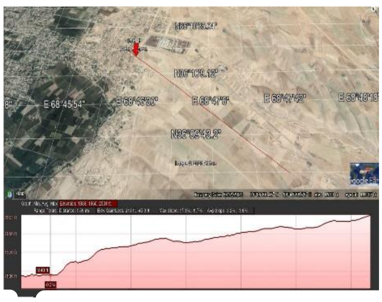

Fig 9. *Cross-Section 2-2*

It is worth noting that three flood events occurred within 10 months, from 1402 to 1403 AH, in the Baghlan Markazi District, causing significant damage, as summarized in Table 1 (Shrestha, Kawasaki, and Zin).

Table 1. *Damage caused by floods in the Sheikh Jalal area of Baghlan markazi from 11/10/1402 AH to 14/07/1403 AH. (Afghanistan: Assessment on Flood Damage, 2024)*

Zone	province	district	A series of flood events	Number of fatalities	Number of injured	Number of affected families	Affected people	Damaged houses	Destroyed houses
Northeast areas	Baghlan	Baghlan markazi	3	33	20	730	5110	484	244

In this study, following comprehensive literature reviews and field surveys, the factors influencing flood occurrence were identified, and corresponding criteria were subsequently defined based on these factors. Thereafter, the first questionnaire was designed using the Analytical Hierarchy Process (AHP) method to determine the weights of the criteria, as presented in Table 1 of Appendix 1. Interviews were conducted with 150 experts, specialists in the field, and residents to collect the necessary data. After obtaining the weights of the criteria, a second questionnaire was developed using the Simple Additive Weighting (SAW) method, and interviews were conducted with 100 experts, relevant officials, and residents. According to the procedures of the SAW method and based on the results obtained from the AHP analysis, the normalized weights of the factors influencing flood occurrence in the eastern areas of the Baghlan Jadid were calculated, and the factors were subsequently ranked. To further clarify the research process, it is essential to illustrate its overall structure. Accordingly, all research steps are presented in the form of a flowchart, as shown in Fig. 10.

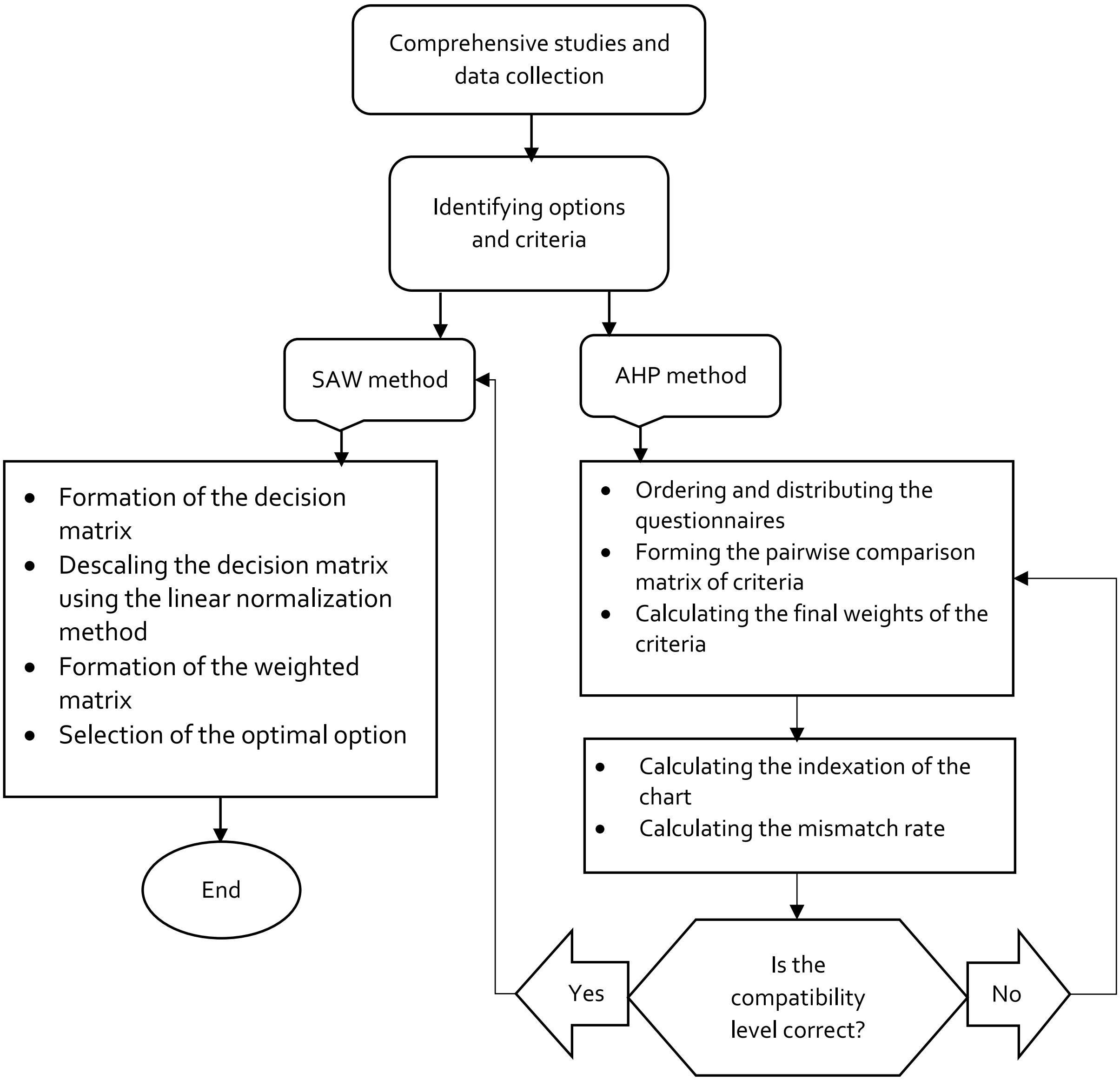

Fig 10. *Overall research flowchart*

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a structured decision-making technique introduced by Thomas L. Saaty in 1972, which has since been widely applied in various fields (Pinto-Pardo, 2024). This method is based on a matrix structure and employs components that provide an approximate estimation of the weights assigned to various criteria. Due to its structured approach, AHP has significant potential in addressing decision-making problems and has been widely applied in various fields, including business, industry, healthcare, and education. Moreover, this method facilitates the resolution of complex and subjective problems by transforming qualitative assessments into quantitative values(Kriswardhana et al., 2025).

The AHP method provides a systematic framework for decomposing complex problems into a logical and simplified hierarchical structure, enabling planners to evaluate available alternatives based on clearly defined criteria and sub-criteria(Aktas Potur et al., 2025) . In essence, the AHP method requires decision-makers to structure their problem in a hierarchical format, which allows for the independent evaluation of each branch (under the assumption that the criteria are uncorrelated). This hierarchical breakdown simplifies the problem's complexity and guides the decision-maker toward the optimal solution through a systematic, step-by-step process. In general, the Analytical Hierarchy Process involves the following steps (Tavana et al., 2023):

1. Designing the hierarchical structure
2. Performing pairwise comparisons of the decision criteria
3. Comparing each alternative against each criterion
4. Extracting priorities from the comparison matrix
5. Concluding and selecting the best alternative

Once the hierarchical structure has been established, pairwise comparison matrices are constructed based on the decision-maker's judgments. These comparisons are conducted independently at each hierarchical level to determine the relative importance of the elements. (Claus & Aldianto, 2024) . In general, if the number of alternatives is denoted by m and the number of criteria by n, the pairwise comparison matrices for the alternatives will be of size $m \times m$, while the pairwise comparison matrix for the criteria will be of size $n \times n$ (Ozgur, 2024).

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \qquad a_{ij} = (a_{ik}) \times (a_{kj}) \qquad 1$$

If in the pairwise comparison matrix, the above relationship does not hold for only one of i , j , k, the matrix will be inconsistent. In general, the pairwise comparison matrix must have the following properties(Ganguly & Robb, 2022):

- If we consider the pairwise comparison matrix $A = (a_{ij})_{n\times n}$ and if $\{\tau_1,\ \tau_2, \dots, \tau_n\}$ If the eigenvalues of matrix $A\ are\ \lambda$, then we have

$$\sum_{i=1}^{n} \tau_i = n \qquad 2$$

If $\tau_{max} = Max_i(\tau_i)$ Furthermore, n is the dimension of the pairwise comparison matrix, then we have:

$$\tau_{max} \geq n \qquad 3$$

If $\tau_{max} = n$, the matrix A is consistent. However, if $\tau_{max} > n$, Indicates matrix incompatibility.(Bozóki et al., 2015) . In inconsistent matrices, some eigenvalues can become negative, so it can be said that for the sum of eigenvalues to be equal to n, $\tau_{max} \geq n$ must be satisfied. Calculating the weights of criteria plays a very decisive role in solving decision-making problems (Shiraishi & Obata, 2021) . The process of calculating weights in the Analytic Hierarchy Process (AHP) is addressed in two distinct stages: the determination of relative weights and the computation of final weights(Vinogradova et al., 2018). Methods for calculating the relative weights of the decision matrix are generally categorized into two main groups: exact methods and approximate methods (Odu, 2019) . In this study, the weights of the criteria are calculated using approximate methods, including the row sum, column sum, arithmetic mean, and geometric mean approaches. Prior to this, the decision matrix must be normalized. The normalization of the matrix is performed using the following formulas.

Calculating the inconsistency rate is crucial for the initial validation of paired comparison data and their applicability in decision-making. If the inconsistency rate exceeds 0.1, the reliability of the paired comparison matrix is significantly compromised. The inconsistency index ($I.I$) and inconsistency rate ($I.R$) are calculated using the following formulas(Salomon & Gomes, 2024):

$$I.I = \frac{\tau_{max} - n}{n-1} \tag{4}$$

$$\tau_{max} = \frac{\sum_{i=1}^{n} \tau_{max}}{n} \tag{5}$$

$$\tau_{max.i} = \frac{A \times W}{W_i} \tag{6}$$

$$A_i = a_{ij} \times W_j \qquad i = 1, \qquad j = 1, \tag{7}$$

$$I.R = \frac{I.I}{R.I.I} \tag{8}$$

If $I.R \leq 0.1$, the system compatibility is acceptable (Salomon & Gomes, 2024) . To calculate the inconsistency rate, the inconsistency index of the random ($R.I.I$)[1] matrix is considered based on the dimensions of the matrix, as presented in Table 2:

***Table 2**: Values of the Random Inconsistency Index ($R.I.I$) Based on Matrix Dimension (Pant et al., 2022)*

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
R.I.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59	1.6	1.61	1.62	1.63	1.64

Simple Aggregate Weighting Method (SAW)

In the Simple Additive Weighting (SAW) method, the weighted average is used to assess the importance of each alternative, and the alternative with the highest resulting value is selected as the optimal choice(Ciardiello & Genovese, 2023). The steps of this method are (Taherdoost, 2023):

1. Construction of the decision matrix
2. Normalization of the decision matrix using the linear normalization method
3. Creation of the weighted matrix
4. Selection of the optimal alternative

[1] *Random Inconsistency Index*

FINDINGS

Identification of Factors and Criteria Influencing Flood Occurrence

To identify the relevant factors and criteria, interviews were conducted with experts, officials, and residents. By synthesizing their opinions, four key factors influencing the issue were identified, and twenty criteria were selected as significant. These factors and criteria are detailed in Table 3.

Table 3: *Factors and Criteria Identified as Influencing Flood Occurrence in the Eastern Areas of the Baghlan Jadid*

options	Criteria				
Environmental	Surface and underground waters (A)	Rainfall (B)	Cutting down trees and forests (C)	Topography of the area (D)	Unsuitable floodplain (E)
Economical	People's Life Level (F)	Livestock existence (G)	Lack of development projects (H)	Measures to combat accidents (I)	Per capita income of the people (J)
Infrastructural	City Development Management (K)	Improper excavations (L)	City Expansion (M)	Construction in the flood path (N)	Construction Regulations (O)
Socially	Harmony among people (P)	Flood History (Q)	Public awareness (R)	Preserving green areas (S)	Population (T)

Determination of Criteria Weights Using the AHP Method

To determine the weights of the criteria, it is first necessary to draw the hierarchical analysis structure and then calculate the remaining items according to the method's steps. The hierarchical structure is drawn and explained in Fig. 11.

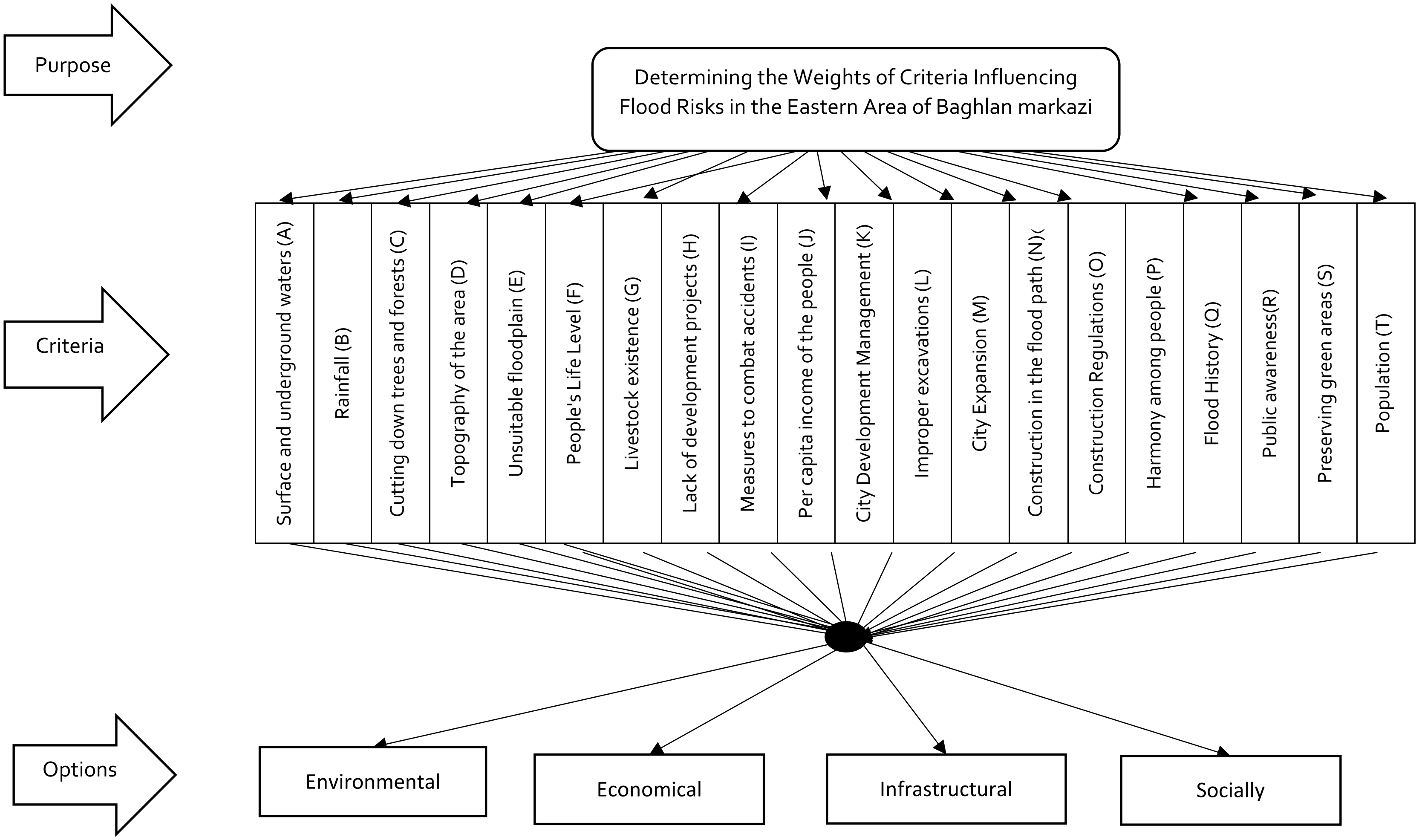

***Figure 11:** General Framework of the Analytic Hierarchy Process (AHP)*

To evaluate the priority of criteria and facilitate expert decision-making through pairwise comparisons, it is essential to define a numerical scale that accurately represents the relative importance of each criterion. The scale used for assessing the relative importance of the criteria is presented in Table 4. Experts conducted pairwise comparisons using the predefined numerical scale, resulting in the construction of the pairwise comparison decision matrix as outlined in Equation 1. The outcomes of this process are presented in Table 2 of Appendix 1.

Table 4. *Scale of scores used for prioritizing the assessment criteria*

Description	Numbers	Reverse numbers
Very much preferred	4	0.25
much preferred	2	0.5
similar	1	1
less preferred	0.5	2
Least preferred	0.25	4

Subsequently, the decision matrix was normalized, and the weights of the criteria were calculated using approximate methods, including row sum, column sum, and arithmetic mean. The results of these calculations are presented in Table 3 of Appendix 1.

The weight matrix of the criteria was constructed using Equation (7), and subsequently, the value of τ_{max} was calculated using Equation (5). The results of these computations are presented in Table 4 of Appendix 1. Continuously, Equation (4) was used to calculate the Inconsistency Index ($I.I$), and the Inconsistency Ratio ($I.R$) was computed using Equation (8). The results are presented in Table 5. The value of the Random inconsistency index ($R.I.I$) was selected from Table 2, based on the dimension of the matrix.

Table 5*: Inconsistency index and criteria inconsistency rate*

Number of criteria	20
lambda max	20.91
Incompatibility index (I.I)	0.05
Incompatibility rate (I.R)	0.03
Random inconsistency index (R.I.I)	1.64

Since the inconsistency ratio is 0.03, which is below the threshold value of 0.1, it can be concluded that the pairwise comparison matrix in this study is consistent.

Ranking of Options Using the SAW Method

Since the weights of the criteria were obtained using the AHP method, the SAW method was then employed to rank the options. Initially, the questionnaires were designed following the SAW method, and a sample of the questionnaire is provided in Table 5 of Appendix 1. Then, according to the method's steps, a range of numbers is defined to assign importance to the criteria in relation to the options; hence, the defined numbers are included in Table 6.

Table 6: *Numerical Values Assigned to Assess the Importance of Criteria Relative to Alternatives*

Definition	Scale
Equal importance	1
Moderate importance	2

Strong importance	3
Very strong	4
Extreme importance	5

After organizing and distributing the questionnaires, the experts assessed the importance of the criteria relative to the options using the defined numerical values. The decision matrix was then constructed based on the results of the questionnaires. Using Equation 9, the details of which are provided in Table 6 of Appendix 1, the decision matrix was formulated.

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \qquad 9$$

After constructing the decision matrix, it was normalized based on both the positive and negative criteria using Equations (10) and (11). The results of this normalization are presented in Table 7 in Appendix 1.

- In the case of positive criteria

$$r_{ij} = \frac{x_{ij}}{x_j^{max}} \qquad i = 1, \ldots 5, \quad j = 1, \ldots .15 \qquad 10$$

- In the case of negative criteria

$$r_{ij} = \frac{x_j^{min}}{x_{ij}} \qquad i = 1, \ldots 5, \quad j = 1, \ldots .15 \qquad 11$$

Based on the results of the normalized matrix and by applying Equation (12), the weighted matrix of the alternatives was constructed. Accordingly, the normalized weights of the alternatives were computed, and the results are presented in Table 8 of Appendix 1.

$$A_i = \sum_{j=1}^{m} W_j \times (X_{ij})_{normal} \qquad i = 1, \ldots .5, \quad j = 1, \ldots 15 \qquad 12$$

In this study, the factors and criteria influencing the occurrence of floods in the Sheikh Jalal, Darwaza Kan, and Shahrak Mohajerin areas of the Baghlan Markazi district were first identified and are presented in Table 3. Subsequently, questionnaires were designed and distributed based on the Analytic Hierarchy Process (AHP) method to determine the weights of the identified criteria. Following the standard steps of the AHP method, the criteria weights were calculated and are presented in Table 3 of Appendix 1. In the subsequent stage, a second questionnaire was developed based on the Simple Additive Weighting (SAW) method. Following the steps of this method, the normalized weights of the influential factors were calculated and are presented in Table 8 of Appendix 1. Finally, the factors influencing the occurrence of floods in the areas of Sheikh Jalal, Darwaza Kan, and Shahrak Mohajerin were ranked based on their normalized weights, as presented in Table 7. Additionally, the percentage contribution of each factor to flood occurrence is illustrated in Fig. 12.

Table 7. *Ranking of Factors Contributing to Flood Occurrence Based on Normalized Weights*

Options	Normalized weights of options	Ranking options
Environmental	0.261	1
Economical	0.224	4

Infrastructural	0.259	2
Socially	0.256	3

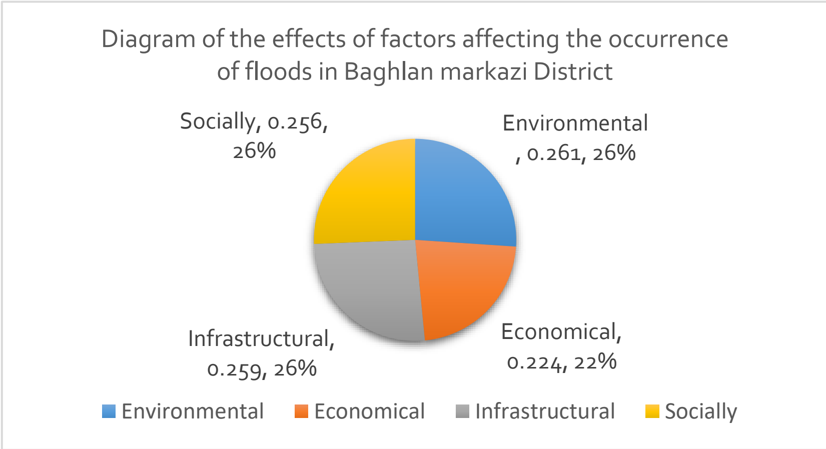

Fig 12*. Percentage Contribution of Factors Affecting Flood Occurrence in the Sheikh Jalal, Darwaza Kan, and Shahrak Mohajerin Areas of Baghlan Markazi District*

CONCLUSION

The results of this study indicate that, in complex and variable regional conditions like those found in the Baghlan Markazi District, the application of multi-criteria decision-making methods, such as AHP and SAW, proves to be an effective tool for analyzing the factors influencing flood occurrence. In this study, utilizing these two methods, four primary factors—namely, environmental, social, infrastructural, and economic—and their associated twenty criteria were evaluated. The results derived from the AHP and SAW analyses revealed that the environmental factor, with a weight of 0.261, was identified as the most significant factor influencing the occurrence of floods. In contrast, the economic factor, with a weight of 0.224, had the least impact.

The final ranking of factors further indicated that the topographic conditions of the region, inadequate vegetation, soil impermeability, and the presence of natural water convergence paths were among the primary environmental causes. Additionally, deficiencies in existing infrastructure, such as surface water drainage systems, a lack of standardized bridges, and unauthorized construction within riverbeds, were identified as key infrastructural factors contributing to the intensification of floods. From a social perspective, the lack of adequate public awareness, ineffective crisis management, and a shortage of trained human resources during emergencies have significantly contributed to increased vulnerability.

Therefore, it is recommended that a comprehensive and integrated approach to flood management be adopted in order to reduce flood risks. This approach should encompass enhancing public awareness, strengthening infrastructure, safeguarding the environment, and implementing supportive economic strategies in areas prone to flooding. Additionally, the ongoing application of multi-criteria decision-making methods to review and update the prioritization of risk factors can serve as a strategic tool in managing natural disasters.

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Appendix 1:

Table 1: Sample Paired Comparison Questionnaire (AHP)

Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
A																				
B																				
C																				
D																				
E																				
F																				
G																				
H																				
I																				
J																				
K																				
L																				
M																				
N																				
O																				
P																				
Q																				
R																				
S																				
T																				

Table 2: Pairwise Comparison Decision Matrix

Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
A	1.00	0.50	0.50	0.25	0.50	2.00	4.00	0.50	2.00	2.00	0.50	0.25	0.25	0.25	0.50	4.00	2.00	2.00	2.00	4.00
B	2.00	1.00	4.00	2.00	2.00	4.00	4.00	2.00	2.00	4.00	0.50	0.25	2.00	0.50	0.50	4.00	2.00	4.00	2.00	2.00
C	2.00	0.25	1.00	2.00	0.50	2.00	2.00	4.00	2.00	0.25	2.00	0.25	0.50	0.25	0.50	2.00	4.00	4.00	2.00	4.00
D	4.00	0.50	0.50	1.00	0.50	4.00	4.00	0.50	0.50	2.00	0.50	0.25	0.25	0.25	0.50	2.00	4.00	4.00	4.00	2.00
E	2.00	0.50	2.00	2.00	1.00	4.00	2.00	2.00	2.00	4.00	0.25	0.50	0.25	0.50	0.25	4.00	2.00	4.00	4.00	4.00
F	0.50	0.25	0.50	0.25	0.25	1.00	2.00	0.25	0.50	2.00	0.50	0.50	0.25	0.25	0.50	4.00	0.50	2.00	0.50	0.50
G	0.25	0.25	0.50	0.25	0.50	0.50	1.00	0.25	0.50	0.50	0.50	0.50	0.50	0.25	0.50	0.50	0.50	0.50	0.25	0.50
H	2.00	0.50	0.25	2.00	0.50	4.00	4.00	1.00	4.00	4.00	0.50	0.50	0.50	0.25	0.50	4.00	2.00	2.00	0.50	2.00
I	0.50	0.50	0.50	2.00	0.50	2.00	2.00	0.25	1.00	2.00	0.50	0.50	0.25	0.25	0.50	2.00	0.50	4.00	2.00	2.00
J	0.50	0.25	0.25	0.50	0.25	0.50	2.00	0.25	0.50	1.00	0.25	0.50	0.25	0.25	0.50	0.50	0.25	0.50	0.50	2.00
K	2.00	2.00	0.50	2.00	4.00	2.00	2.00	2.00	2.00	4.00	1.00	2.00	0.50	0.25	0.50	2.00	0.50	4.00	2.00	4.00
L	4.00	4.00	4.00	4.00	2.00	2.00	2.00	2.00	2.00	2.00	0.50	1.00	0.50	0.25	2.00	4.00	2.00	4.00	2.00	2.00
M	4.00	0.50	2.00	4.00	4.00	4.00	2.00	2.00	4.00	4.00	2.00	2.00	1.00	0.25	2.00	4.00	2.00	4.00	2.00	4.00
N	4.00	2.00	4.00	4.00	2.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	1.00	2.00	4.00	2.00	4.00	2.00	4.00
O	2.00	2.00	2.00	2.00	4.00	2.00	2.00	2.00	2.00	2.00	2.00	0.50	0.50	0.50	1.00	4.00	2.00	4.00	2.00	4.00
P	0.25	0.25	0.50	0.50	0.25	0.25	2.00	0.25	0.50	2.00	0.50	0.25	0.25	0.25	0.25	1.00	0.50	0.50	0.25	0.50
Q	0.50	0.50	0.25	0.25	0.50	2.00	2.00	0.50	2.00	4.00	2.00	0.50	0.50	0.50	0.50	2.00	1.00	2.00	0.50	0.50
R	0.50	0.25	0.25	0.25	0.25	0.50	2.00	0.50	0.25	2.00	0.25	0.25	0.25	0.25	0.25	2.00	0.50	1.00	0.50	0.50
S	0.50	0.50	0.50	0.25	0.25	2.00	4.00	2.00	0.50	2.00	0.50	0.50	0.50	0.50	0.50	4.00	2.00	2.00	1.00	0.50
T	0.25	0.50	0.25	0.50	0.25	2.00	2.00	0.50	0.50	0.50	0.25	0.50	0.25	0.25	0.25	2.00	2.00	2.00	2.00	1.00
Total columns	32.75	17.00	24.25	30.00	24.00	44.75	51.00	26.75	32.75	48.25	19.00	15.50	13.25	7.00	14.00	56.00	32.25	54.50	32.00	44.00

Table 3: The normalized decision matrix and the normalized weighted average of the criteria.

Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Average normalized weights of criteria
A	0.03	0.03	0.02	0.01	0.02	0.04	0.08	0.02	0.06	0.04	0.03	0.02	0.02	0.04	0.04	0.07	0.06	0.04	0.06	0.09	**0.041**
B	0.06	0.06	0.16	0.07	0.08	0.09	0.08	0.07	0.06	0.08	0.03	0.02	0.15	0.07	0.04	0.07	0.06	0.07	0.06	0.05	**0.072**
C	0.06	0.01	0.04	0.07	0.02	0.04	0.04	0.15	0.06	0.01	0.11	0.02	0.04	0.04	0.04	0.04	0.12	0.07	0.06	0.09	**0.056**
D	0.12	0.03	0.02	0.03	0.02	0.09	0.08	0.02	0.02	0.04	0.03	0.02	0.02	0.04	0.04	0.04	0.12	0.07	0.13	0.05	**0.050**
E	0.06	0.03	0.08	0.07	0.04	0.09	0.04	0.07	0.06	0.08	0.01	0.03	0.02	0.07	0.02	0.07	0.06	0.07	0.13	0.09	**0.060**
F	0.02	0.01	0.02	0.01	0.01	0.02	0.04	0.01	0.02	0.04	0.03	0.03	0.02	0.04	0.04	0.07	0.02	0.04	0.02	0.01	**0.025**
G	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.03	0.03	0.04	0.04	0.04	0.01	0.02	0.01	0.01	0.01	**0.018**
H	0.06	0.03	0.01	0.07	0.02	0.09	0.08	0.04	0.12	0.08	0.03	0.03	0.04	0.04	0.04	0.07	0.06	0.04	0.02	0.05	**0.050**
I	0.02	0.03	0.02	0.07	0.02	0.04	0.04	0.01	0.03	0.04	0.03	0.03	0.02	0.04	0.04	0.04	0.02	0.07	0.06	0.05	**0.035**
J	0.02	0.01	0.01	0.02	0.01	0.01	0.04	0.01	0.02	0.02	0.01	0.03	0.02	0.04	0.04	0.01	0.01	0.01	0.02	0.05	**0.019**
K	0.06	0.12	0.02	0.07	0.17	0.04	0.04	0.07	0.06	0.08	0.05	0.13	0.04	0.04	0.04	0.04	0.02	0.07	0.06	0.09	**0.065**
L	0.12	0.24	0.16	0.13	0.08	0.04	0.04	0.07	0.06	0.04	0.03	0.06	0.04	0.04	0.14	0.07	0.06	0.07	0.06	0.05	**0.081**
M	0.12	0.03	0.08	0.13	0.17	0.09	0.04	0.07	0.12	0.08	0.11	0.13	0.08	0.04	0.14	0.07	0.06	0.07	0.06	0.09	**0.090**
N	0.12	0.12	0.16	0.13	0.08	0.09	0.08	0.15	0.12	0.08	0.21	0.26	0.30	0.14	0.14	0.07	0.06	0.07	0.06	0.09	**0.128**
O	0.06	0.12	0.08	0.07	0.17	0.04	0.04	0.07	0.06	0.04	0.11	0.03	0.04	0.07	0.07	0.07	0.06	0.07	0.06	0.09	**0.072**
P	0.01	0.01	0.02	0.02	0.01	0.01	0.04	0.01	0.02	0.04	0.03	0.02	0.02	0.04	0.02	0.02	0.02	0.01	0.01	0.01	**0.018**
Q	0.02	0.03	0.01	0.01	0.02	0.04	0.04	0.02	0.06	0.08	0.11	0.03	0.04	0.07	0.04	0.04	0.03	0.04	0.02	0.01	**0.037**
R	0.02	0.01	0.01	0.01	0.01	0.01	0.04	0.02	0.01	0.04	0.01	0.02	0.02	0.04	0.02	0.04	0.02	0.02	0.02	0.01	**0.019**
S	0.02	0.03	0.02	0.01	0.01	0.04	0.08	0.07	0.02	0.04	0.03	0.03	0.04	0.07	0.04	0.07	0.06	0.04	0.03	0.01	**0.038**
T	0.01	0.03	0.01	0.02	0.01	0.04	0.04	0.02	0.02	0.01	0.01	0.03	0.02	0.04	0.02	0.04	0.06	0.04	0.06	0.02	**0.027**
																					1.00

Table 4: Criteria weight matrix along with the calculation of the Incompatibility Index (I.I) and Incompatibility Rate (I.R).

Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Sum of normalized weights of criteria	$\tau_{max.i}$
A	0.04	0.04	0.03	0.01	0.03	0.05	0.07	0.02	0.07	0.04	0.03	0.02	0.02	0.03	0.04	0.07	0.07	0.04	0.08	0.11	0.912	22.5
B	0.08	0.07	0.22	0.10	0.12	0.10	0.07	0.10	0.07	0.08	0.03	0.02	0.18	0.06	0.04	0.07	0.07	0.08	0.08	0.05	1.698	23.6
C	0.08	0.02	0.06	0.10	0.03	0.05	0.04	0.20	0.07	0.00	0.13	0.02	0.04	0.03	0.04	0.04	0.15	0.08	0.08	0.11	1.352	24.1
D	0.16	0.04	0.03	0.05	0.03	0.10	0.07	0.02	0.02	0.04	0.03	0.02	0.02	0.03	0.04	0.04	0.15	0.08	0.15	0.05	1.166	23.2
E	0.08	0.04	0.11	0.10	0.06	0.10	0.04	0.10	0.07	0.08	0.02	0.04	0.02	0.06	0.02	0.07	0.07	0.08	0.15	0.11	1.413	23.5
F	0.02	0.02	0.03	0.01	0.02	0.02	0.04	0.01	0.02	0.04	0.03	0.04	0.02	0.03	0.04	0.07	0.02	0.04	0.02	0.01	0.546	22.0
G	0.01	0.02	0.03	0.01	0.03	0.01	0.02	0.01	0.02	0.01	0.03	0.04	0.04	0.03	0.04	0.01	0.02	0.01	0.01	0.01	0.414	23.1
H	0.08	0.04	0.01	0.10	0.03	0.10	0.07	0.05	0.14	0.08	0.03	0.04	0.04	0.03	0.04	0.07	0.07	0.04	0.02	0.05	1.142	22.9
I	0.02	0.04	0.03	0.10	0.03	0.05	0.04	0.01	0.03	0.04	0.03	0.04	0.02	0.03	0.04	0.04	0.02	0.08	0.08	0.05	0.809	23.1
J	0.02	0.02	0.01	0.03	0.02	0.01	0.04	0.01	0.02	0.02	0.02	0.04	0.02	0.03	0.04	0.01	0.01	0.01	0.02	0.05	0.438	22.7
K	0.08	0.14	0.03	0.10	0.24	0.05	0.04	0.10	0.07	0.08	0.07	0.16	0.04	0.03	0.04	0.04	0.02	0.08	0.08	0.11	1.580	24.2
L	0.16	0.29	0.22	0.20	0.12	0.05	0.04	0.10	0.07	0.04	0.03	0.08	0.04	0.03	0.14	0.07	0.07	0.08	0.08	0.05	1.973	24.3
M	0.16	0.04	0.11	0.20	0.24	0.10	0.04	0.10	0.14	0.08	0.13	0.16	0.09	0.03	0.14	0.07	0.07	0.08	0.08	0.11	2.166	24.2
N	0.16	0.14	0.22	0.20	0.12	0.10	0.07	0.20	0.14	0.08	0.26	0.32	0.36	0.13	0.14	0.07	0.07	0.08	0.08	0.11	3.059	23.9
O	0.08	0.14	0.11	0.10	0.24	0.05	0.04	0.10	0.07	0.04	0.13	0.04	0.04	0.06	0.07	0.07	0.07	0.08	0.08	0.11	1.728	24.1
P	0.01	0.02	0.03	0.03	0.02	0.01	0.04	0.01	0.02	0.04	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.401	22.4
Q	0.02	0.04	0.01	0.01	0.03	0.05	0.04	0.02	0.07	0.08	0.13	0.04	0.04	0.06	0.04	0.04	0.04	0.04	0.02	0.01	0.829	22.3
R	0.02	0.02	0.01	0.01	0.02	0.01	0.04	0.02	0.01	0.04	0.02	0.02	0.02	0.03	0.02	0.04	0.02	0.02	0.02	0.01	0.415	22.1
S	0.02	0.04	0.03	0.01	0.02	0.05	0.07	0.10	0.02	0.04	0.03	0.04	0.04	0.06	0.04	0.07	0.07	0.04	0.04	0.01	0.841	22.3
T	0.01	0.04	0.01	0.03	0.02	0.05	0.04	0.02	0.02	0.01	0.02	0.04	0.02	0.03	0.02	0.04	0.07	0.04	0.08	0.03	0.617	22.8

$\sum \tau_{max.i}$	**418.3**
τ_{max}	**20.91**

Table 5: Sample questionnaire formatted according to the SAW method

Options/Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Environmental																				
Economical																				
Infrastructural																				
Socially																				

Table 6: Decision matrix based on the SAW method

Options/Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
max/min	max	max	max	max	max	min	min	max	max	min	max	max	max	max	max	max	min	min	max	min
Environmental	5	4	5	2	1	2	3	4	2	3	2	4	4	2	1	1	1	1	2	3
Economical	2	1	1	2	1	4	3	5	4	5	2	1	3	3	3	1	1	2	3	2
Infrastructural	2	2	3	2	2	3	2	4	4	2	4	2	3	4	3	2	1	1	2	1
Socially	1	2	2	2	2	4	2	3	2	3	4	3	3	4	3	2	2	1	2	2
max/min	5	4	5	2	2	2	2	5	4	2	4	4	4	4	3	2	1	1	3	1

Table 7: Normalized matrix in the SAW method

Options/Criteria	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
max/min	max	max	max	max	max	min	min	max	max	min	max	max	max	max	max	max	min	min	max	min
Environmental	1	1	1	1	0.5	1	1.5	0.8	0.5	1.5	0.5	1	1	0.5	0.3333	0.5	1	1	0.667	3
Economical	0.4	0.25	0.2	1	0.5	2	1.5	1	1	2.5	0.5	0.25	0.75	0.75	1	0.5	1	2	1.000	2
Infrastructural	0.4	0.5	0.6	1	1	1.5	1	0.8	1	1	1	0.5	0.75	1	1	1	1	1	0.667	1

Socially	0.2	0.5	0.4	1	1	2	1	0.6	0.5	1.5	1	0.75	0.75	1	1	1	2	1	0.667	2

Table 8: Weight matrix and normalized option weights in the SAW method

Options/Criteria	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	Weights of options	Normalized weights of options
N. W. C	0.04	0.07	0.06	0.05	0.06	0.02	0.02	0.05	0.03	0.02	0.07	0.08	0.09	0.13	0.07	0.02	0.04	0.02	0.04	0.03		
Environmental	0.203	0.287	0.280	0.101	0.060	0.050	0.054	0.199	0.070	0.058	0.130	0.324	0.358	0.256	0.072	0.018	0.037	0.019	0.075	0.081	2.733	0.261
Economical	0.081	0.072	0.056	0.101	0.060	0.099	0.054	0.249	0.140	0.096	0.130	0.081	0.269	0.384	0.215	0.018	0.037	0.038	0.113	0.054	2.348	0.224
Infrastructural	0.081	0.144	0.168	0.101	0.120	0.074	0.036	0.199	0.140	0.039	0.261	0.162	0.269	0.512	0.215	0.036	0.037	0.019	0.075	0.027	2.715	0.259
Socially	0.041	0.144	0.112	0.101	0.120	0.099	0.036	0.150	0.070	0.058	0.261	0.243	0.269	0.512	0.215	0.036	0.074	0.019	0.075	0.054	2.688	0.256
																					10.484	1.000