Multicriteria Algorithms with Applications

Journal Homepage: sciencesforce.com/mawa

Multicriteria. Algo. Appl. Vol. 2 (2024) 1–28.

Paper Type: Original Article

A Global Analysis of the Policies and Regulations in Place to Address the Impacts of Climate Change

Mohamed Abouhawwash [1,2,*], Nebojsa Bacanin [3] and K Venkatachalam [4]

[1] Department of Mathematics, Faculty of Science, Mansoura University, Mansoura 35516, Egypt.

[2] Department of Computational Mathematics, Science, and Engineering (CMSE), Michigan State University, East Lansing, United States ; abouhaww@msu.edu.

[3] Singidunum University, Belgrade, Serbia; nbacanin@singidunum.ac.rs.

[4] Department of Applied Cybernetics, Faculty of Science, University of Hradec Králové, 50003 Hradec Králové, Czech Republic; venkatachalam.k@ieee.org.

Received: 01 Aug 2023 **Revised:** 21 Dec 2023 **Accepted:** 02 Jan 2024 **Published:** 05 Jan 2024

Abstract

Primary policy tools include the target decomposition and evaluation system, the accounting and reporting system, and the carbon emission trading program. This research provides an overview of climate governance by tracing the development of policies, analyzing main policy instruments, determining the degree to which policies are successful, and identifying obstacles. This research illustrates that: (1) climate policies have a favorable influence on carbon reduction, economic development, technological innovation, and energy efficiency; and (2) climate policies provide numerous spillover benefits that are not related to climate change. The ramifications for public policy include the adoption of national legislation, the optimization of the policy mix, the equitable distribution of the tradeoffs across governments, and the enhancement of public participation. Overall, this research discusses the policies for climate change. Also, it shows the structured process, including a panel of experts and the participation of stakeholders, will be designed to establish and assess policy options.

Keywords: Climate Change; Climate Policies; Global Adaptation; Carbon Reduction; Climate Governance.

1 | Introduction

Since the beginning of the Industrial Revolution, there has been an increase in the amount of pollution that contributes to the greenhouse effect. This has had a variety of effects, some of which are connected to climate change. However, adapting to this circumstance is a subject that involves a great deal of complication. The policies that address adaptation have an impact in a number of different domains and include a wide variety of stakeholders. The involvement of stakeholders in the process of making decisions pertaining to the environment is actively promoted by a number of international treaties. It is impossible to ignore the mountain of evidence suggesting that the climate is shifting. The globe will continue to warm to some degree in the future regardless of how much progress is made toward mitigating climate change, and this warming will almost certainly exceed the 2-degree Celsius threshold that many people consider to be an indication of 'dangerous' involvement. It now seems more possible that the Earth will experience a temperature increase

Corresponding Author: abouhaww@msu.edu

https://doi.org/10.61356/j.mawa.2024.26461

of 4 degrees Celsius by the year 2100 due to the failure of international efforts to build a framework for controlling emissions. Adaptation is unavoidable.

Research on adaptation, which has traditionally been considered the "poor cousin" of mitigation, has been given a new lease of life as a result of the acceptance of the inevitability of climate change. The results of this research show that options for adaptation do exist, that they are possible, and that they may be integrated into preexisting policy goals. Importantly, the difficulty of adaptation is not necessarily a new one, since human beings have lived with climate fluctuation for a long time and have created management strategies to deal with this unpredictability. Adaptation has been a struggle for as long as there have been people. In spite of this potential, questions have been raised over the capacity of human systems to adapt owing to the magnitude of the expected consequences, the existing vulnerabilities, and the inadequate attention paid to adaptation. Extreme occurrences have shown that even in industrialized countries, there are major gaps in prevention and preparation. The ability for adaptation does not automatically equate to actual adaption.

Our capability to assess these assumptions and monitor the progress of adaptation, on the other hand, is hindered by the lack of quantitative results or indicators that can be used to determine whether or not adaptation is happening and how it is taking place. The challenge of mitigating climate change is one that may be evaluated by making reference to the total amount of greenhouse gases in the atmosphere. Adaptation is a more complicated process that involves making changes to human systems on a range of various dimensions (from local to global) and by a variety of different actors (such as the government, people, families, etc.). These changes may only be partly formed in response to the climate's influences. Because of this, progress on adaptation is seldom monitored, which may be one factor that contributes to the unwillingness of governments to engage in adaptation programs.

The involvement and participation of stakeholders is typically beneficial for the development of policies on climate change; yet, there may be major knowledge and communication gaps between specialists and the general public. Concerning the long-term effects, there is a significant amount of ambiguity in comparison to the possible expenses in the current day. The general people may have a very clear understanding of the current difficulties and requirements associated with adaptation; nevertheless, they may be unaware of the longer-term tendencies associated with adaptation and the governmental responses to it. On the other side, experts and politicians may be guilty of underestimating the ordinary people's sense of the costs associated with climate policy. For the purpose of maintaining the policymaking process's credibility, it is necessary to include a wide variety of stakeholders, such as representatives of corporations, local governments, and academic institutions. When stakeholders are involved in decision-making, it is important to recognize the difference between technical and sociological decision-making. In the former, only those with relevant expertise are involved in the decision-making process, while in the later, both relevant expertise and social actors are required. The participation of stakeholders is of utmost significance in the development of national and/or cross-sectoral policy initiatives. Policies regarding the climate must have consequences that are socially acceptable in order to be considered feasible. When it comes to determining which policy interventions should be prioritized and carrying them out, it is critical to consult all of the necessary stakeholders and to establish policies in a way that is both fair and transparent. When integrated with the participative process, multi-criteria decision-making (MCDM) makes it easier to describe the decision context and investigate the preferences of the many stakeholders [1].

The application of the MCDM to the task of analyzing top-level policy pertaining to climate change is discussed in this paper. In the beginning, it discusses the concept of collective adaptation. Also, it presents a defense of the reasoning for combining the AHP and TOPSIS methodologies. The procedure of determining and ranking different policy choices is discussed in this section.

2 | Collective Adaptation

It is becoming more obvious that communities all over the world are facing an ever-increasing and, in many cases, preeminent challenge in the form of the need to adapt to the existing and foreseeable consequences of climate change. What is far less evident is how communities as a whole cope with that difficulty, as well as what role the sociocultural makeup plays in doing so. A substantial body of research has shown that communities are often distinguished by a high degree of internal variety as well as steep gradients of vulnerability and adaptive capability. On the other hand, adaptation is at least partially a collective endeavor, given that communities are connected to one another in many different ways, whether it be via infrastructure, geography, or the management of resources. As a result, there has been a growing realization that effective adaptation needs joint efforts on the ground, especially in situations where there is a lack of institutional or other external adaptation, as is the case in many scenarios, including marginalized community settings. However, with the exception of the normative demands for collective adaptation, the term continues to be very weakly defined and conceptualized across the body of academic research. Although there are various definitions of associated concepts like community adaptation, collective climate action, and similar terms, these definitions cannot be immediately transferred to collective adaptation since they only cover portions of that notion.

The need of this is brought home in an especially glaring way by cities. Many urban and urbanizing places combine a high susceptibility with high exposure to climate hazards, such as on coastlines, as well as a lack of institutional adaptation and a high degree of sociocultural variety. For example, beaches provide high exposure to climate hazards. In principle, this variety might give rise to chances for adaptation and the development of resilience. Bringing together a diverse range of viewpoints and people has the potential to promote solutions that are successful and broadly accepted, as well as stimulate creativity and eliminate inequalities. On the other hand, it is possible to claim that the considerable sociocultural diversity that exists in cities gives rise to a variety of perspectives on risk reduction and the behaviors that are associated with it. It is possible for distinct risk-based social identities to arise and coexist when there is a significant variety of risk perceptions in close vicinity. This is due to the fact that people tend to identify with one another based on perceived commonalities, such as shared judgments of the severity of potential dangers. People who take on one of these social identities partially define who they are by distinguishing their own in-group from other out-groups, which in the context of environmental risk are other risk-based social identities. Such inequalities may make it more difficult for people from various risk-based social identities to work together on adaptation strategies. This may be the case, for instance, when climate change skeptics living in the same neighborhood or city should engage with climate change believers. Both of these social identities are said to have their origins in distinct worldviews and political orientations, which impede the collective efforts that are being made to adapt on a broader scale.

3 | Climate-related Policy Tools

In this section, some of the climate policy tools used in many countries of the world are presented.

3.1 | Target Breakdown and Evaluation System

The dissection and evaluation of the goals outlined in local governments' five-year plans have a considerable impact on environmental governance since this kind of governance is one of the most important tools available. The national goals are broken down into sub-goals for each province by the central government, taking into account both the province's level of economic growth and the amount of energy it consumes. When deconstructing objectives for lower-level governments, provincial governments take into consideration local resource endowment and emissions in addition to other factors. In a similar fashion, provincial governments offer an administrative framework for putting objectives into action and evaluating their effectiveness via the use of rules.

3.2 | System for Accounting and Reporting

Accurate accounting and reporting are essential components of establishing and evaluating climate goals as well as putting those goals into action. The regulators and those who are regulated are both parts of the accounting and reporting system. Climate authorities at all levels, professional institutions, and social organizations are all included in the category of regulators. In addition to the development of data management systems, several organizations also engage in data gathering and quality assurance. When data accessibility is taken into account, the regulated parties include both private businesses and state entities. Participating businesses and governmental organizations in the accounting and reporting system use their level of carbon emissions as the criterion for deciding whether or not to take on responsibilities. The system does not take consumption-based emissions into account owing to the scattered emission sources. Despite the fact that consumption-based accounting has become more crucial to prevent carbon leakage and implement more equitable climate policies, the system does not take consumption-based emissions into account.

3.3 | Trading of Carbon Discharge

The government serves as the primary policymaker and implements the baseline technique in order to distribute quotas. Instead of directly subsidizing businesses that have surplus emission reduction, the government adopts a market-oriented method to assist businesses to trade their excess reduction and profit from them. This is in place of directly subsidizing businesses that have excess emission reduction. Auctioning off quotas results in financial subsidies being awarded to businesses that have achieved high levels of emission reduction, while businesses that have achieved low levels of reduction are required to pay additional expenses.

4 | Policies to Combat Climate Change

In this section, the mechanism for compiling policies that are generally used to confront climate change globally is explained. An online questionnaire was presented that included many questions about the main adaptation challenges and the most priority policies to confront climate change. Many relevant stakeholders and experts participate in the survey. The questionnaire was conducted twice. In the first time, the selected policies were organized and some were combined with others according to the opinions of the participants. For the second time, eight goals were settled to confront these climate changes, as presented in Figure 1, and each goal includes four policies, as shown in Figure 2.

The selected policies are included in eight specific main goals, namely water management and the water regime (Goal_1), population health and individual well-being (Goal_2), adaptive forestry (Goal_3), nature and the variety of life on earth (Goal_4), sustainable agriculture (Goal_5), cross-cutting measures (Goal_6), adaptive habitat (Goal_7), and the concerns on the technical, economic, and social fronts (Goal_8). In this regard, the first goal includes four high-priority policies, namely the changes in the outflow regime, as well as regulations on water management (Policy_1), management of floods and waterworks to ensure the safety of the people (Policy_2), enhancement of the protection afforded to the region (Policy_3), and the adaptation as well as improvements in water planning; control of risks (Policy_4). The second goal includes four high-priority policies, namely the increasing the effectiveness of vaccination campaigns (Policy_5), promoting communication between entities concerned with public health and environmental protection (Policy_6), integrated monitoring systems for detecting and preventing food contamination (Policy_7), and the improving the local microclimate while also bolstering the health rescue service (Policy_8). The third goal includes four high-priority policies, namely the alteration in the species of timber, leading to increased forest resilience (Policy_9), woodlands that have been damaged by a catastrophe undergoing adaptation and restoration (Policy_{10}), protecting the genetic material of trees that are under risk due to climate change (Policy_{11}), and the promoting the genetic variety of woodlands and their ability to adapt (Policy_{12}).

Figure 1. Eight goals to confront climate changes.

The fourth goal includes four high-priority policies, namely the retention of water in land management and the administration of wetlands (Policy_{13}), creating different landscapes while using green infrastructure (Policy_{14}), the incorporation of biological variety into agricultural settings (Policy_{15}), and the ecologically sound forest management that prioritizes the preservation and revitalization of natural forests (Policy_{16}). The fifth goal includes four high-priority policies, namely the preventing the drying out of the soil (Policy_{17}), efforts to reduce the amount of soil and water that is lost are being made (Policy_{18}), encouragement of beekeeping as well as protection for various pollinators (Policy_{19}), and the encouragement of overall protective frameworks for the ground (Policy_{20}). The sixth goal includes four high-priority policies, namely the enhancing the context of existing policies for climate change adaption (Policy_{21}), putting more of a scientific emphasis on finding solutions to climate change (Policy_{22}), management of emergencies that is both effective and all-encompassing (Policy_{23}), and the adaptation education and awareness campaigns in response to climate change (Policy_{24}). The seventh goal includes four high-priority policies, namely the introducing regulations to ensure the continued viability of habitats (Policy_{25}), integration of concerns on climate change into planning regulations (Policy_{26}), establishing a national framework for the provision of assistance for habitat adaption (Policy_{27}), and the establishment of a nationwide information system on environmental habitat (Policy_{28}). The eighth goal includes four high-priority policies, namely the constructing environmentally friendly infrastructure while also enhancing connectivity (Policy_{29}), providing support for the implementation of adaptation policy initiatives in the energy sector (Policy_{30}), the reduction of potential hazards and the enhancement of tourism's competitiveness (Policy_{31}), and the adaptation of underprivileged populations to climate change (Policy_{32}).

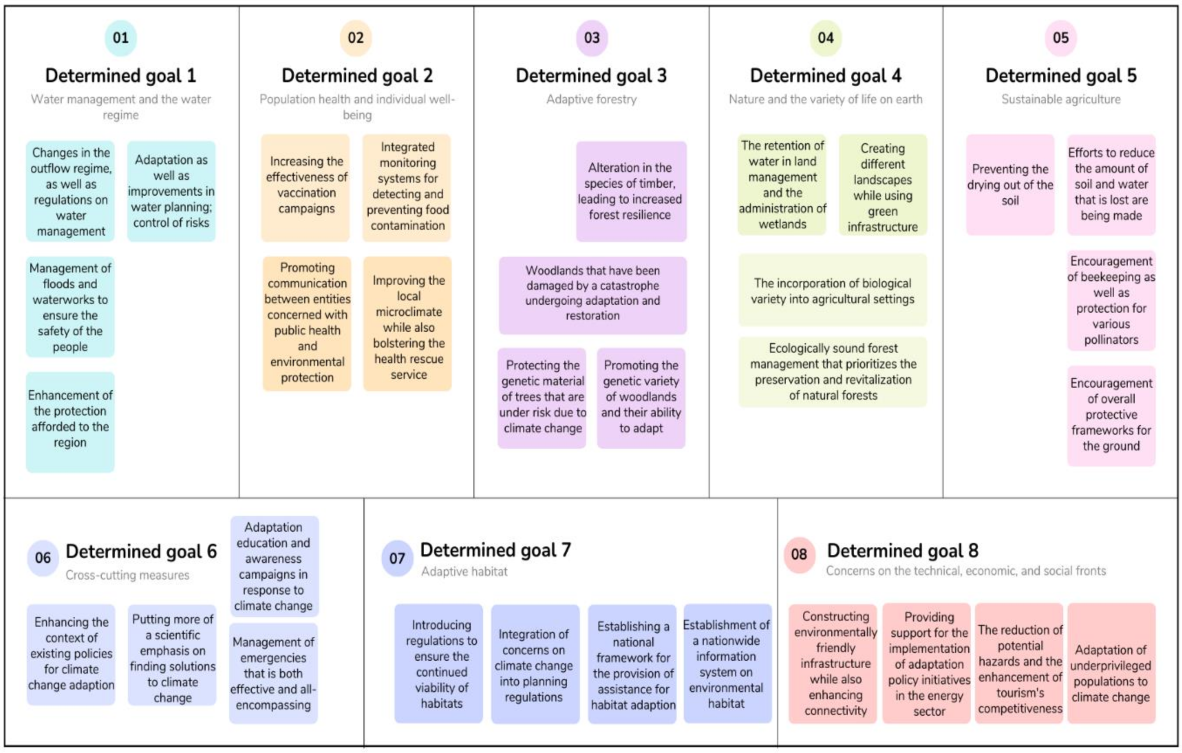

Figure 2. Generally recommended policies to address climate change.

5 | Materials and Methods

In this section, the methods used to solve the problem of determining the highest priority policies for implementation to deal with climate change are presented. In the beginning, a brief overview of the analytical hierarchy process (AHP) method is presented, and then the technique for order of preference by similarity to ideal solution (TOPSIS) method. Also, some preliminaries related to spherical fuzzy (SF) theory and their numbers are introduced. Finally, the steps of the proposed AHP-TOPSIS methodology by using spherical fuzzy numbers (SFNs) are presented.

5.1 | AHP Method

AHP developed by Saaty is a well-known and widely used method of making decisions based on several criteria [2]. One of the defining characteristics of the AHP technique is the way in which it combines qualitative and quantitative research approaches. A matrix of the numerous conditioning components will be produced, and an expert judgment will be combined with objective evaluation in order to quantitatively indicate the significant link that exists between each aspect. Another advantage of using the AHP model is that it allows for the measurement of consistency. The generation of the matrix for pair-wise comparisons, the computation of the Eigenvector, the weighting coefficient, and the consistency ratio are the essential steps in the AHP modeling procedure [3]. Again, the AHP is a quantitative method that organizes an issue with many attributes, multiple people, and several time periods in a hierarchical fashion in order to make it easier to find answers [4]. The relative efficiency with which this approach handles several criteria is one of the most significant benefits of using this strategy. It is capable of handling qualitative as well as quantitative data in an efficient manner. Even if the purpose of AHP is to capture the knowledge of specialists, the traditional use of AHP cannot represent the ambiguity that is inherent in human thought processes [5]. As a result, spherical fuzzy AHP (SF-AHP), which is an extension of AHP that takes into account spherical fuzzy data, was created as a solution to the hierarchical fuzzy issues, and several fuzzy AHP approaches were presented by a variety of authors.

5.2 | TOPSIS Method

In 1981, Hwang and Yoon [6] came up with the TOPSIS approach, which is part of the MCDM methods and is included in the multi-quality decision-making methods. It was designed to overcome the challenges associated with MCDM and to deal with aspects of uncertainty in the information, such as fuzziness and imprecision. The method that is used to find a solution for TOPSIS involves finding the alternative that is the closest to the positive ideal solution and the alternative that is the farthest away from the negative ideal solution [7]. By extending TOPSIS, a spherical fuzzy TOPSIS (SF-TOPSIS) technique may tackle issues involving collective decision-making in an environment characterized by uncertainty [8]. Using the SF-TOPSIS approach, it is possible to find solutions to situations involving many decision-makers (DMs) and uncertainty. This approach uses verbal terms rather than numerical data in order to provide a more accurate representation of the environment. DMs are required to orally communicate their thoughts and views when evaluating the criteria and available options. After that, an SFN is produced using these verbal phrases. The closeness coefficient for each choice is determined after going through this conversion procedure. The most appropriate option is decided upon by selecting the alternatives in accordance with their respective closeness coefficients [9].

5.3 | Spherical Fuzzy Theory

The inclusion of additional types of fuzzy sets (FSs), such as intuitionistic fuzzy sets (IFSs), Pythagorean fuzzy sets (PFSs), and neutrosophic sets (NSs), which utilize membership functions based on three dimensions, serves the purpose of providing a more comprehensive and explicit representation of expert opinions. The literature provides an introduction to generalized three-dimensional SFSs, highlighting their essential distinctions from other FSs [10]. It also discusses the arithmetic, aggregation, and defuzzification operations associated with SFS. It is not always possible to express human judgments using satisfaction and displeasure grades, since there may be an appearance of a neutral element inside the viewpoints, which cannot be accommodated with membership nor with non-membership [11]. The SFSs, which are the competent extension of the old models, have the advantage of being able to integrate the neutral views in addition to the positive and negative membership grades. This enables it to cover every shade of ambiguous opinion and dominate over the FSs, IFSs, and PFSs. Because of the ample room provided by SFSs, decision-makers are able to more freely and independently voice their opinions, which ultimately results in an increase in the decision's level of precision. The merits of SFSs, including their prominent model, larger area, competent framework, and modeling capabilities, prompted us to choose this model for making complicated decisions [12]. In this regard, some definitions, operations, and concepts related to SFSs are presented.

Definition 1. A fuzzy set T, defined in reference H, is in the form of Eq. (1) [10].

$$\mathrm{T} = \left[\left(h, (\mu_{\mathrm{T}}(h), \upsilon_{\mathrm{T}}(h), \pi_{\mathrm{T}}(h)\right) \mid h \in \mathrm{H}\right] \tag{1}$$

Where the function $\mu_{\mathrm{T}}: \mathrm{H} \rightarrow [0, 1]$ describes the degree of membership of an item to the sets T, $\upsilon_{\mathrm{T}}: \mathrm{H} \rightarrow [0, 1]$ describes the degree of non-membership of an item to the sets T, and $\pi_{\mathrm{T}}: \mathrm{H} \rightarrow [0, 1]$ describes the degree of hesitant of an item to the sets T, with the condition in Eq. (2) that:

$$0 \leq (\mu_{\mathrm{T}}(h))^2 + (\upsilon_{\mathrm{T}}(h))^2 + (\pi_{\mathrm{T}}(h))^2 \leq 1, \text{ for } \forall\, \mathrm{h} \in \mathrm{H} \tag{2}$$

Definition 2. [10] Let $\mathrm{T}_1 = \left(\mu_{\mathrm{T}_1}, \upsilon_{\mathrm{T}_1}, \pi_{\mathrm{T}_1}\right)$ and $\mathrm{T}_2 = \left(\mu_{\mathrm{T}_2}, \upsilon_{\mathrm{T}_2}, \pi_{\mathrm{T}_2}\right)$ be two SFNs, q is a fixed number greater than zero. The mathematical procedures of these two SFNs is implemented the Eqs. (3), (4), (5), and (6).

$$\mathrm{T}_1 \oplus \mathrm{T}_2 = \left[\sqrt{\mu_{\mathrm{T}_1}{}^2 + \mu_{\mathrm{T}_2}{}^2 - \mu_{\mathrm{T}_1}{}^2\mu_{\mathrm{T}_2}{}^2}, \upsilon_{\mathrm{T}_1}\upsilon_{\mathrm{T}_2}, \sqrt{\left(1 - \mu_{\mathrm{T}_2}{}^2\right)\pi_{\mathrm{T}_1} + \left(1 - \mu_{\mathrm{T}_1}{}^2\right)\pi_{\mathrm{T}_2} - \pi_{\mathrm{T}_1}\pi_{\mathrm{T}_2}}\right] \tag{3}$$

$$\mathrm{T}_1 \otimes \mathrm{T}_2 = \left[\mu_{\mathrm{T}_1}\mu_{\mathrm{T}_2}, \sqrt{\upsilon_{\mathrm{T}_1}{}^2 + \upsilon_{\mathrm{T}_2}{}^2 - \upsilon_{\mathrm{T}_1}{}^2\upsilon_{\mathrm{T}_2}{}^2}, \sqrt{\left(1 - \upsilon_{\mathrm{T}_2}{}^2\right)\pi_{\mathrm{T}_1}{}^2 + \left(1 - \upsilon_{\mathrm{T}_1}{}^2\right)\pi_{\mathrm{T}_2}{}^2 - \pi_{\mathrm{T}_1}{}^2\pi_{\mathrm{T}_2}{}^2}\right] \tag{4}$$

$$qT = \left[\sqrt{1-(1-\mu_T^2)^q}, \upsilon_T^2, \sqrt{(1-\mu_T^2)^q-(1-\mu_T^2-\pi_T^2)^q}\right] \quad (5)$$

$$T^q = \mu_T^q, \sqrt{1-(1-\upsilon_T^2)^q}, \sqrt{(1-\upsilon_T^2)^q-(1-\upsilon_T^2-\pi_T^2)^q} \quad (6)$$

Definition 3. Let $T_1 = (\mu_{T_1}, \upsilon_{T_1}, \pi_{T_1})$ and $T_2 = (\mu_{T_2}, \upsilon_{T_2}, \pi_{T_2})$ be two SFNs. The following essentials with the condition $q, q_1, q_2 > 0$, on these SFNs according to the Eqs. (7), (8), (9), (10), (11), (12) is done.

$$T_1 \oplus T_2 = T_2 \oplus T_1 \quad (7)$$

$$T_1 \otimes T_2 = T_2 \otimes T_1 \quad (8)$$

$$q(T_1 \oplus T_2) = qT_1 \oplus qT_2 \quad (9)$$

$$q_1T_1 \oplus q_2T_1 = (q_1 + q_2)\, T_1 \quad (10)$$

$$(T_1 \otimes T_2)^q = T_1^q \otimes T_2^q \quad (11)$$

$$T_1^{q_1} \otimes T_1^{q_2} = T_1^{q_1+q_2} \quad (12)$$

Definition 4. [10] Let $T = (\mu_T, \upsilon_T, \pi_T)$ describes a SFN. The score value (s_j) and the accuracy value (a_j) of the number T are computed as follows.

$$s_j(T) = (\mu_T - \pi_T)^2 - (\upsilon_T - \pi_T)^2 \quad (13)$$

$$a_j(T) = \mu_T^2 + \upsilon_T^2 + \pi_T^2 \quad (14)$$

$s_j(T_1) < s_j(T_2)$ or

$$s_j(T_1) = s_j(T_2) \text{ and } a_j(T_1) < a_j(T_2) \quad (15)$$

If the answers that are collected based on the score and accuracy are erroneous, it is possible to receive a value that is either negative or zero. It's possible that the performance will have the same degree of accuracy. As a direct consequence of this, the Prioritization Function (PF) is factored into the calculation of SFS numbers using Eq. (16).

$$PF(T) = \mu_T \times (1-\upsilon_T) \times (1-\pi_T) \quad (16)$$

5.4 | Hybrid AHP-TOPSIS Model

In this part, the detailed steps of the proposed model applied in this paper are presented to solve the problem of evaluating and determining the highest priority policies to confront climate change. The proposed model consists of two MCDM methods, namely the SF-AHP method and the SF-TOPSIS method. The SF-AHP method is used to evaluate the criteria specified in the study. Then, The SF-TOPSIS method is applied to rank the selected alternatives. Figure 3 presents the detailed steps of the model used to assess climate change policies.

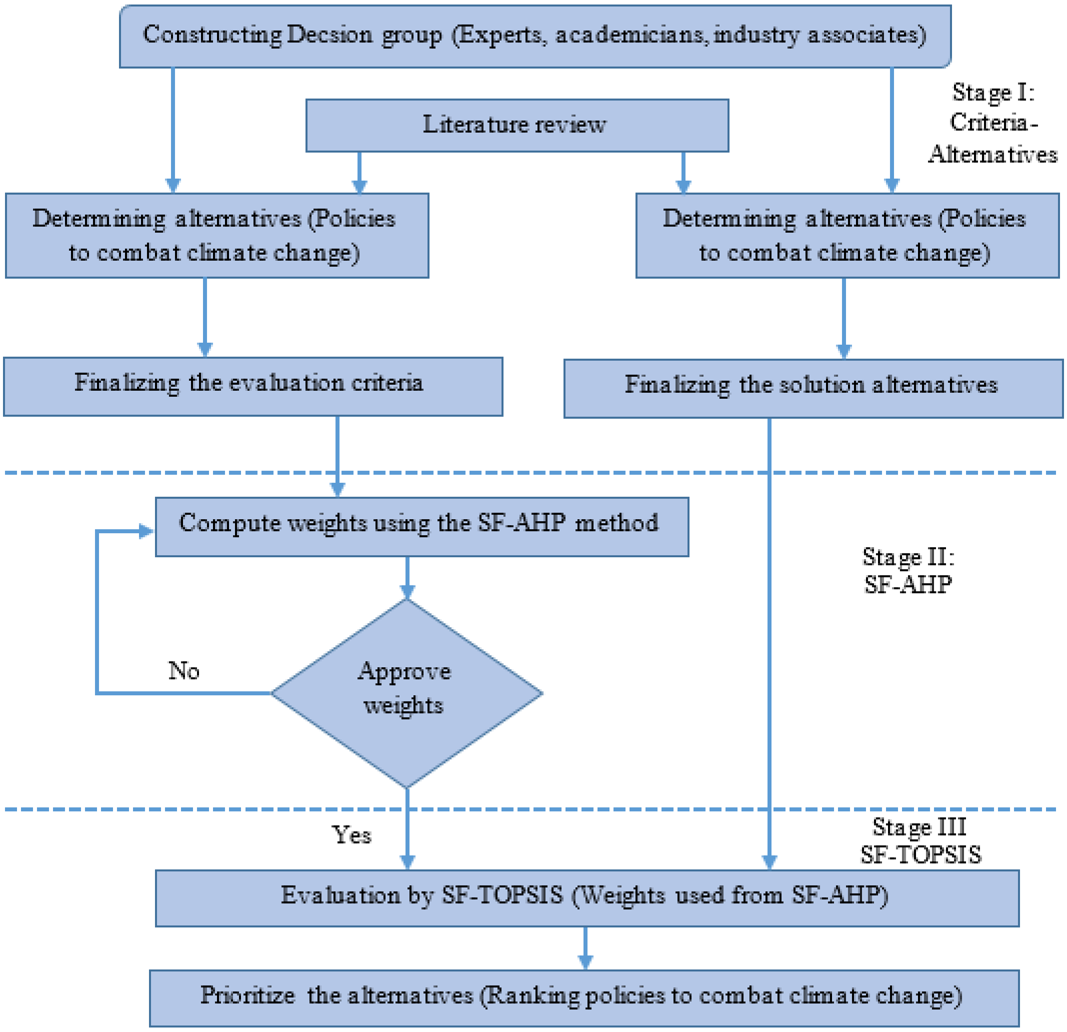

Figure 3. General scheme of the model used to evaluate climate change policies.

Step 1. The problem is studied in detail and the factors affecting the problem are identified. Also, the experts and specialists participating in the study are identified as exhibited in Table 1. Also, the linguistic terms and their corresponding SFNs are identified as provided in Table 2.

Table 1. Information about experts.

Experts	Experience (Years)	Occupation	Profession	Academic degree
Expert$_1$	10	Academia	Environmental Scientist	Ph.D.
Expert$_2$	15	Industry	Environmental Science and Protection Technician	Ph.D.
Expert$_3$	10	Industry	Environmental Emergency Planner	Ph.D.

Table 2. Linguistic terms and corresponding SFNs for assessing criteria and alternatives.

Linguistic terms	Abbreviations	Spherical fuzzy numbers		
		μ	υ	π
Quite weak importance	UWM	0.10	0.90	0.10
Very weak importance	VWM	0.20	0.80	0.20
Weak importance	WEC	0.30	0.70	0.30
Slightly weak importance	SWP	0.40	0.60	0.40
Evenly importance	EVM	0.50	0.50	0.50
Slightly high importance	SHM	0.60	0.40	0.40
High importance	HGM	0.70	0.30	0.30
Very high importance	VGM	0.80	0.20	0.20
Quite high importance	HMP	0.90	0.10	0.10

Step 2. Main criteria are selected through an analysis of the related works, as well as the opinions of the participating experts. Let $C_j = (C_1, C_2, \dots, C_n)$, with *j = 1, 2, ..., n*. Also, $w = (w_1, w_2, \dots, w_n)$ be the vector set used for delineation the criteria weights, where $w_j > 0$ and $\sum_{j=1}^{n} w_j = 1$. Finally, the concluding list of current alternatives for utilize in the study is determined. The set $A_i = \{A_1, A_2, \dots, A_m\}$, having i = 1, 2, ..., m alternatives, is measured by n decision criteria of set $C_j = \{C_1, C_2, \dots, C_n\}$, with *j = 1, 2, ..., n*.

Step 3. Construct the pairwise comparison matrix. A pairwise comparison matrix is constructed between the criteria and themselves according to Eq. (17) by all experts to give their opinions for these criteria. Let experts $= (\text{expert}_1, \dots, \text{expert}_t)$ be a set of experts who give their valuation report for each criterion C_j(*j* = 1, 2... *n*) against themselves C_j(*j* = 1, 2... *n*).

$$\begin{bmatrix} \text{EVM} & (\mu_{T_{12}}, \upsilon_{T_{12}}, \pi_{T_{12}}) & \cdots & (\mu_{T_{1n}}, \upsilon_{T_{1n}}, \pi_{T_{1n}}) \\ 1/(\mu_{T_{12}}, \upsilon_{T_{12}}, \pi_{T_{12}}) & \text{EVM} & \cdots & (\mu_{T_{2n}}, \upsilon_{T_{2n}}, \pi_{T_{2n}}) \\ \vdots & \vdots & \ddots & \vdots \\ 1/(\mu_{T_{1n}}, \upsilon_{T_{1n}}, \pi_{T_{1n}}) & 1/(\mu_{T_{2n}}, \upsilon_{T_{2n}}, \pi_{T_{2n}}) & & \text{EVM} \end{bmatrix}_{n\times n} \quad (17)$$

Step 4. Convert the SFNs to crisp values for each element of the pairwise comparison by using the PF provided in Eq. (16). Let $X = (x_{ij})_{n\times n}$ be the aggregated assessment matrix as a score matrix in Eq. (18).

$$X = (x_{ij})_{n\times n} = \begin{bmatrix} \text{EVM} & x_{12} & \cdots & x_{1n} \\ 1/x_{21} & \text{EVM} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/x_{n1} & 1/x_{n2} & \cdots & \text{EVM} \end{bmatrix}_{n\times n} \quad (18)$$

Step 5. Check the consistency ratio (CR) for the constructed pairwise comparison matrix according to Eq. (20). In addition, the consistency index (CI) has been calculated according to Eq. (19).

$$\text{CI} = \frac{\lambda_{max} - n}{n-1} \quad (19)$$

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \quad (20)$$

λ_{max} is the maximum eigenvalue of the pairwise comparison assessment matrix *X*. Random index (RI) is calculated based on matrix order (n) by utilizing the table developed by Saaty.

Step 6. Here, the TOPSIS method is introduced. Create the initial decision matrix according to Eq. (21) by utilizing the linguistic terms in Table 2, then by using the SFNs in Table 2. $Y = (y_{ij})_{m\times n}$ is constructed on the basis of the opinions of all experts, where item y_{ij} (*i = 1, 2... m; j* = 1, 2... *n*) denotes the initial estimated value of alternative A_i under the indicator C_j.

$$Y = \left(y_{ij}\right)_{m\times n} = \begin{bmatrix} y_{11} & y_{21} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{m1} & y_{m2} & \cdots & x_{mn} \end{bmatrix}_{m\times n} \quad (21)$$

where i = 1, 2, ..., m and j = 1, 2, ..., n.

Step 7. Convert the SFNs to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 8. Compute the normalized decision matrix for each alternative $y_i \in Y$ according to Eq. (22).

$$z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} y_{ij}^2}} \quad (22)$$

Step 9. Compute the weighted normalized decision matrix by multiplying the weights (w_j) with the normalized decision matrix (z_{ij}) according to Eq. (23).

$$u_{ij} = z_{ij} \times w_j \quad (23)$$

Step 10. Calculate the positive ideal solution (PIS) and the negative ideal solution (NIS) according to Eq. (24) and Eq. (25).

$$A^* = (u_1^*, u_1^*, ..., u_n^*) \text{ where } u_j^* = \max_i \{u_{ij}\} \quad (24)$$

$$A^- = (u_1^-, u_1^-, ..., u_n^-) \text{ where } u_j^- = \min_i \{u_{ij}\} \quad (25)$$

Step 11. Calculate the distance between each alternate and either PIS or NIS by utilizing Eq. (26) and Eq. (27).

$$S_i^* = \sum_{j=1}^{N} d_r(u_{ij}, u_j^*), \text{ i = 1, 2... n, j = 1, 2, ..., m.} \quad (26)$$

$$S_i^- = \sum_{j=1}^{N} d_r(u_{ij}, u_j^-), \text{ i = 1, 2... n, j = 1, 2, ..., m.} \quad (27)$$

Step 12. Define the closeness coefficient P_i for each substitute by using Eq. (28). Finally, based on the P_i value, the substitutes are ordered in ascending order.

$$P_i = \frac{S_i^-}{S_i^- + S_i^*} \quad (28)$$

6 | Experimental Results

6.1 | Application of the Proposed Methodology

In this section, the steps of the proposed SF-AHP-TOPSIS methodology are applied to solve the problem of evaluating and determining the most priority policies to confront climate change.

Step 1. The problem was studied in detail and its main objective was identified, which is to highlight the most priority policies for implementation to confront climate change. Also, the alternatives that are studied in this research are identified. The alternatives used are divided into eight groups. The eight groups, each of which includes four policies, are water management and the water regime (Goal_1), population health and individual well-being (Goal_2), adaptive forestry (Goal_3), nature and the variety of life on earth (Goal_4), sustainable agriculture (Goal_5), cross-cutting measures (Goal_6), adaptive habitat (Goal_7), and the concerns on the technical, economic, and social fronts (Goal_8). Also, the policies used in this study for the evaluation process are listed in Figure 2. In addition, three criteria are presented that have a direct impact on the identification and selection of the policy with the highest implementation priority and the most feasible. The three criteria to be used in evaluating policies are the relevance, urgency, and feasibility. The appropriate definition of the three criteria is illustrated as follows:

- **Relevance C_1**

The policy priority is very important, and it plays a big role, in the process of adjusting to the effects of climate change. If the action were not put into effect, it would lead to severe and long-lasting harm to the environment, as well as the social and economic systems.

- **Urgency C_2**

It is essential that the policy priority be put into effect as quickly as is practically practicable. In addition, the policy measure serves as a prerequisite for the execution of subsequent policies in the process.

- **Feasibility C_3**

Do you believe that the governments will be able to carry out the policies that have been prioritized? Some of the difficulties associated with climate change adaptation are of the utmost significance for the development of the future. Some of the other difficulties were within the purview of the government's ability to intervene, but in the past, the government failed to execute the policy goals in an effective manner.

Step 2. Three experts were selected to participate in conducting the study, and a set of standards and principles were set for selecting these experts, as shown in Table 1.

Step 3. Here, the SF-AHP method is applied to evaluate the three criteria with the participation of the three experts. Three pairwise comparison matrices were constructed by the three experts between the criteria and themselves according to Eq. (17) using linguistic terms provided in Table 2 as presented in Table 3, then using SFNs provided in Table 2, as presented in Table 4. In addition, the SFNs were converted to crisp values for each element of the pairwise comparison matrix according to Eq. (16).

Step 4. The CI was computed according to Eq. (19), as presented in Table 5. Then, the CR was checked according to Eq. (20), as presented in Table 5. Finally, the weights of the three criteria are introduced in Table 5 and shown in Figure 4.

Table 3. Evaluation of criteria using linguistic terms by all experts using the SF-AHP method.

$\mathbf{Expert_1}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{C_1}$	EVM	HMP	$^1/_{\mathrm{HGM}}$
$\mathbf{C_2}$	$^1/_{\mathrm{HMP}}$	EVM	VGM
$\mathbf{C_3}$	HGM	$^1/_{\mathrm{VGM}}$	EVM
$\mathbf{Expert_2}$	C_1	C_2	C_3
$\mathbf{C_1}$	EVM	VGM	$^1/_{\mathrm{HGM}}$
$\mathbf{C_2}$	$^1/_{\mathrm{VGM}}$	EVM	HMP
$\mathbf{C_3}$	HGM	$^1/_{\mathrm{HMP}}$	EVM
$\mathbf{Expert_3}$	C_1	C_2	C_3
$\mathbf{C_1}$	EVM	HGM	$^1/_{\mathrm{HMP}}$
$\mathbf{C_2}$	$^1/_{\mathrm{HGM}}$	EVM	VGM
$\mathbf{C_3}$	HMP	$^1/_{\mathrm{VGM}}$	EVM

Table 4. Evaluation of criteria using SFNs by all experts using the SF-AHP method.

$\mathbf{Expert_1}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{C_1}$	$\langle 0.50, 0.50, 0.50 \rangle$	$\langle 0.90, 0.10, 0.10 \rangle$	$^1/_{\langle 0.70, 0.30, 0.30 \rangle}$
$\mathbf{C_2}$	$^1/_{\langle 0.90, 0.10, 0.10 \rangle}$	$\langle 0.50, 0.50, 0.50 \rangle$	$\langle 0.80, 0.20, 0.20 \rangle$

C_3	$\langle 0.70, 0.30, 0.30\rangle$	$1/\langle 0.80, 0.20, 0.20\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
Expert$_2$	C_1	C_2	C_3
C_1	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.80, 0.20, 0.20\rangle$	$1/\langle 0.70, 0.30, 0.30\rangle$
C_2	$1/\langle 0.80, 0.20, 0.20\rangle$	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.90, 0.10, 0.10\rangle$
C_3	$\langle 0.70, 0.30, 0.30\rangle$	$1/\langle 0.90, 0.10, 0.10\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
Expert$_3$	C_1	C_2	C_3
C_1	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$1/\langle 0.90, 0.10, 0.10\rangle$
C_2	$1/\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.80, 0.20, 0.20\rangle$
C_3	$\langle 0.90, 0.10, 0.10\rangle$	$1/\langle 0.80, 0.20, 0.20\rangle$	$\langle 0.50, 0.50, 0.50\rangle$

Table 5. Final weights of criteria using the SF-AHP method.

Expert$_1$	**C_1**	**C_2**	**C_3**	**λ_{max}**	**C.I.**	**C.R.**	**Weights**	**Final**
C_1	0.500	0.729	2.900	3.014	0.007	0.012	0.419	0.349
C_2	1.400	0.500	0.512				0.292	0.345
C_3	0.343	2.000	0.500				0.288	0.305
Expert$_2$	C_1	C_2	C_3	λ_{max}	C.I.	C.R.	Weights	Final
C_1	0.500	0.512	2.900	3.014	0.007	0.012	0.373	0.349
C_2	2.000	0.500	0.729				0.371	0.345
C_3	0.343	1.400	0.500				0.256	0.305
Expert$_3$	C_1	C_2	C_3	λ_{max}	C.I.	C.R.	Weights	Final
C_1	0.500	0.343	1.400	3.014	0.007	0.012	0.256	0.349
C_2	2.900	0.500	0.512				0.373	0.345
C_3	0.729	2.000	0.500				0.371	0.305

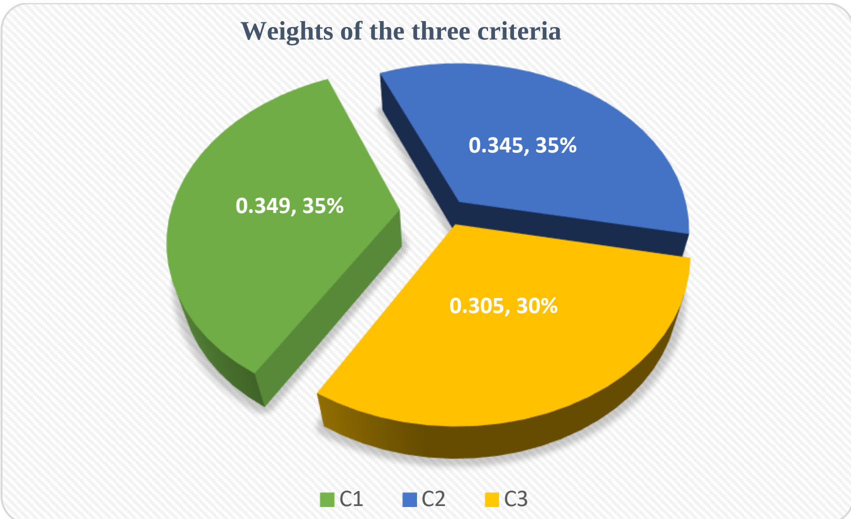

Figure 4. Final weights of criteria using the SF-AHP method.

Step 5. Here, the TOPSIS method is applied to assess the four policies of the first goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 6, then by using the SFNs provided in Table 2, as exhibited in Table 7. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 6. The normalized decision matrix was computed for each policy of the first goal according to Eq. (22), as presented in Table 8.

Step 7. The weighted normalized decision matrix was computed for each policy of the first goal according to Eq. (23), as presented in Table 9.

Step 8. The PIS and NIS for each policy of the first goal were determined according to Eq. (24) and Eq. (25), as presented in Table 9.

Step 9. The distance between each policy of the first goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 10.

Step 10. The closeness coefficient P_i for each policy of the first goal was determined according to Eq. (28), as exhibited in Table 10. Finally, the four policies of the first goal were ranked in ascending order, as presented in Table 10 and shown in Figure 5.

Table 6. Evaluation matrix of the four policies of the first goal using linguistic terms by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_1}$	UWM	SWP	VGM
$\mathbf{Policy_2}$	HGM	VWM	EVM
$\mathbf{Policy_3}$	HMP	WEC	HGM
$\mathbf{Policy_4}$	SWP	SHM	UWM

Table 7. Evaluation matrix of the four policies of the first goal using SFNs by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_1}$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.80, 0.20, 0.20\rangle$
$\mathbf{Policy_2}$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.20, 0.80, 0.20\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
$\mathbf{Policy_3}$	$\langle 0.90, 0.10, 0.10\rangle$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$
$\mathbf{Policy_4}$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.10, 0.90, 0.10\rangle$

Table 8. Normalized evaluation matrix of the four policies of the first goal by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_1}$	0.0111	0.3891	0.8141
$\mathbf{Policy_2}$	0.4227	0.1297	0.1988
$\mathbf{Policy_3}$	0.8984	0.2554	0.5454
$\mathbf{Policy_4}$	0.1183	0.8755	0.0143

Table 9. Weighted normalized evaluation matrix of the four policies of the first goal by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_1}$	0.0039	0.1342	0.2483
$\mathbf{Policy_2}$	0.1475	0.0447	0.0606
$\mathbf{Policy_3}$	0.3136	0.0881	0.1663
$\mathbf{Policy_4}$	0.0413	0.3021	0.0044
$\boldsymbol{A^*}$	0.3136	0.3021	0.2483
$\boldsymbol{A^-}$	0.0039	0.0447	0.0044

Table 10. Final ranking of the four policies of the first goal using the SF-TOPSIS method.

$\mathbf{Expert_s}$	$\boldsymbol{Si^+}$	$\boldsymbol{Si^-}$	**Pi**	**Rank**
$\mathbf{Policy_1}$	0.3522	0.2598	0.4245	2
$\mathbf{Policy_2}$	0.3592	0.1543	0.3005	4
$\mathbf{Policy_3}$	0.2291	0.3522	0.6058	1
$\mathbf{Policy_4}$	0.3656	0.2600	0.4156	3

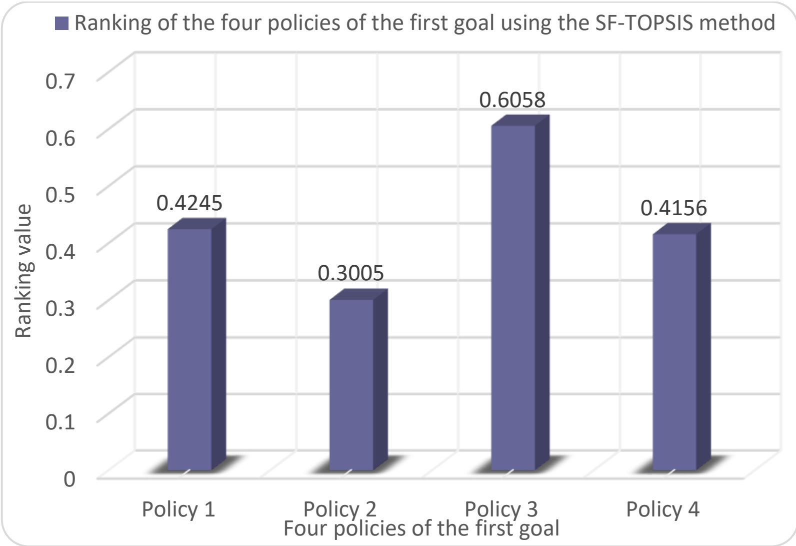

Figure 5. Final ranking of the four policies of the first goal.

Step 11. The TOPSIS method is applied to assess the four policies of the second goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 11, then by using the SFNs provided in Table 2, as exhibited in Table 12. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 12. The normalized decision matrix was computed for each policy of the second goal according to Eq. (22), as presented in Table 13.

Step 13. The weighted normalized decision matrix was computed for each policy of the second goal according to Eq. (23), as presented in Table 14.

Step 14. The PIS and NIS for each policy of the second goal were determined according to Eq. (24) and Eq. (25), as presented in Table 14.

Step 15. The distance between each policy of the second goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 15.

Step 16. The closeness coefficient P_i for each policy of the second goal was determined according to Eq. (28), as exhibited in Table 15. Finally, the four policies of the second goal were ranked in ascending order, as presented in Table 15 and shown in Figure 6.

Table 11. Evaluation matrix of the four policies of the second goal using linguistic terms by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_5}$	UWM	HGM	HGM
$\mathbf{Policy_6}$	WEC	EVM	EVM
$\mathbf{Policy_7}$	SWP	WEC	HGM
$\mathbf{Policy_8}$	SWP	SHM	UWM

Table 12. Evaluation matrix of the four policies of the second goal using SFNs by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_5}$	$\langle 0.10, 0.90, 0.10 \rangle$	$\langle 0.70, 0.30, 0.30 \rangle$	$\langle 0.70, 0.30, 0.30 \rangle$
$\mathbf{Policy_6}$	$\langle 0.30, 0.70, 0.30 \rangle$	$\langle 0.50, 0.50, 0.50 \rangle$	$\langle 0.50, 0.50, 0.50 \rangle$
$\mathbf{Policy_7}$	$\langle 0.40, 0.60, 0.40 \rangle$	$\langle 0.30, 0.70, 0.30 \rangle$	$\langle 0.70, 0.30, 0.30 \rangle$
$\mathbf{Policy_8}$	$\langle 0.40, 0.60, 0.40 \rangle$	$\langle 0.60, 0.40, 0.40 \rangle$	$\langle 0.10, 0.90, 0.10 \rangle$

Table 13. Normalized evaluation matrix of the four policies of the second goal by all experts.

Expert_s	C_1	C_2	C_3
Policy_5	0.0600	0.7998	0.6846
Policy_6	0.4202	0.2915	0.2495
Policy_7	0.6403	0.1469	0.6846
Policy_8	0.6403	0.5037	0.0180

Table 14. Weighted normalized evaluation matrix of the four policies of the second goal by all experts.

Expert_s	C_1	C_2	C_3
Policy_5	0.0209	0.2759	0.2088
Policy_6	0.1466	0.1006	0.0761
Policy_7	0.2234	0.0507	0.2088
Policy_8	0.2234	0.1738	0.0055
A^*	0.2234	0.2759	0.2088
A^-	0.0209	0.0507	0.0055

Table 15. Final ranking of the four policies of the second goal using the SF-TOPSIS method.

Expert_s	Si^+	Si^-	Pi	Rank
Policy_5	0.2025	0.3035	0.5998	1
Policy_6	0.2330	0.1526	0.3957	4
Policy_7	0.2253	0.2870	0.5602	2
Policy_8	0.2276	0.2370	0.5101	3

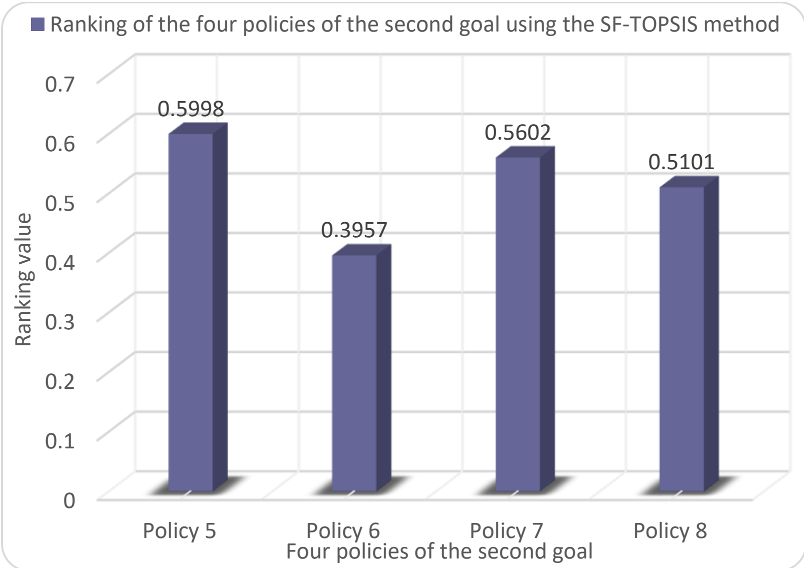

Figure 6. Final ranking of the four policies of the second goal.

Step 17. The TOPSIS method is applied to assess the four policies of the third goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 16, then by using the SFNs provided in Table 2, as exhibited in Table 17. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 18. The normalized decision matrix was computed for each policy of the third goal according to Eq. (22), as presented in Table 18.

Step 19. The weighted normalized decision matrix was computed for each policy of the third goal according to Eq. (23), as presented in Table 19.

Step 20. The PIS and NIS for each policy of the third goal were determined according to Eq. (24) and Eq. (25), as presented in Table 19.

Step 21. The distance between each policy of the third goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 20.

Step 22. The closeness coefficient $\mathrm{P_i}$ for each policy of the third goal was determined according to Eq. (28), as exhibited in Table 20. Finally, the four policies of the third goal were ranked in ascending order, as presented in Table 20 and shown in Figure 7.

Table 16. Evaluation matrix of the four policies of the third goal using linguistic terms by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_9}$	UWM	HGM	EVM
$\mathbf{Policy_{10}}$	SHM	EVM	EVM
$\mathbf{Policy_{11}}$	SWP	HMP	HGM
$\mathbf{Policy_{12}}$	WEC	SHM	UWM

Table 17. Evaluation matrix of the four policies of the third goal using SFNs by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_9}$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
$\mathbf{Policy_{10}}$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
$\mathbf{Policy_{11}}$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.90, 0.10, 0.10\rangle$	$\langle 0.70, 0.30, 0.30\rangle$
$\mathbf{Policy_{12}}$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.10, 0.90, 0.10\rangle$

Table 18. Normalized evaluation matrix of the four policies of the third goal by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_9}$	0.0368	0.4067	0.3239
$\mathbf{Policy_{10}}$	0.8824	0.1482	0.3239
$\mathbf{Policy_{11}}$	0.3922	0.8643	0.8886
$\mathbf{Policy_{12}}$	0.2574	0.2561	0.0233

Table 19. Weighted normalized evaluation matrix of the four policies of the third goal by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_9}$	0.0128	0.1403	0.0988
$\mathbf{Policy_{10}}$	0.3080	0.0511	0.0988
$\mathbf{Policy_{11}}$	0.1369	0.2982	0.2710
$\mathbf{Policy_{12}}$	0.0898	0.0884	0.0071
$\boldsymbol{A^*}$	0.3080	0.2982	0.2710
$\boldsymbol{A^-}$	0.0128	0.0511	0.0071

Table 20. Final ranking of the four policies of the third goal using the SF-TOPSIS method.

$\mathbf{Expert_s}$	$\boldsymbol{Si^+}$	$\boldsymbol{Si^-}$	**Pi**	**Rank**
$\mathbf{Policy_9}$	0.3764	0.1279	0.2536	3
$\mathbf{Policy_{10}}$	0.3012	0.3090	0.5064	2
$\mathbf{Policy_{11}}$	0.1711	0.3822	0.6908	1
$\mathbf{Policy_{12}}$	0.4016	0.0855	0.1756	4

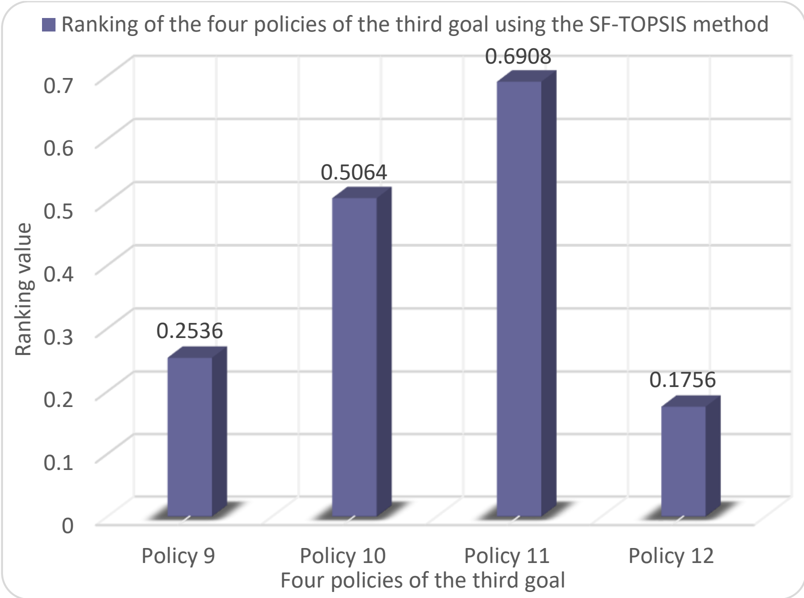

Figure 7. Final ranking of the four policies of the third goal.

Step 23. The TOPSIS method is applied to assess the four policies of the fourth goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 21, then by using the SFNs provided in Table 2, as exhibited in Table 22. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 24. The normalized decision matrix was computed for each policy of the fourth goal according to Eq. (22), as presented in Table 23.

Step 25. The weighted normalized decision matrix was computed for each policy of the fourth goal according to Eq. (23), as presented in Table 24.

Step 26. The PIS and NIS for each policy of the fourth goal were determined according to Eq. (24) and Eq. (25), as presented in Table 24.

Step 27. The distance between each policy of the fourth goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 25.

Step 28. The closeness coefficient P_i for each policy of the fourth goal was determined according to Eq. (28), as exhibited in Table 25. Finally, the four policies of the fourth goal were ranked in ascending order, as presented in Table 25 and shown in Figure 8.

Table 21. Evaluation matrix of the four policies of the fourth goal using linguistic terms by all experts.

Expert_s	C_1	C_2	C_3
Policy_{13}	WEC	HGM	EVM
Policy_{14}	SHM	WEC	EVM
Policy_{15}	SWP	HMP	HGM
Policy_{16}	HGM	HGM	UWM

Table 22. Evaluation matrix of the four policies of the fourth goal using SFNs by all experts.

Expert_s	C_1	C_2	C_3
Policy_{13}	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
Policy_{14}	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
Policy_{15}	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.90, 0.10, 0.10\rangle$	$\langle 0.70, 0.30, 0.30\rangle$
Policy_{16}	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.10, 0.90, 0.10\rangle$

Table 23. Normalized evaluation matrix of the four policies of the fourth goal by all experts.

Expert_s	C_1	C_2	C_3
Policy_{13}	0.1495	0.3907	0.3239
Policy_{14}	0.5127	0.0718	0.3239
Policy_{15}	0.2279	0.8304	0.8886
Policy_{16}	0.8142	0.3907	0.0233

Table 24. Weighted normalized evaluation matrix of the four policies of the fourth goal by all experts.

Expert_s	C_1	C_2	C_3
Policy_{13}	0.0522	0.1348	0.0988
Policy_{14}	0.1789	0.0248	0.0988
Policy_{15}	0.0795	0.2865	0.2710
Policy_{16}	0.2841	0.1348	0.0071
A^*	0.2841	0.2865	0.2710
A^-	0.0522	0.0248	0.0071

Table 25. Final ranking of the four policies of the fourth goal using the SF-TOPSIS method.

Expert_s	Si^+	Si^-	Pi	Rank
Policy_{13}	0.3263	0.1432	0.3050	4
Policy_{14}	0.3305	0.1564	0.3212	3
Policy_{15}	0.2046	0.3727	0.6456	1
Policy_{16}	0.3044	0.2567	0.4575	2

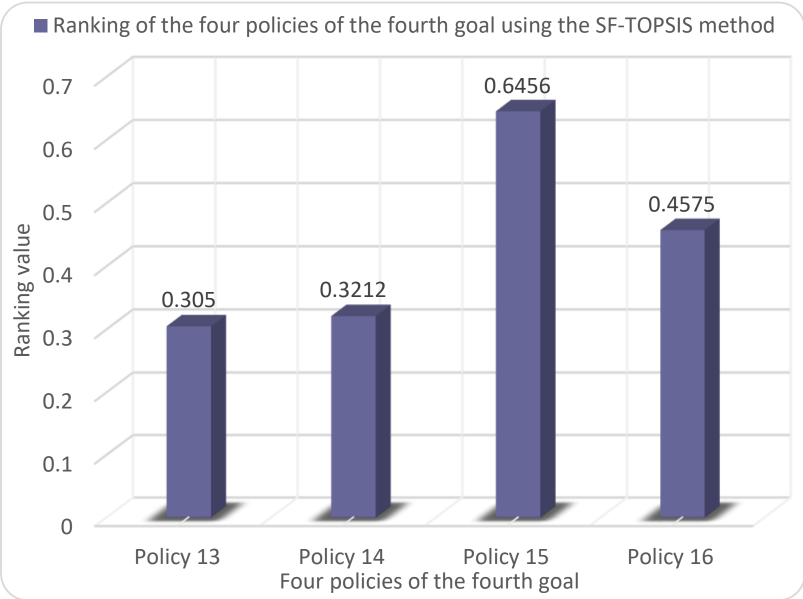

Figure 8. Final ranking of the four policies of the fourth goal.

Step 29. The TOPSIS method is applied to assess the four policies of the fifth goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 26, then by using the SFNs provided in Table 2, as exhibited in Table 27. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 30. The normalized decision matrix was computed for each policy of the fifth goal according to Eq. (22), as presented in Table 28.

Step 31. The weighted normalized decision matrix was computed for each policy of the fifth goal according to Eq. (1.23), as presented in Table 1.29.

Step 32. The PIS and NIS for each policy of the fifth goal were determined according to Eq. (24) and Eq. (25), as presented in Table 29.

Step 33. The distance between each policy of the fifth goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 30.

Step 34. The closeness coefficient P_i for each policy of the fifth goal was determined according to Eq. (28), as exhibited in Table 30. Finally, the four policies of the fifth goal were ranked in ascending order, as presented in Table 30 and shown in Figure 9.

Table 26. Evaluation matrix of the four policies of the fifth goal using linguistic terms by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{17}$	WEC	HGM	EVM
$Policy_{18}$	SHM	WEC	EVM
$Policy_{19}$	SWP	UWM	WEC
$Policy_{20}$	HGM	HMP	VGM

Table 27. Evaluation matrix of the four policies of the fifth goal using SFNs by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{17}$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
$Policy_{18}$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
$Policy_{19}$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.30, 0.70, 0.30\rangle$
$Policy_{20}$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.90, 0.10, 0.10\rangle$	$\langle 0.80, 0.20, 0.20\rangle$

Table 28. Normalized evaluation matrix of the four policies of the fifth goal by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{17}$	0.1495	0.4244	0.2292
$Policy_{18}$	0.5127	0.0780	0.2292
$Policy_{19}$	0.2279	0.0111	0.1155
$Policy_{20}$	0.8142	0.9020	0.9389

Table 29. Weighted normalized evaluation matrix of the four policies of the fifth goal by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{17}$	0.0522	0.1464	0.0699
$Policy_{18}$	0.1789	0.0269	0.0699
$Policy_{19}$	0.0795	0.0038	0.0352
$Policy_{20}$	0.2841	0.3112	0.2864
A^*	0.2841	0.3112	0.2864
A^-	0.0522	0.0038	0.0352

Table 30. Final ranking of the four policies of the fifth goal using the SF-TOPSIS method.

$Expert_s$	Si^+	Si^-	Pi	Rank
$Policy_{17}$	0.3575	0.1467	0.2910	2
$Policy_{18}$	0.3725	0.1334	0.2637	3
$Policy_{19}$	0.4465	0.0273	0.0577	4
$Policy_{20}$	0.0000	0.4597	1.0000	1

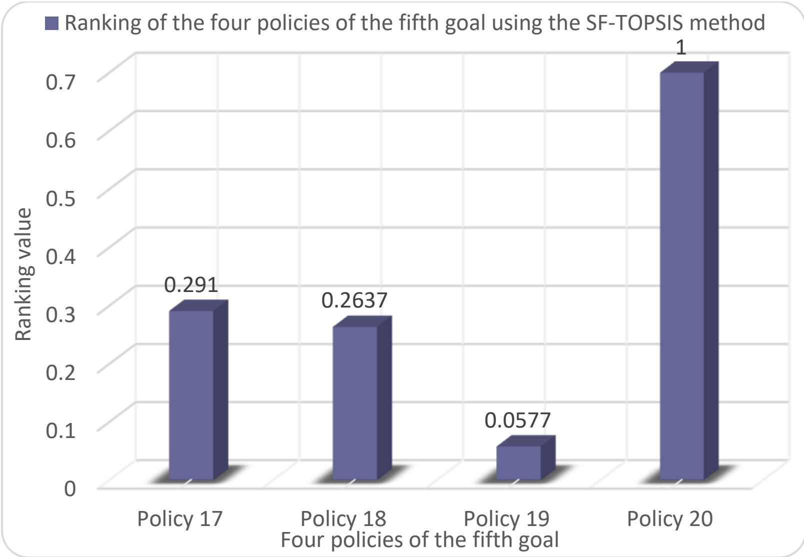

Figure 9. Final ranking of the four policies of the fifth goal.

Step 35. The TOPSIS method is applied to assess the four policies of the sixth goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 31, then by using the SFNs provided in Table 2, as exhibited in Table 32. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 36. The normalized decision matrix was computed for each policy of the sixth goal according to Eq. (22), as presented in Table 33.

Step 37. The weighted normalized decision matrix was computed for each policy of the sixth goal according to Eq. (23), as presented in Table 34.

Step 38. The PIS and NIS for each policy of the sixth goal were determined according to Eq. (24) and Eq. (25), as presented in Table 34.

Step 39. The distance between each policy of the sixth goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 35.

Step 40. The closeness coefficient P_i for each policy of the sixth goal was determined according to Eq. (28), as exhibited in Table 35. Finally, the four policies of the sixth goal were ranked in ascending order, as presented in Table 35 and shown in Figure 10.

Table 31. Evaluation matrix of the four policies of the sixth goal using linguistic terms by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{21}}$	WEC	HGM	EVM
$\mathbf{Policy_{22}}$	SHM	WEC	VGM
$\mathbf{Policy_{23}}$	SWP	UWM	WEC
$\mathbf{Policy_{24}}$	EVM	UWM	VGM

Table 32. Evaluation matrix of the four policies of the sixth goal using SFNs by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{21}}$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.50, 0.50, 0.50\rangle$
$\mathbf{Policy_{22}}$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.80, 0.20, 0.20\rangle$
$\mathbf{Policy_{23}}$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.30, 0.70, 0.30\rangle$
$\mathbf{Policy_{24}}$	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.80, 0.20, 0.20\rangle$

Table 33. Normalized evaluation matrix of the four policies of the sixth goal by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{21}$	0.2293	0.9829	0.1695
$Policy_{22}$	0.7863	0.1805	0.6943
$Policy_{23}$	0.3495	0.0258	0.0854
$Policy_{24}$	0.4550	0.0258	0.6943

Table 34. Weighted normalized evaluation matrix of the four policies of the sixth goal by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{21}$	0.0800	0.3391	0.0517
$Policy_{22}$	0.2744	0.0623	0.2117
$Policy_{23}$	0.1220	0.0089	0.0261
$Policy_{24}$	0.1588	0.0089	0.2117
A^*	0.2744	0.3391	0.2117
A^-	0.0800	0.0089	0.0261

Table 35. Final ranking of the four policies of the sixth goal using the SF-TOPSIS method.

$Expert_s$	Si^+	Si^-	Pi	Rank
$Policy_{21}$	0.2518	0.3312	0.5681	1
$Policy_{22}$	0.2768	0.2741	0.4975	2
$Policy_{23}$	0.4084	0.0419	0.0931	4
$Policy_{24}$	0.3499	0.2017	0.3657	3

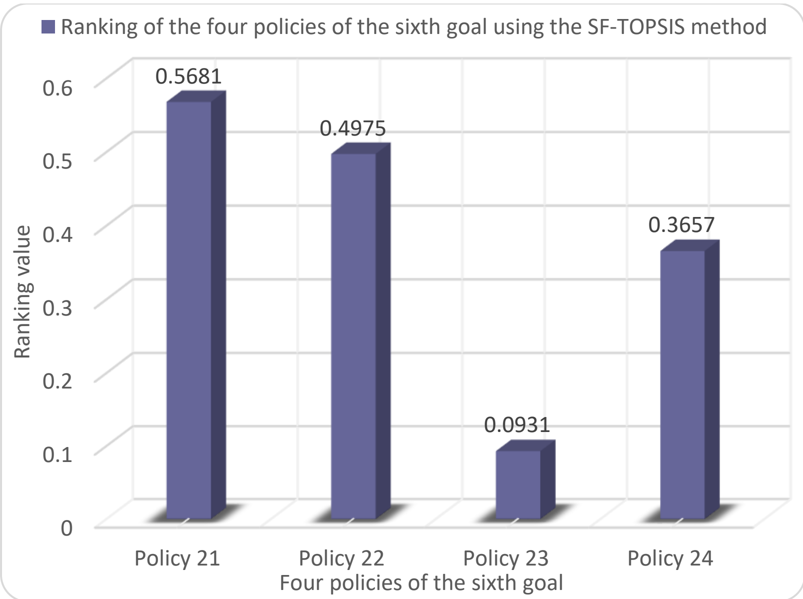

Figure 10. Final ranking of the four policies of the sixth goal.

Step 41. The TOPSIS method is applied to assess the four policies of the seventh goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 36, then by using the SFNs provided in Table 2, as exhibited in Table 37. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 42. The normalized decision matrix was computed for each policy of the seventh goal according to Eq. (22), as presented in Table 38.

Step 43. The weighted normalized decision matrix was computed for each policy of the seventh goal according to Eq. (23), as presented in Table 39.

Step 44. The PIS and NIS for each policy of the seventh goal were determined according to Eq. (24) and Eq. (25), as presented in Table 39.

Step 45. The distance between each policy of the seventh goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 40.

Step 46. The closeness coefficient P_i for each policy of the seventh goal was determined according to Eq. (28), as exhibited in Table 40. Finally, the four policies of the seventh goal were ranked in ascending order, as presented in Table 40 and shown in Figure 11.

Table 36. Evaluation matrix of the four policies of the seventh goal using linguistic terms by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{25}}$	WEC	HGM	SWP
$\mathbf{Policy_{26}}$	VWM	WEC	VGM
$\mathbf{Policy_{27}}$	SWP	SHM	SWP
$\mathbf{Policy_{28}}$	EVM	UWM	VGM

Table 37. Evaluation matrix of the four policies of the seventh goal using SFNs by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{25}}$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.40, 0.60, 0.40\rangle$
$\mathbf{Policy_{26}}$	$\langle 0.20, 0.80, 0.20\rangle$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.80, 0.20, 0.20\rangle$
$\mathbf{Policy_{27}}$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.40, 0.60, 0.40\rangle$
$\mathbf{Policy_{28}}$	$\langle 0.50, 0.50, 0.50\rangle$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.80, 0.20, 0.20\rangle$

Table 38. Normalized evaluation matrix of the four policies of the seventh goal by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{25}}$	0.3647	0.8360	0.1303
$\mathbf{Policy_{26}}$	0.1853	0.1535	0.6950
$\mathbf{Policy_{27}}$	0.5558	0.5264	0.1303
$\mathbf{Policy_{28}}$	0.7237	0.0219	0.6950

Table 39. Weighted normalized evaluation matrix of the four policies of the seventh goal by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{25}}$	0.1273	0.2884	0.0397
$\mathbf{Policy_{26}}$	0.0647	0.0530	0.2120
$\mathbf{Policy_{27}}$	0.1940	0.1816	0.0397
$\mathbf{Policy_{28}}$	0.2526	0.0076	0.2120
$\boldsymbol{A^*}$	0.2526	0.2884	0.2120
$\boldsymbol{A^-}$	0.0647	0.0076	0.0397

Table 40. Final ranking of the four policies of the seventh goal using the SF-TOPSIS method.

$\mathbf{Expert_s}$	$\boldsymbol{Si^+}$	$\boldsymbol{Si^-}$	**Pi**	**Rank**
$\mathbf{Policy_{25}}$	0.2130	0.2877	0.5747	1
$\mathbf{Policy_{26}}$	0.3012	0.1781	0.3716	4
$\mathbf{Policy_{27}}$	0.2109	0.2168	0.5069	2
$\mathbf{Policy_{28}}$	0.2808	0.2549	0.4758	3

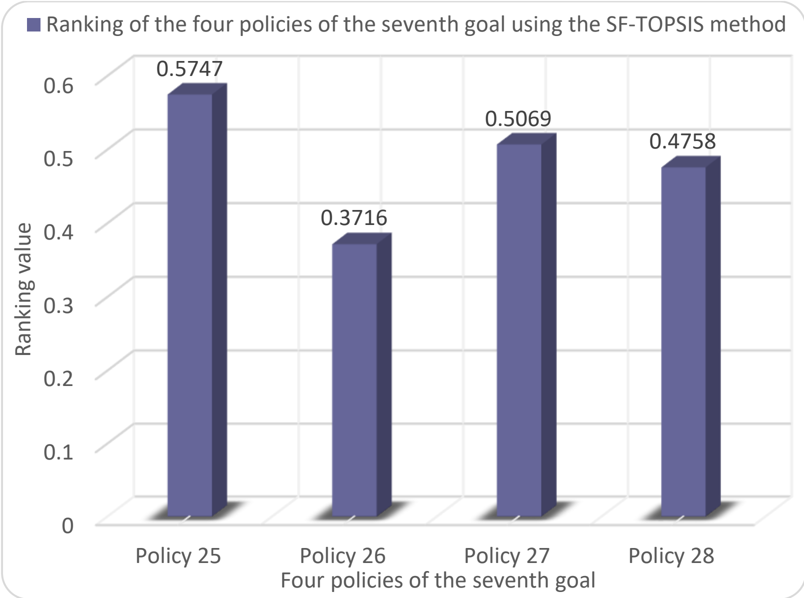

Figure 11. Final ranking of the four policies of the seventh goal.

Step 47. The TOPSIS method is applied to assess the four policies of the eighth goal. The initial decision matrix was constructed according to Eq. (21) by utilizing the linguistic terms in Table 2 as presented in Table 41, then by using the SFNs provided in Table 2, as exhibited in Table 42. Also, the SFNs were converted to crisp values for each element of the initial decision matrix by using the PF provided in Eq. (16).

Step 48. The normalized decision matrix was computed for each policy of the eighth goal according to Eq. (22), as presented in Table 43.

Step 49. The weighted normalized decision matrix was computed for each policy of the eighth goal according to Eq. (23), as presented in Table 44.

Step 50. The PIS and NIS for each policy of the eighth goal were determined according to Eq. (24) and Eq. (25), as presented in Table 44.

Step 51. The distance between each policy of the eighth goal and (PIS or NIS) was computed according to Eq. (26) and Eq. (27), as presented in Table 45.

Step 52. The closeness coefficient P_i for each policy of the eighth goal was determined according to Eq. (28), as exhibited in Table 45. Finally, the four policies of the eighth goal were ranked in ascending order, as presented in Table 45 and shown in Figure 12.

Table 41. Evaluation matrix of the four policies of the eighth goal using linguistic terms by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{29}}$	WEC	HGM	SWP
$\mathbf{Policy_{30}}$	HGM	WEC	WEC
$\mathbf{Policy_{31}}$	SWP	HGM	SWP
$\mathbf{Policy_{32}}$	SHM	UWM	VGM

Table 42. Evaluation matrix of the four policies of the eighth goal using SFNs by all experts.

$\mathbf{Expert_s}$	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$
$\mathbf{Policy_{29}}$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.40, 0.60, 0.40\rangle$
$\mathbf{Policy_{30}}$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.30, 0.70, 0.30\rangle$	$\langle 0.30, 0.70, 0.30\rangle$
$\mathbf{Policy_{31}}$	$\langle 0.40, 0.60, 0.40\rangle$	$\langle 0.70, 0.30, 0.30\rangle$	$\langle 0.40, 0.60, 0.40\rangle$
$\mathbf{Policy_{32}}$	$\langle 0.60, 0.40, 0.40\rangle$	$\langle 0.10, 0.90, 0.10\rangle$	$\langle 0.80, 0.20, 0.20\rangle$

Table 43. Normalized evaluation matrix of the four policies of the eighth goal by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{29}$	0.1495	0.7011	0.1800
$Policy_{30}$	0.8142	0.1288	0.1181
$Policy_{31}$	0.2279	0.7011	0.1800
$Policy_{32}$	0.5127	0.0184	0.9598

Table 44. Weighted normalized evaluation matrix of the four policies of the eighth goal by all experts.

$Expert_s$	C_1	C_2	C_3
$Policy_{29}$	0.0522	0.2419	0.0549
$Policy_{30}$	0.2841	0.0444	0.0360
$Policy_{31}$	0.0795	0.2419	0.0549
$Policy_{32}$	0.1789	0.0063	0.2927
A^*	0.2841	0.2419	0.2927
A^-	0.0522	0.0063	0.0360

Table 45. Final ranking of the four policies of the eighth goal using the SF-TOPSIS method.

$Expert_s$	Si^+	Si^-	Pi	Rank
$Policy_{29}$	0.3322	0.2363	0.4156	4
$Policy_{30}$	0.3239	0.2351	0.4205	3
$Policy_{31}$	0.3138	0.2379	0.4312	2
$Policy_{32}$	0.2580	0.2863	0.5260	1

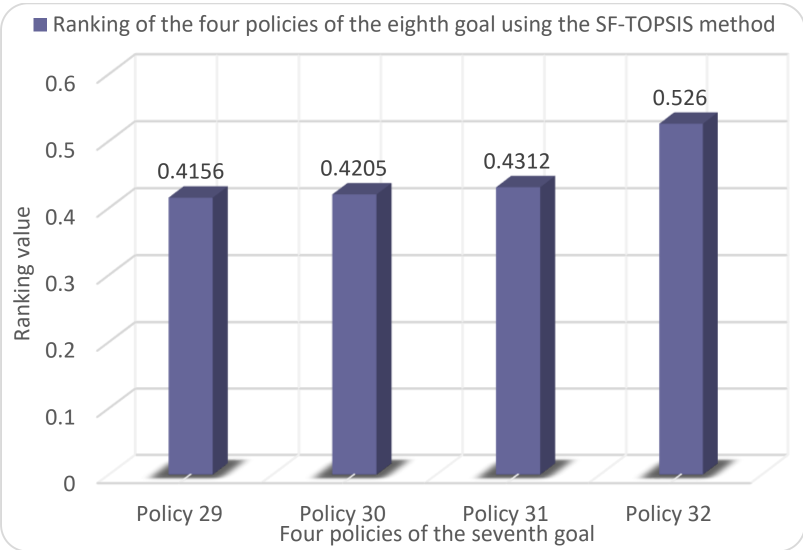

Figure 12. Final ranking of the four policies of the eighth goal.

6.2 | Results and Discussion

In this part, explanations are given for the outstanding results obtained from the application of the proposed SF-AHP-TOPSIS model to find out the most priority policies to confront climate change. In the beginning, the three criteria that have a direct impact on the selection and ranking of the aforementioned policies were assessed and prioritized using the SF-AHP method. The results in Table 5 indicate that the relevance criterion has the highest impact with a weight of 0.349, followed by the urgency criterion, while the feasibility criterion has the least impact with a weight of 0.305.

Then, thirty-two identified policies counteracting climate change were evaluated. The thirty-two policies are divided into eight groups, and each group includes four policies. In this regard, the policies were evaluated and ranked by applying the SF-TOPSIS method. First, the four policies of the first group were evaluated as shown in Table 10. The results indicate that the enhancement of the protection afforded to the region policy is the most priority to address climate change, followed by the changes in the outflow regime, as well as regulations on water management policy, while the management of floods and waterworks to ensure the safety of the people policy is the least priority. Second, the four policies of the second group were evaluated as shown in Table 15. The results indicate that the increasing the effectiveness of vaccination campaigns policy is the most priority to address climate change, followed by integrated monitoring systems for detecting and preventing food contamination policy, while the promoting communication between entities concerned with public health and environmental protection policy is the least priority. Third, the four policies of the third group were evaluated as shown in Table 20. The results indicate that the protecting the genetic material of trees that are under risk due to climate change policy is the most priority to address climate change, followed by woodlands that have been damaged by a catastrophe undergoing adaptation and restoration policy, while the promoting the genetic variety of woodlands and their ability to adapt policy is the least priority. Fourth, the four policies of the fourth group were evaluated as shown in Table 25. The results indicate that the incorporation of biological variety into agricultural settings policy is the most priority to address climate change, followed by ecologically sound forest management that prioritizes the preservation and revitalization of natural forests policy, while the retention of water in land management and the administration of wetlands policy is the least priority. Fifth, the four policies of the fifth group were evaluated as shown in Table 30. The results indicate that the encouragement of overall protective frameworks for the ground policy is the most priority to address climate change, followed by preventing the drying out of the soil policy, while the encouragement of beekeeping as well as protection for various pollinators' policy is the least priority. Sixth, the four policies of the sixth group were evaluated as shown in Table 35. The results indicate that the enhancing the context of existing policies for climate change adaption policy is the most priority to address climate change, followed by putting more of a scientific emphasis on finding solutions to climate change policy, while the management of emergencies that is both effective and all-encompassing policy is the least priority. Seventh, the four policies of the seventh group were evaluated as shown in Table 40. The results indicate that the introducing regulations to ensure the continued viability of habitats policy is the most priority to address climate change, followed by establishing a national framework for the provision of assistance for habitat adaption policy, while the integration of concerns on climate change into planning regulations policy is the least priority. Eighth, the four policies of the eighth group were evaluated as shown in Table 45. The results indicate that the adaptation of underprivileged populations to climate change policy is the most priority to address climate change, followed by reduction of potential hazards and the enhancement of tourism's competitiveness policy, while the constructing environmentally friendly infrastructure while also enhancing connectivity policy is the least priority.

7 | Conclusions

This paper provides an overview of the policies pertaining to climate change, discusses the mechanisms that are used to implement those policies, analyses the consequences such policies have, and suggests potential obstacles and implications. In addition to that, a selection of the climate policy instruments used by numerous nations throughout the globe is discussed below. In addition, this paper offers a working definition of the notion of collective adaptation, which aims to make the idea more generally applicable in light of the rising need to adapt to climate change at the community level.

In this study, an empirical study was conducted to determine the most priority policies for implementation to address climate change. The MCDM approach, consisting of two methods, AHP-TOPSIS, was applied to evaluate thirty-two selected policies from among a wide range of candidate policies to address climate change according to the opinions of experts and specialists. Using the SF-AHP method, criteria that influence the selection of the most priority policies for implementation are evaluated and prioritized. Then, the SF-TOPSIS method was applied to evaluate and rank the thirty-two policies divided into eight groups.

According to the results of the SF-AHP method, the results indicate that the relevance criterion has the highest impact with a weight of 0.349, followed by the urgency criterion, while the feasibility criterion has the least impact with a weight of 0.305. According to the results of the SF-TOPSIS method, eight policies were selected as the most priority policies for implementation to address climate change. The eight policies identified are the enhancement of the protection afforded to the region policy, the increasing the effectiveness of vaccination campaigns policy, the protecting the genetic material of trees that are under risk due to climate change policy, the incorporation of biological variety into agricultural settings policy, the encouragement of overall protective frameworks for the ground policy, the enhancing the context of existing policies for climate change adaption policy, the introducing regulations to ensure the continued viability of habitats policy, and the adaptation of underprivileged populations to climate change policy.

Acknowledgments

The author is grateful to the editorial and reviewers, as well as the correspondent author, who offered assistance in the form of advice, assessment, and checking during the study period.

Author Contributaion

All authors contributed equally to this work.

Funding

This research has no funding source.

Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

[1] Abdel-Monem , A., A.Nabeeh , N., & Abouhawwash, M. (2023). An Integrated Neutrosophic Regional Management Ranking Method for Agricultural Water Management. Neutrosophic Systems With Applications, 1, 22–28. https://doi.org/10.61356/j.nswa.2023.4

[2] Saaty, T. L. (1980). The analytical hierarchy process, planning, priority. Resource allocation. RWS publications, USA.

[3] Başaran, Y., Aladağ, H., & Işık, Z. (2023). Pythagorean Fuzzy AHP Based Dynamic Subcontractor Management Framework. Buildings, 13(5), 1351. https://doi.org/10.3390/buildings13051351

[4] Waleed Tawfiq Al-Nami. (2023). Ranking and Analysis the Strategies of Crowd Management to Reduce the Risks of Crushes and Stampedes in Crowded Environments and Ensure the Safety of Passengers. Neutrosophic Systems With Applications, 8, 61–78. https://doi.org/10.61356/j.nswa.2023.50

[5] Singh, V., Kumar, V., & Singh, V. B. (2023). A hybrid novel fuzzy AHP-Topsis technique for selecting parameter-influencing testing in software development. Decision Analytics Journal, 6, 100159. https://doi.org/10.1016/j.dajour.2022.100159

[6] Tzeng, G. H., & Huang, J. J. (2011). Multiple attribute decision making: methods and applications. CRC press.

[7] Hajiaghaei-Keshteli, M., Cenk, Z., Erdebilli, B., Özdemir, Y. S., & Gholian-Jouybari, F. (2023). Pythagorean fuzzy TOPSIS method for green supplier selection in the food industry. Expert Systems with Applications, 224, 120036. https://doi.org/10.1016/j.eswa.2023.120036

[8] Toker, K., & Görener, A. (2023). Evaluation of circular economy business models for SMEs using spherical fuzzy TOPSIS: an application from a developing countries' perspective. Environment, development and sustainability, 25(2), 1700-1741. https://doi.org/10.1007/s10668-022-02119-7

[9] Gurmani, S. H., Chen, H., & Bai, Y. (2023). Multi-attribute group decision-making model for selecting the most suitable construction company using the linguistic interval-valued T-spherical fuzzy TOPSIS method. Applied Intelligence, 53(10), 11768-11785. https://doi.org/10.1007/s10489-022-04103-0

[10] Kutlu Gündoğdu, F., & Kahraman, C. (2019). Spherical fuzzy sets and spherical fuzzy TOPSIS method. Journal of intelligent & fuzzy systems, 36(1), 337-352. https://doi.org/10.3233/JIFS-181401

[11] Jan, N., Mahmood, T., Zedam, L., Abdullah, L., & Ullah, K. (2021). Analysis of double domination by using the concept of spherical fuzzy information with application. Journal of Ambient Intelligence and Humanized Computing, 1-16. https://doi.org/10.1007/s12652-021-03370-y

[12] Akram, M., Zahid, K., & Kahraman, C. (2023). Integrated outranking techniques based on spherical fuzzy information for the digitalization of transportation system. Applied Soft Computing, 134, 109992. https://doi.org/10.1016/j.asoc.2023.109992