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Ranking Strategic Goals with Fuzzy Entropy Weighting and Fuzzy TOPSIS Methods: A Case of the Scientific and Technological Research Council of Türkiye

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Abstract: This study involves an integrated approach consisting of the Fuzzy AEW Method which considers all relevant criteria and involves the contribution of all members of a strategic planning team in the determination of strategic goals as well as the Fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method. The Fuzzy AEW method has been used in weighing the criteria whereas the Fuzzy TOPSIS method has been used in determining the order of the alternatives. This article presents a real-world case using this model in setting targets for improving the institutional capacity of the Scientific and Technological Research Council of Türkiye (TÜBITAK). In this study, strategic goals have been set forth considering the opinion of strategic planning experts and previous strategic plans, and then the said method has been applied. The model could easily be applied both in the public and private sectors. This new model involves the effective planning of scarce resources and ensures digitalization in planning as well as the determination of goals through analytical methods. Ineffective meetings and workshops of the past will be replaced by a participatory and transparent structure.

Keywords: fuzzy AEW; fuzzy TOPSIS; multi-criteria decision-making (MCDM); strategic planning; strategic management; goal selection

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1. Introduction

Strategy development is one of the most significant phases of the management process. Strategic planning involves determining medium to long-term goals for an institution/organization and allocating relevant resources. This phase requires a decision-making process to choose the most appropriate goals and targets. Since strategic goals determine an institution's/organization's roadmap in the mid-term, they must be laid down using analytical methods and these goals need to meet certain criteria. As these goals are set forth; there is a need to adopt an analytical method that would take these criteria into account and include the opinion of all the strategic planning team members. The 2018 and 2021 Strategic Planning Guidelines for Public Administrations imposed limitations on the number of goals to be set and required the determination of at least two goals and at most seven goals. In line with these limitations, strategic planning needs analytic and high-precision, decision-making algorithms. Addressing the issue of strategic planning only through numerical, measurable factors may not be sufficient. Since it is based on vague, uncertain data and is difficult to express through data and figures; Fuzzy Anti-Entropy Weighting (AEW) stands out as one of the most convenient methods in that sense.

Strategic planning is the process of setting long-term goals, prioritizing actions to achieve the goals, and mobilizing human and financial resources to execute the actions, is a valuable tool for anticipating and addressing such challenges [1].

It is an important step in the strategic planning phase in terms of determining strategic goals, allocating corporate resources more accurately, and understanding preferences and priorities more easily. Strategic goals, which are the captain of the plan, should reflect the results and effects that the management wants to achieve. This critical phase should be conducted in a participatory manner using analytical methods. For this reason, the aim is to select the objectives with the equal participation of all decision-makers and in the light of the determined criteria.

Determining strategic goals plays a key role in preparing a successful strategic plan. This critical phase should be conducted in a participatory manner using analytical methods. For this reason, it is aimed to select the objectives with the equal participation of all decision makers and the determined criteria.

In accordance with the "Public Finance Management and Control Law of the Republic of Türkiye" numbered 5018 and dated 10 December 2003, all public institutions in Türkiye are obliged to prepare a strategic plan (Article 9). Institutions in Türkiye are preparing their strategic plans in accordance with version 3.1 of the "Strategic Planning Guide for Public Administrations" published in 2021. This situation creates the need to make a choice. For these reasons, a selection-ranking model is needed to determine the goals. In the Strategic Planning Guide for Public Administrations, it is stated that strategic goals are criteria that must be met with institutional capacity is imposed. Within the scope of the study, an analytical model has been proposed that will facilitate the creation of strategic goals with equal participation and enable institutions to prepare their own strategic plans.

Goal selection is a complex process involving uncertainty. Each decision maker may place more emphasis on the purpose related to the operation of the department. Due to this uncertainty, it is possible that the decisions regarding the goals are subjective. It is apparent that fuzzy logic is a practical and effective approach that can be used in the problem of strategic goal selection.

It is obvious that the evaluation of the 5-year goal alternatives of the Institution with the criteria specified in the guide and the determination of the most suitable ones are Multi-Criteria Decision Making (MCDM) problems. For this reason, Zadeh developed the use of fuzzy set theory with MCDM methods. This allows the modelling of human judgment and even experience, unlike traditional MCDM methods, which would be the most suitable solution [2].

In the scope of this study, fuzzy MCDM methods, which can be defined as a group of methods that produce analytical solutions for decision-makers under uncertainty, have been used because the problem is participatory and has a multi-criterion structure.

It is recommended to weight the criteria with the Anti-Entropy Weighting (AEW) method, which is an important method used in management decisions, and to rank the alternative targets with the TOPSIS method, which is a frequently used ranking algorithm in the literature, which produces effective results with these weights and has many advantages.

The basis of strategic planning includes goals, objectives set under these goals, and the strategies to be developed. This very significant phase of planning, which sets forth the 5-year goals and objectives for companies, is unfortunately prone to the domination of the organization's managers/directors through inefficient meetings. This study focuses on the definition of strategic goals by eliminating the decision-making process followed during inefficient meetings where dominant managers steer the process, and introduces an analytical decision-making model. To the best of the authors' knowledge, no study in the literature has used this method to select strategic goals in Türkiye.

This study considers the criteria set forth in the Strategic Planning Guideline and aims to provide an analytical solution to this significant problem.

In this study we propose an integrated approach consisting of the Fuzzy Anti-Entropy Weighting (AEW) method and the Fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method to select strategic goals for the institutional capacity of the Scientific and Techno logical Research Council of Türkiye (TÜBİTAK) (See Figure 1).

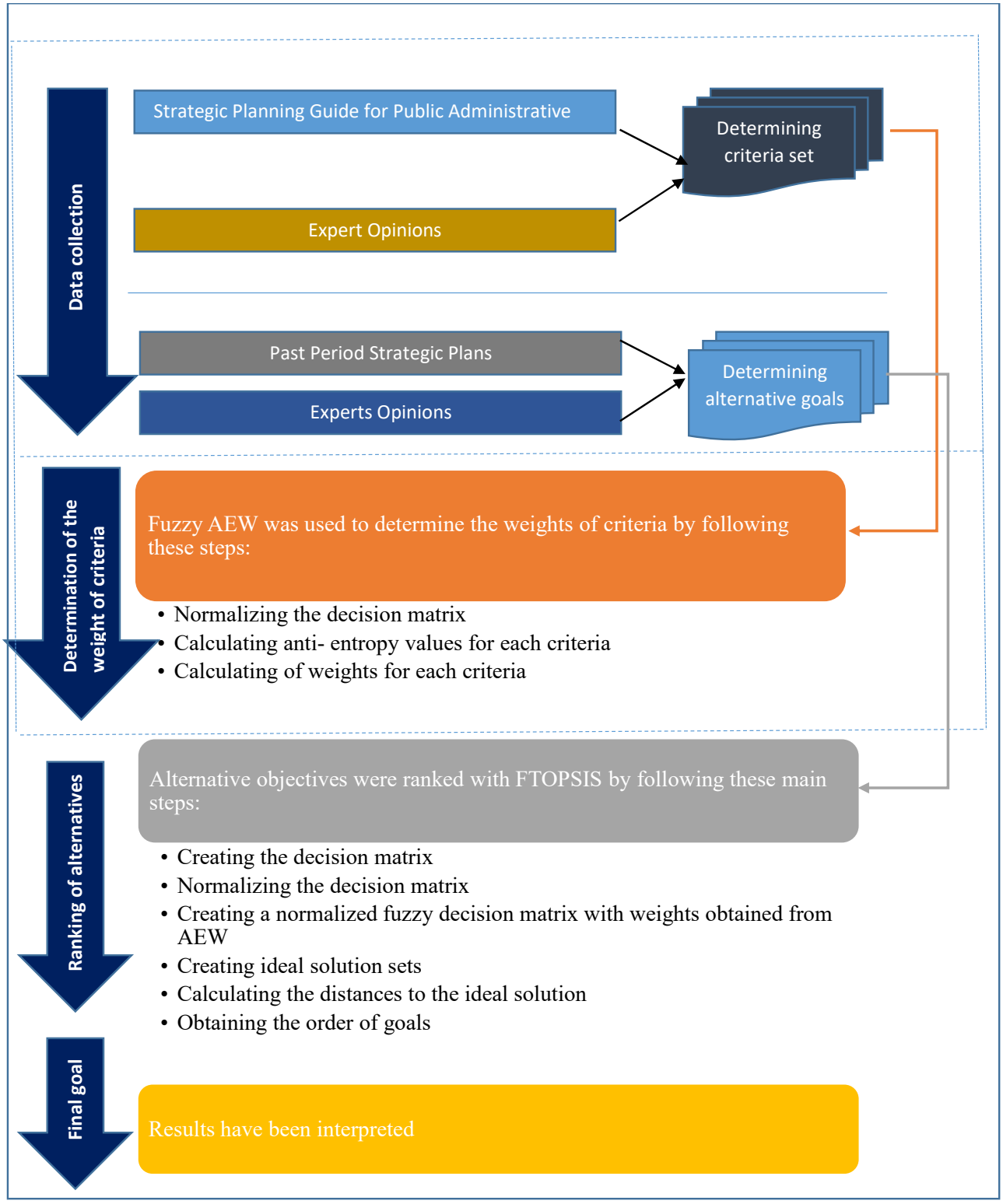

Figure 1. Working systematic of proposed methodology.

TÜBİTAK is a non-profit governmental organization in Türkiye whose main duties are:

- Developing scientific and technological policies;
- Managing R&D institutes;
- Conducting research, technology, and development studies in line with national priorities;
- Acting as advisory agency to the Turkish government;

As an advisory agency, strategic planning is one of the most crucial tasks carried out at TÜBİTAK.

The general methodology for strategic goal selection is as follows: The strategic planning team receives the input of stakeholders. Draft objectives are submitted to the Strategy Development Board for evaluation. The board consists of several senior executives. All these processes are carried out with a lot of official correspondence and inefficient meetings. There are many criteria to be considered in the selection of objectives. However, unfortunately, not all criteria can be considered in the meetings with discussions. If the selected objectives do not meet the criteria sufficiently, they are not accepted by the Presidency of Strategy and Budget, and are sent back. This causes all the efforts to be wasted and the process to be started again. Another disadvantage of this current process is that the dominant executives, who are members of the board, usually say something. This hinders objective and equal participation. However, strategic objectives should reflect the "ideal" and "common" view of the administration for the future.

The number of objectives that can be selected is limited. There is a strong need for a method that can ensure equal participation and make selections considering the criteria that the objectives must meet.

The contributions of this study, which focuses on the identification and analysis of performance indicators for the goal of increasing Türkiye's competitiveness in the defense, space, and aviation sectors and developing high-value-added technology, products, and services, as far as is known from the literature, are as follows:

- Application and applicability: Strategic objectives are very important in terms of determining what the organization intends to achieve. Goals, performance indicators, and the route of the institution is determined according to these goals. At this point, determining the strategic goals with the model we propose will provide a reference point for determining the competitive, growth and innovative power it will create with its talents and resources, and the place it will reach in the future, which will guide the activities of the institution. Using such an analytical method; decision making and resource management, performance improvement, accountability and reputation will make significant contributions. Determining strategic goals is a problem of both the public and private sectors. Our model is a tool that can be easily used by all sectors such as private, public and academia in solving this problem.
- Economic benefit: Government and public institutions determine and implement their strategic policies through objectives; private sector stakeholders shape their business strategies with strategic objectives and maintain their competitive advantage; academic and research organizations analyze developments in the industry and provide science-based recommendations to policy makers; on the other hand, non-governmental organizations and industrial unions follow the responsibilities related to the sector and measure the social impact. Analytical evaluation of the objectives will contribute to obtaining economic benefits and taking the necessary steps to grow on a sustainable axis by ensuring the participation of these stakeholders.
- Academic: As far as is known from the literature, there is no comprehensive study that specifically focuses on the prioritization of the objectives included in the strategic plans and especially the institutional capacity objectives. Therefore, the importance of this study is that it contributes to decision makers making more informed and data-based decisions by providing a framework for determining and prioritizing strategic goals. This study will be a valuable resource for decision makers to shape the future of institutions and organizations.
- Methodology: The use of fuzzy language scales and the involvement of experts reveal the unique aspects of the methodology. This approach allows us to analyze subjective assessments objectively and combines the views of different stakeholders in a balanced way. This methodology strengthens the decision-making processes and supports obtaining more accurate and effective results in determining the objectives.

The model proposed in the article has been applied in determining the institutional capacity goal of TÜBİTAK. There are four main chapters in this study. Section 2 gives a literature review. Section 3 consists of the importance of strategic planning, how the choice of purpose is made, and the contributions of the study to the literature and studies in the literature. MCDM methods used in solving the problem are introduced, and the methodology is presented in Section 4. Finally, in Section 5, the application of the proposed methodology has been performed to determine the institutional capacity goal of TÜBİTAK, and the study has been completed with the conclusion sections.

2. Literature Review

Considering the studies in which analytical methods are used while making strategic planning, multi-criteria decision-making techniques; genetic algorithms; and mathematical methods are the most frequently used. Furthermore, the MCDM techniques are used in the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis part of the strategic planning (Table 1).

Table 1. Summary of the literature review in strategic planning.

Reference	Field of Application	Method Used
Wruk et al. [3]	Low-voltage networks	Generic Algorithm
Nasab and Milani [4]	Tile company	Fuzzy MCDM
Dyson [5]	University	SWOT analysis
Fagerholt et al. [6]	Maritime transportation	Monte Carlo simulation and mathematical modelling
Brauers and Weber [7]	General	Scnario Analysis and mathematical modelling
Milani et al. [8]	General	ELECTRE
Chang and Chinh [9]	Photovoltic Distribution	Coyote Optimization Algorithm
Esfandiari and Rizvandi [10]	General	TOPSIS

The adoption of the MCDM techniques and selection methods dates to 2000. A good survey on MCDM method and its applications is given in Aruldoss et al. [11] and in Yalcin et al. [12].This approach starts with Analytical Hierarchy Process (AHP) and prioritizes SWOT components. The hybrid method was tested together with a case study of forest certification. They also used the results of SWOT-AHP method to evaluate two strategies as timber-production-oriented forestry and forestry according to certification criteria however were not included in the AHP hierarchy as decision alternatives [13].

SWOT analysis, AHP and strategy alternatives were first integrated by Kurttila et al. [13] with the development of a new method: "A'WOT analysis". In 2003, the same researchers improved this method by adding some details. A hybrid method of the Stochastic Multi-Criteria Acceptability Analysis with Ordinal criteria (SMAA-O) and SWOT was developed as an elaboration of the basic ideas of A'WOT. The method is called S-O-S (SMAA-O in SWOT). SMAA-O enables the handling of ordinal preference information as well as mixed data consisting of both ordinal and cardinal information. When using SMAA-O, it is enough to rank decision elements instead of giving them cardinal preference or priority ratios as required by the most-used MCDM methods. Using SMAA-O, in addition to analyzing what the recommended action is under certain priorities of the criteria, enables one to analyze what kind of preferences would support each action. SMAA-O belongs to the family of Stochastic Multi-criteria Acceptability Analysis (SMAA) methods. SMAA methods have been developed for discrete multi-criteria problems, where criteria data are uncertain or inaccurate and where, for some reason, it is impossible to obtain accurate or any weight information from the decision makers SMAA methods are based on exploring the weight space in order to describe the valuations that would make each alternative to be the preferred one, or that would give a certain rank to an alternative. In their problem, some criteria are measured on ordinal scales. Ordinal rank information cannot be treated as cardinal data in arithmetic computations. In summary, instead of calculating the classical pairwise comparison of A'WOT method, they order the decision elements which are criteria and decision alternatives according to their

priority caused by their conditional distribution [14]. Polat used A'WOT analysis to determine the strategy for the cadastre 2034 vision [15].

3. Strategic Goals

Strategic plans are the core outputs of the strategic planning process and formalize the problems and objectives set by decision makers and stakeholders [1]. Setting goals correctly is one of the most important factors in the success of the plan.

Strategic objectives are a very important issue in the strategic planning phase. Strategic goals, which are the captain of the plan, are the conceptual expressions of the results that the organization aims to achieve.

Pursuant to the "Public Finance Management and Control Law of the Republic of Türkiye numbered 5018 and dated 10 December 2003, all public institutions in Türkiye are obliged to make strategic plans (Article 9). The institutions in Türkiye prepare their strategic plans in accordance with the "Strategic Planning Guide for Public Administrations", version 3.1 published in 2021. In the Guide, it is stated that there are criteria that strategic goals must have. According to the guidelines, the points to be considered in determining goals are as follows:

i. It is important that the goals are assertive but accessible.
ii. It clearly reveals the desired point to be reached but should not give details on how to reach it.
iii. Must cover a medium- and long-term time frame.
iv. It should be a framework for the objectives.

In addition to these, the number of goals is limited to between two and seven in the guide. It states that one of them should be related to the development of institutional capacity. This situation creates the need to make a choice. Therefore, a selection method is needed to set goals.

Setting goals correctly is one of the most important factors in the success of the plan. Strategic goals should be strengthened by policies and projects in practice. In real life, strategic goals are determined in workshops and meetings organized by public institutions. Drafts of targets are prepared by strategic planning teams with the support of spending units. Institutions should also consider the Development Plan Corporate Responsibilities Table when determining their targets.

Unfortunately, inefficient meetings shape the future of the 5-year goals and objectives of the institutions. In the selection of strategic goals, the discourses of dominant managers are generally considered and a selection-ordering technique is not used. However, for a successful strategic plan, this stage must be carried out in a participatory manner.

For these reasons, a ranking and selection model is needed to identify goals. Since the institution in question has 5-year goals, it is important to make this choice with analytical methods.

Goal selection is a complex process involving uncertainty. Each decision maker can give more importance to the purpose of his department's work. Due to this uncertainty, it is possible that the decisions regarding the targets include subjectivity. Therefore, the strategic planning team needs experience, knowledge, to working across different departments, etc. Different logical systems will be needed to model subjective judgments. Criteria and values estimated by experts are defined by linguistic expressions such as "high" or "low". For these expressions to be used in mathematical operations, the process must be managed with different approaches. It is apprent that fuzzy logic is a practical and effective approach that can be used in the problem of strategic goal selection.

It is obvious that the evaluation of goal alternatives of the Institution with the criteria specified in the guide and the determination of the most suitable ones are MCDM problems. For this reason, the use of fuzzy set theory with MCDM methods would be the most suitable solution.

4. Methods

In this study, Fuzzy AEW was used to determine the weights of criteria. The determined criteria were evaluated by experts. Then, the order of alternatives with the Fuzzy TOPSIS was realized. This part of the study is aimed at providing information on using analytical approaches. The method used in this study is as follows:

- Creating the decision matrix
- Normalizing the decision matrix
- Creating a normalized fuzzy decision matrix with weights obtained from AEW
- Creating ideal solution sets
- Calculating the distances to the ideal solution
- Obtaining the order of goals

4.1. Anti-Entropy Weighting

AEW technique is an important method used in weight calculation by applying management decisions. The concept of entropy was introduced by thermodynamics in physics, which represents an information theory of the degree of disorder of a system. The entropy weighting method can use an accurate calculation to determine the uncertainty probability of random events. The weight calculation of the corresponding entropy not only has the advantages of high accuracy, adaptability, and objectivity, but can also reduce the influence of human subjective factors in the evaluation process [16].

The weight of criteria are calculated according to the decision matrix. In particular, the method is responsible for producing detailed data. The following steps describe how criteria weights are determined via the AEW method.

Step 1: The decision matrix is normalized as given in Equation (1).

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \tag{1}$$

i**:** alternatives;
j**:** criteria;
P_{ij}**:** normalized value;
X_{ij}**:** the value of the benefit given.

Step 2: Anti-entropy values are calculated for each criterion. The anti-entropy can be obtained via Equation (2). Entropy value:

$$e_{ij} = -\frac{1}{\ln m} \sum_{i=1}^{m} P_{ij} \ln P_{ij} \tag{2}$$

$\frac{1}{\ln m}$: entropy coefficient;
e_{ij} **:** entropy value.

Step 3: The weight of each criterion is calculated. The determination of the criteria's weights is important in MCDM problems in terms of aining accurate results.

The goal weights of criteria are derived considering the information provided by the decision matrix. The weights of criteria can be determined objectively by calculating entropy measures of criteria.

Low values of entropy reveal that the evaluation scores of the alternatives, according to a criterion, are less similar and more information is transmitted by the criterion, and thus, the weight of the criterion is higher [17].

In this step, the weights of criteria are obtained with the help of the IF-entropy measure, which can be obtained via Equation (3).

$$w_i = \frac{1 - e_{ij}}{\sum_{j=1}^{n} (1 - e_{ij})} \tag{3}$$

w_i : importance level.

4.2. Fuzzy TOPSIS

The TOPSIS method is one of the common MCDM approaches [18]. The option chosen in this method should be the minimum distance from the Positive Ideal Solution and the greatest distance from the Negative Ideal Solution [19].

Fuzzy TOPSIS is a frequently used multi-criteria decision-making system that can rank many alternatives with the advantages of quickly identifying the best alternative among the leading methods [20].

This method includes 6 main steps:

Step 1: The decision matrix is created.

Step 2: The decision matrix is subjected to normalization process. Normalization is a mathematical process that allows the comparison of each criterion to [0, 1], and to compare the results. The mathematical representation of a fuzzy normalized decision matrix is given in Equations (4)–(7).

$$r_{i,j} = \frac{X_{i,j}}{u_j^+} = \left(\frac{l_{X_{ij}}}{u_j^+}; \frac{m_{X_{ij}}}{u_j^+}; \frac{u_{X_{ij}}}{u_j^+} \right) \; j \; \epsilon B \tag{4}$$

$$r_{i,j} = \frac{l_j^-}{X_{i,j}} = \left(\frac{l_j^-}{u_{ij}^+}; \frac{l_j^-}{m_{ij}^+}; \frac{l_j^-}{l_{ij}^+} \right) j \; \epsilon \, C \tag{5}$$

$$u_j^+ = max\left(u_{i,j}\right) \; \forall i = 1, \ldots.., m \quad j \; \epsilon \; B \tag{6}$$

$$l_j^- = min\left(l_{i,j}\right) \quad \forall i = 1, \ldots.., m \quad j \; \epsilon \; C \tag{7}$$

$r_{i,j}$: normalized fuzzy decision matrix.

Equations for the normalization process are handled in two cases: benefit and cost. If the criterion is a criterion of benefit or cost criterion, the above procedures are performed.

Step 3: w_j is the weight of each criterion and the decision matrix is multiplied by w_j values to obtain a weighted normalized fuzzy decision matrix.

$$\widetilde{v}_{i,j} = \widetilde{r}_{i,j} * w_j$$

$\widetilde{v}_{i,j}$: weighted normalized fuzzy decision matrix.

Step 4: In this step, fuzzy positive ideal solution $\mathbf{A^+}$, and fuzzy negative ideal solution $\mathbf{A^-}$ are obtained. Mathematical equations for obtaining ideal solutions are given in Equations (8)–(11):

$$\boldsymbol{A}^+ = (V_1^+; \; V_J^+, \ldots\ldots\ldots, \; V_n^+) \tag{8}$$

$$\boldsymbol{A}^- = (V_1^-; \; V_J^-, \ldots\ldots\ldots, \; V_n^-) \tag{9}$$

$$V_J^+ = \begin{cases} (1,1,1) j \; \epsilon B \\ (0,0,0) j \; \epsilon C \end{cases} \tag{10}$$

$$V_J^- = \begin{cases} (0,0,0) j \; \epsilon B \\ (1,1,1) j \; \epsilon C \end{cases} \tag{11}$$

$\boldsymbol{A}^+$**:** fuzzy positive ideal solution;
$\boldsymbol{A}^-$**:** fuzzy negative ideal solution.

For the positive ideal solution and for the negative ideal solution, it can be seen that the fuzzy expression of the structures determined in terms of the benefit and cost criteria differ from each other.

Step 5: After obtaining fuzzy positive and negative ideal solutions, n-dimensional separation distances are obtained.

The fuzzy optimal ideal solution distance and the worst ideal solution distance are calculated via Equations (12) and (13), respectively. The distance measurement between two fuzzy numbers is represented as d (. , .).

$$D_J^* = \sum_{j=1}^{n} d(\widetilde{v}_{ij}, \widetilde{v}_i^*) \quad j = 1, 2, ...J \tag{12}$$

$$D_J^- = \sum_{j=1}^{n} d(\widetilde{v}_{ij}, \widetilde{v}_i^-) \quad j = 1, 2, ...J \tag{13}$$

In the current study, the distance between two fuzzy numbers was measured via the Vertex Method in Equation (14):

$$d\left(\widetilde{A}_1, \widetilde{A}_2\right) = \sqrt{1/3[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2} \tag{14}$$

Step 6: The closeness index is calculated for each criterion in the last step. The calculation of this index is in Equation (15):

$$CC_J = \frac{D_J^-}{D_J^* + D_J^-} \quad j = 1, 2, ...J \tag{15}$$

CC_J **:** closeness coefficient

5. Case Study

To demonstrate the applicability/feasibility of the suggested model; the goal of building the institutional capacity of TÜBİTAK has been selected. A literature review has been made during the selection of the strategic goal and the opinion of an experienced strategic planning expert, who works for the Department of Strategy Development at TÜBİTAK, has been sought. Three of the criteria, which affect the selection process of goals, were taken from the Strategic Planning Guideline prepared by the Presidency of the Republic of Türkiye and these criteria are assertiveness, covering medium and long-term frames, and clarity. Since the guideline introduced the obligation for setting an objective on institutional capacity, another criterion, the fourth criterion, has been added, which is the "institutional capacity framework".

Five alternative goals have been defined as a result of the literature review and the previous strategic plans of TÜBİTAK.

5.1. Data Collection

A strategist working in the institution was consulted about what the alternatives could be. For confidentiality reasons, the identity of the expert is not disclosed here. It has been decided that these data can be obtained from the old strategic plans of the institution.

Thus, all the past corporate strategic plans were examined, and 27 goals were analyzed. Together with the strategist, those related to institutional capacity were selected. Guidelines were taken as the basis for establishing the criteria. As a result of this stage, goal alternatives and evaluation criteria set were created.

5.1.1. Institutional Capacity Improving Objective Alternatives

In the guidebook, there must be a purpose for developing institutional capacity. The first strategic plan of the council covered the years 2008–2012. The last one is for the 2019–2023 period, and four strategic plans have been published to date. There are 28 aims in total, of which only 3 are for institutional capacity improvement.

The aim of developing five alternative institutional capacities has been determined by a strategic planning expert in the strategy development unit of the council. Three of these are strategic goals in this area, in the previous periods. All the previous institutional

strategic goals have been taken as alternatives. The other two are the goals suggested by the Strategy Development Unit. All aim alternatives are as follows:

GOAL 1: Strengthening institutional capacity and human structure.

GOAL 2: To improve the corporate governance, informatics, and communication capacity to ensure efficient, fast, reliable, and transparent operation of the activities of the council's units (2019–2023 Strategic Plan (SP)).

GOAL 3: Conducting studies to increase the administrative and managerial power of the council.

GOAL 4: To ensure the establishment of the legal and administrative infrastructure that will enable the effective realization of science, technology, and innovation activities throughout the country (2008–2012 SP).

GOAL 5: Improving corporate governance and information capacity (2018–2022 SP).

5.1.2. Institutional Capacity Improving Goal Criteria

Assertiveness, medium–long term, and openness are the features that the goals listed in the guide should have. In practice, since the problem of choosing the institutional capacity goal has been studied, the criterion of the "institutional capacity framework" has also been determined as one of the evaluation criteria. What the criteria mean is outlined in Table 2.

Table 2. Criteria Definitions.

Criteria Number	Criteria	Definition
C1	Assertiveness	A goal should be assertive but achievable.
C2	Being Medium–Long Term	It should cover a medium and long-term time frame.
C3	Clarity	It clearly reveals the desired outcome to be achieved but should not give details on how to achieve it.
C4	Institutional Capacity Framework	It should be a framework for the Institutional Capacity Improvement Goals.

5.2. Proposed Methodology

The proposed model includes five institutional capacity goals. It is aimed to evaluate them using four criteria. For this, the hierarchical model in Figure 2 was created.

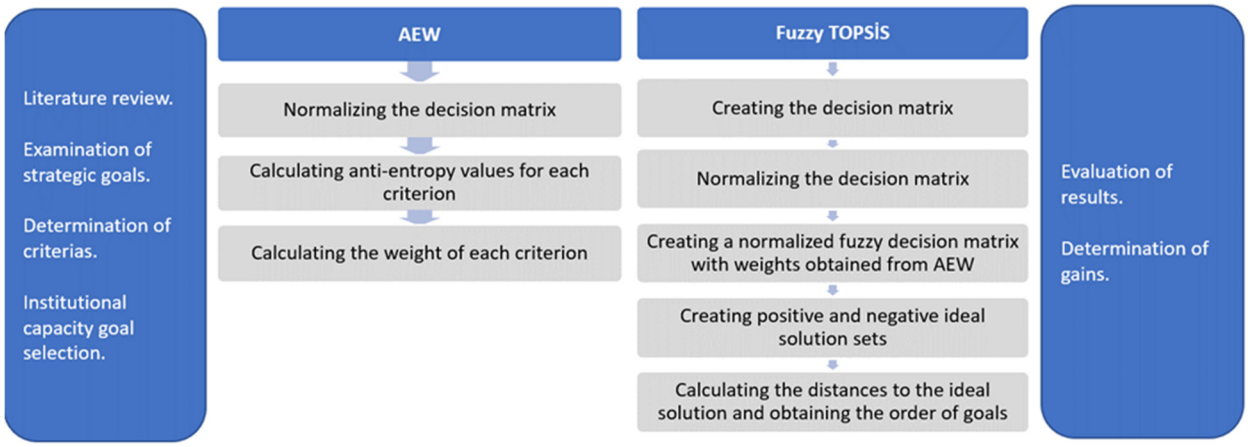

Figure 2. Conceptual framework of case study.

5.2.1. Weighting Evaluation Criteria Using Anti-Entropy Method

Linguistic decision matrix is given in Table 3. To determine the severity criteria, the decision matrix consisting of 4 evaluation criteria and 5 alternatives was created as in Table 4.

Table 3. Linguistic Decision Matrix.

	Assertiveness	Medium–Long Term	Institutional Capacity Framework	Clarity
GOAL 1	VH	VH	M	H
GOAL 2	VH	H	H	E
GOAL 3	M	H	M	M
GOAL 4	M	H	M	H
GOAL 5	H	M	H	H

Table 4. Decision Matrix.

	Assertiveness			Medium–Long Term			Institutional Capacity Framework			Clarity		
GOAL 1	(0.6)	0.8	(1)	(0.6)	0.8	(1)	(0.2)	0.4	(0.6)	(0.6)	0.8	(1)
GOAL 2	(0.6)	0.8	(1)	(0.4)	0.6	(0.8)	(0.4)	0.6	(0.8)	(0.8)	1	(1)
GOAL 3	(0.2)	0.4	(0.6)	(0.4)	0.6	(0.8)	(0.2)	0.4	(0.6)	(0.2)	0.4	(0.6)
GOAL 4	(0.2)	0.4	(0.6)	(0.4)	0.6	(0.8)	(0.2)	0.4	(0.6)	(0.4)	0.6	(0.8)
GOAL 5	(0.4)	0.6	(0.8)	(0.2)	0.4	(0.6)	(0.4)	0.6	(0.8)	(0.4)	0.6	(0.8)

After the decision matrix is formed, the entropy values of criteria, the degree of difference, and importance weights were calculated by using the equations according to the Anti-Entropy Weight method steps and fuzzy arithmetic operations and presented in Table 5. The most important criterion is Institutional Capacity Framework.

Table 5. The Entropy Values, Degree of Difference, and Importance Weights of Criteria.

	Assertiveness	Medium–Long Term	Institutional Capacity Framework	Clarity
Entropy Values (e_{ij})	0.9334	0.9485	0.9181	0.9513
Divergences ($1 - e_{ij}$)	0.0666	0.0515	0.0819	0.0488
Weights (w_j)	0.2676	0.2072	0.3293	0.1959

Criteria have been weighed through the evaluation of the expert and the AEW method. The results of the evaluation of the criteria in the study by the expert team show that the Institutional Capacity Framework is the most important criterion (0.3293). Assertiveness has a secondary priority (0.2676) and Being Medium–Long Term has a tertiary priority (0.2072) by taking expert opinions. Clarity criteria are ranked last (0.1959).

5.2.2. Selection of Goal Using Fuzzy TOPSIS

Application steps for the Fuzzy TOPSIS method were given. The results of the calculations conducted following the application steps related to the problem are given in Tables 4 and 5. All criteria are criteria of benefit in terms of the evaluation of alternatives.

A weighted assessment for alternative institutional capacity goals is given in Table 6.

Table 6. Weighted Assessment for Alternative Institutional Capacity Goals.

	Assertiveness	Medium–Long Term	Institutional Capacity Framework	Clarity
Goal 1	(0.1606 0.2141 0.2676)	(0.1243 0.1657 0.2072)	(0.0659 0.1317 0.1976)	(0.1176 0.1568 0.1959)
Goal 2	(0.1606 0.2141 0.2676)	(0.0829 0.1243 0.1657)	(0.1317 0.1976 0.2634)	(0.1568 0.1959 0.1959)
Goal 3	(0.0535 0.1070 0.1606)	(0.0829 0.1243 0.1657)	(0.0659 0.1317 0.1975)	(0.0392 0.0784 0.1176)
Goal 4	(0.0535 0.1070 0.1606)	(0.0829 0.1243 0.1657)	(0.0659 0.1317 0.1975)	(0.0784 0.1176 0.1567)
Goal 5	(0.1070 0.1606 0.2141)	(0.0414 0.0829 0.1243)	(0.1317 0.1976 0.2634)	(0.0784 0.1176 0.1567)

According to goal ranking based on fuzzy TOPIS results, Goal 2 is the first with 0, 18,302 stated in Table 7.

Table 7. Goal Ranking.

Rank	Goals	D_J^*	D_J^-	CC_J
1	Goal 2	3.28503696	0.735891755	0.18302
2	Goal 1	3.335877282	0.689910164	0.17137
3	Goal 5	3.445575621	0.582507748	0.14461
4	Goal 4	3.523337426	0.508555358	0.12613
5	Goal 3	3.562504745	0.471366902	0.11685

GOAL 2: To improve the corporate governance, informatics and, communication capacity to ensure efficient, fast, reliable and transparent operation of the activities of the council's units (2019–2023 Strategic Plan (SP)).

6. Results and Discussions

In this study, an integrated approach that combines Fuzzy AEW) and Fuzzy TOPSIS methods, has been adopted. This study suggests the use of Fuzzy AEW—a significant method used in management decisions while weighing the criteria and Fuzzy TOPSIS, one of the most efficient algorithms among multi-criteria decision-making methods for sequencing the alternatives in the literature.

To demonstrate the applicability/feasibility of the suggested model; the goal of building the institutional capacity of TÜBİTAK has been selected in this study. A literature review has been made during the selection of the strategic goals and the opinion of an experienced Strategic Planning expert, who works for the Department of Strategy Development at TÜBITAK, has been sought. Three of the criteria, which affect the selection process of the goals, were taken from the Strategic Planning Guideline prepared by the Presidency of the Republic of Türkiye and these criteria are assertiveness, covering medium- and long-term frames, and clarity. Since the guideline introduced the obligation for setting a goal on institutional capacity, another criterion, the fourth criterion, has been added, which is the Institutional Capacity Framework. A hierarchical model of selecting corporate capacity goals is given in Figure 3.

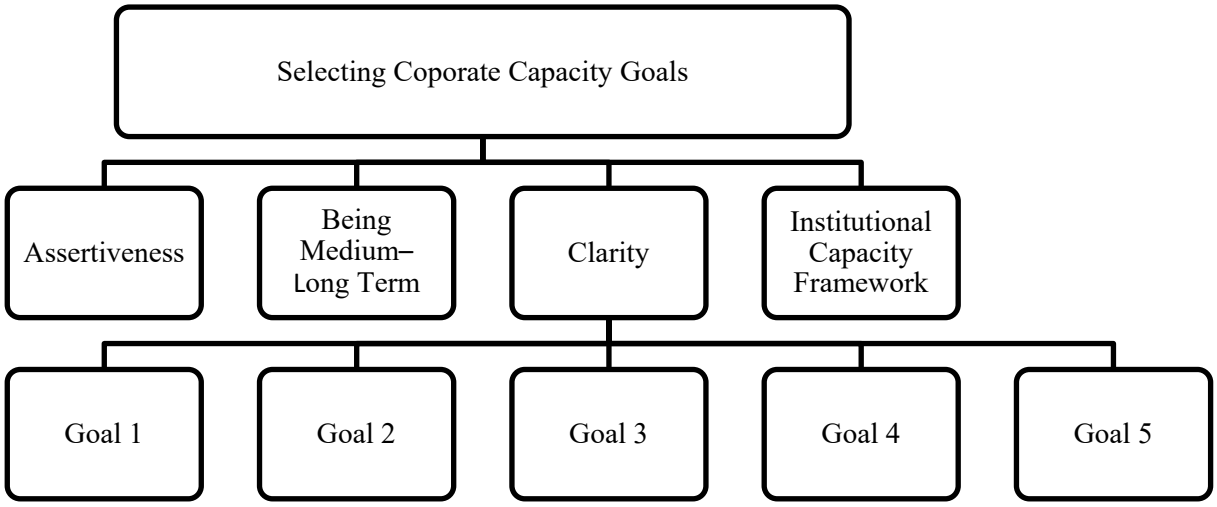

Figure 3. Hierarchical model of selecting corporate capacity goal.

Criteria have been weighed through the evaluation of the expert and the AEW method.

The results of the evaluation of the criteria in the study by the expert team show that the "Institutional Capacity Framework" is the most important criterion (0.3293). Goals should be assertive but achievable. Results show that Assertiveness has a secondary priority (0.2676). Goals should cover a medium and long-term time frame. Being Medium–Long Term has a third priority (0.2072) by taking expert opinions. Clarity means that it clearly

reveals the desired outcome to be achieved but should not give details on how to achieve it. It is apparent that the priorities of the criteria are ranked last (0.1959).

Alternative goals have been defined as the result of the literature review and the previous strategic plans of TÜBITAK. Three goals for the institutional capacity development of TÜBITAK have been detected in 2008–2012, 2018–2022, and 2019–2023's Strategic Plans and these goals have been defined as "alternative goals".

In addition to these, two more goals have been laid down: "strengthening institutional capacity and human resources" and "carrying out relevant activities to increase the administrative and managerial capacity of TÜBITAK", which were previously developed by the members of the strategic planning team.

As the result of the evaluation of these alternatives using the Fuzzy TOPSIS method, and seeking the opinion of the strategy development experts, Goal 2 has been selected as the final goal for developing institutional capacity. Goal 2 includes enhancing the managerial, governance and communication capacity of TÜBITAK departments to ensure that they operate at the fastest, most efficient, reliable, and transparent fashion possible (2019–2023 sp). This goal is published in the most recent version of the strategic plan of the organization. This reveals the effect of the suggested model.

7. Conclusions

Strategic planning is extremely important for organizations, as it provides a path for an organization to follow in the following five years and thus, mitigates the uncertainty the future holds. It has long been the preferred approach to strategy formulation in public organizations at all levels of government [21].

Since the determination of goals requires the assessment of decision-making criteria, it is a multi-criteria decision-making process. The multi-criteria decision-making process provides a beneficial and successful method to scrutinize three main decision-making challenges, namely selection, scoring, and sequencing [22].

It might not be sufficient to tackle the strategic planning issue merely through numerical and measurable factors. There is sufficient evidence to suggest relying on Fuzzy Decision-Making Methods, since strategic planning depends on ambiguous, vague data, and it is difficult to define the strategic planning process through numerical data.

In this study, a hybrid fuzzy MCDM methodology consisting of AEW and Fuzzy TOPSIS methods has been adopted. It suggests the use of Fuzzy AEW—a significant method used in management decisions while weighing the criteria, and Fuzzy TOPSIS, one of the most efficient algorithms among multi-criteria decision-making methods for sequencing the alternatives in the literature.

The greatest contribution of this study is that strategic goals could be set forth through analytical methods. Accurately set goals shall bring success to an organization. The model suggested in this study shall prevent the domination of the decision-making process by the organization's managers and thus, strategic goals can be set forth in an analytical manner.

The model may also be applied in other stages of strategic planning. This model could ensure a more effective rendering of strategic planning. The model could easily be applied to public sector administrations and private sector entities.

The model suggested in this study may also be applied in other stages of strategic planning. The use of the Model in defining the strategies shall also provide benefits. The model could evolve into a decision support system (DSS). MCDM methods constitute a very significant component of DSS in similar problems.

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