Article

An Integrated AFS-Based SWOT Analysis Approach for Evaluation of Strategies Under MCDM Environment

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Abstract

This article outlines the development of a hybrid methodology aimed to help the policymakers in strategic planning. The proposed methodology integrates the axiomatic fuzzy set (AFS) theory, analytic hierarchy process (AHP), and the concept of simple additive weighting (SAW) to evaluate the strategies by strengths, weaknesses, opportunities, and threats (SWOT) analysis. The combination of AHP with SWOT yields analytically determined weights of the factors included in SWOT analysis. The SAW technique provides a flexible technique to obtain the final ranking of strategies in multi-criteria decision situations. In SAW, the strategies are described using the AFS-based AHP calculation framework for normalization and consistent ratings over the SWOT factors. The AFS theory is incorporated in the model to overcome the uncertainty and ambiguity in human decision-making processes. The proposed integrated methodology copes with the inconsistency caused by different types of fuzzy numbers and normalization methods required in solving multi-criteria decision-making (MCDM) problems. A real-world application is conducted to illustrate the utilization of the model to evaluate SWOT analysis and strategies for tourism development.

Keywords

Strategic planning, multi-criteria decision-making, SWOT analysis, hybrid method, AHP, AFS theory

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Introduction

In order to stay effective and successful in the marketplace, every organization is required to perform strategic planning based on its internal and external environment. In general, the strategic planning process involves two main activities: formulation of strategies and choosing the best strategy from among multiple strategies to achieve the organizational objectives.

The formulation of a strategy requires environmental scanning for internal and external factors that may affect organizations' performance. A consistent study of the organization's environment helps in forecasting trends and decision-making processes of the organization. Strengths, weaknesses, opportunities, and threats (SWOT) analysis is a commonly used tool for assessing organizations' internal strengths and weaknesses as well as probable opportunities and threats from the external environment. It is a foundation to formulate the strategies that best align an organization's internal and external factors.

For effective planning and management, SWOT analysis is utilized by various industries, including agriculture (Wah & Merican, 2009), environment (Lozano & Valles, 2007), healthcare (Cicea, Busu, & Armeanu, 2011), marketing (Novicevic, Harvey, Autry, & Bond, 2004), general management (Jackson, Joshi, & Erhardt, 2003), coal (Niu, Song, & Xiao, 2017), medical tourism (Mohezar, Moghavvemi, & Zailani, 2017), and logistics (Rojas, 2018).

The literature review of conventional SWOT analysis reveals that the importance of factors is not quantified to provide the effect of each factor on the formulated strategy (Chang & Huang, 2006; Masozera, Alavalapati, Jacobson, & Shrestha, 2006) and therefore needs to be utilized with other scientific techniques, especially multi-criteria decision-making (MCDM) and quantifying techniques. The integration of SWOT analysis with MCDM techniques helps in systematically evaluating SWOT factors and equating their intensities (Ananda & Herath, 2003; Kurttila, Pesonen, Kangas, & Kajanus, 2000). In recent years, several studies have utilized MCDM techniques in SWOT analysis to attain a systematic approach and support the decision-making process (Ajmera, 2017; Ervural, Zaim, Demirel, Aydin, & Delen, 2018; Eslamipoor & Sepehriar, 2014; Görener, Toker, & Uluçay, 2012; Lee & Walsh, 2011; Singh, Chauhan, & Singh, 2015; Tavana, Zareinejad, Caprio, & Kaviani, 2016; Yavuz & Baycan, 2013).

It is important for organizations to adopt an optimal strategy to meet their objectives effectively. In general, determining an optimal strategy is a complex decision-making problem where different strategies dominate each other in terms of different factors. The optimal strategy among multiple strategies can be defined as the strategy with high performance on identified internal and external factors.

In practice, it is common to find strategy prioritization and selection process involving both quantitative and qualitative aspects. The quantitative aspects are generally assessed by means of precise numerical values, but qualitative aspects are complex to assess with precise and exact values. It is not possible to model such imprecise situations using traditional MCDM approaches and hence requires combining these with fuzzy logic and other techniques in a hybrid manner to deal with the qualitative aspects and uncertainty in the decision-making process. However, the fuzzy set theory deals with fuzzy numbers, and the use of different fuzzy numbers by decision-makers in different knowledge areas may lead to different results. In addition, a lot of normalization (converting different types of attribute values into the dimensionless form) methods have been developed and the choice of different methods might change the final selection and ranking for a specific problem (Jahan & Edwards, 2015).

This article focuses on the development of an integrated methodology aimed to help the policymakers in understanding an organization's internal and external factors, providing an analytical tool for developing effective strategies and selecting an optimal strategy to achieve organizational objectives. The integration of the axiomatic fuzzy set (AFS) theory, analytic hierarchy process (AHP), and simple additive weighting (SAW) approaches paves a new way for ranking strategies under the multi-criteria decision environment. AFS theory is utilized for modeling the fuzziness in human knowledge representation and the reasoning process.

The presentation of our work on developing an integrated methodology is organized as follows. In the second section, the background of MCDM techniques (AHP and SAW) is provided. The concept of AFS theory is also discussed in the second section. The third section outlines the development steps of methodology. The fourth section presents the utilization of developed methodology in a case study of tourism. In the fifth section, a comparative analysis and validation is reported. Finally, the sixth section concludes the article.

Theoretical Background

Although the theoretical background of AHP, AFS theory, and SAW has been documented in the literature, a brief outline of these methods is included further in the context of the present work.

Analytic Hierarchy Process (AHP)

AHP, developed by Saaty (1980), is a mathematical technique which addresses how to determine the relative importance of a set of criteria or factors in a decision problem. The ability to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria makes AHP an ideal methodology for prioritization problems having a set of potentially conflicting criteria. Recent literature reveals a large number of studies (Adhiarna, Hwang, Park, & Rho, 2013; Gumus, 2017; Myronidis, Papageorgiou, & Theophanous, 2016; Nagar & Raj, 2012; Pandey, Kumar, & Shrivastava, 2014; S. P. Singh & P. Singh, 2018; Singh et al., 2015; Taha, Banakar, & Tahriri, 2011) utilizing AHP and its variants to solve many complex decision problems.

The procedure of AHP starts with organizing the decision problem in a hierarchical structure of decision elements. Pair-wise comparisons are performed based on Saaty's (1980) standardized 9-point scale, as given in Table 1, to determine relative importance value (also known as weight) for each criterion using the eigenvalue calculation framework.

Table 1. Scale for Pair-wise Comparison

Intensity of Importance	1	3	5	7	9	2, 4, 6, 8
Definition	Equal	Moderate	Strong	Demonstrated	Extreme	Intermediate Value

Source: Saaty (1980).

Axiomatic Fuzzy Set (AFS) Theory

AFS theory, proposed by Liu (1998a), is a mathematical framework that aims to explore how fuzzy set theory and probability can be made to work in concert, so that the uncertainty of randomness and of imprecision can be treated in a unified and coherent manner. It provides an effective tool to convert the information in observed data into the membership functions and logic operations of fuzzy concepts. The literature review of AFS studies and their applications (Li et al., 2017; Li, Liu, & Chen, 2012; Liu, Feng, & Pedrycz, 2013; Liu, Wang, & Pedrycz, 2015; Ren, Li, Liu, & Li, 2016; S. P. Singh & P. Singh, 2018; Tian, Liu, & Wang, 2014) reveal that it is a flexible and powerful framework for representing human knowledge and studying intelligent systems in real-world applications.

AFS theory is based on the AFS algebra—a kind of semantic methodology of fuzzy concepts and the AFS structure—which is a kind of mathematical description of data structures.

Axiomatic Fuzzy Set (AFS) Algebra

Liu (1998a) defined a family of completely distributive lattices, referred to as AFS algebras, and applied them to study the semantics of expressions and representations of fuzzy concepts. In the MCDM environment, let $X=\{x_1,x_2,\ldots,x_5\}$ be a set of decision alternatives, $M=\{m_1,m_1^{'},\ldots,m_5,m_5^{'}\}$ be a set of fuzzy attributes on X, where m_1: 'attribute 1 is good', $m_1^{'}$: 'attribute 1 is not good', …, m_5: 'attribute 5 is good', $m_5^{'}$: 'attribute 5 is not good'. For each set of concepts $A\subseteq M, \prod_{m\in A} m$ represents a conjunction of the concepts in A; for instance, $A=\{m_2,m_4\}\subseteq M$, $\prod_{m\in A} m = m_2 m_4$ represents a new fuzzy concept 'attribute 1 is good and attribute 5 is good'. $\sum_{i\in I}\left(\prod_{m\in A_i} m\right)$, a formal sum of $\prod_{m\in A_i} m, A_i\subseteq M, i\in I$, is the disjunction of the conjunctions represented by $\prod_{m\in A_i} m$'s (i.e., the disjunctive normal form of a formula representing a concept). For instance, we may have $m_1m_2+m_1m_4+m_5$ which translates as 'attribute 1 and attribute 2 are good', 'attribute 1 and attribute 4 are good', or 'attribute 5 is good' (the '+' sign represents disjunction of concepts). For $A_i\subseteq M$ and $i\in I$, $\sum_{i\in I}\left(\prod_{m\in A_i} m\right)$ has a well-defined meaning as discussed earlier. The semantics of the logic expressions such as 'equivalent to', 'or', and 'and', as expressed by $\sum_{i\in I}\left(\prod_{m\in A_i} m\right)$, , can be formulated in terms of the AFS algebra (EM^*), defined as:

$$EM^* = \left\{\sum_{i\in I}\left(\prod_{m\in A_i} m\right) \mid A_i \subseteq M, i\in I, I \text{ is an non-empty indexing set}\right\} \quad (1)$$

Definition 1 (Liu, 1998a): Let M be a non-empty set; a binary relation R on EM^* is defined as follows: $\forall\sum_{i\in I}\left(\prod_{m\in A_i} m\right)$ and $\sum_{j\in J}\left(\prod_{m\in B_j} m\right)\in EM^*$, $\left[\sum_{i\in I}\left(\prod_{m\in A_i} m\right) R \sum_{j\in J}\left(\prod_{m\in B_j} m\right)\right] \Leftrightarrow$ (a) $\forall A_i\,(i\in I)$, $\exists B_h\,(h\in J)$ such that $B_h\subseteq A_i$ and (b) $\forall B_j\,(j\in J), \exists A_k\,(k\in I)$ such that $A_k\subseteq B_j$.
It is obvious that R is an equivalence relation and the quotient set (EM^* / R) is denoted by *EM*. The notation $\sum_{i\in I}\left(\prod_{m\in A_i} m\right)=\sum_{j\in J}\left(\prod_{m\in B_j} m\right)$ means that $\sum_{i\in I}\left(\prod_{m\in A_i} m\right)$ and $\sum_{j\in J}\left(\prod_{m\in B_j} m\right)$ are equivalent (represent the same semantics) under relation R.
Theorem 1 (Liu, 1998a): Let M be a non-empty set, then $(EM,\wedge,\vee)$ forms a completely distributive lattice under the binary compositions $\wedge$ and $\vee$, defined as follows: $\forall\sum_{i\in I}\left(\prod_{m\in A_i} m\right)$, $\sum_{j\in J}\left(\prod_{m\in B_j} m\right)\in EM^*$:

$$\sum_{i\in I}\left(\prod_{m\in A_i} m\right)\wedge\sum_{j\in J}\left(\prod_{m\in B_j} m\right)=\sum_{i\in I,\, j\in J}\left(\prod_{m\in A_i\cup B_j} m\right) \quad (2)$$

$$\sum_{i\in I}\left(\prod_{m\in A_i} m\right)\vee\sum_{j\in J}\left(\prod_{m\in B_j} m\right)=\sum_{k\in I\sqcup J}\left(\prod_{m\in C_k} m\right) \quad (3)$$

where for any set $k\in I\sqcup J$ (the disjoint union of I and J, that is, every element in I and every element in J, is always regarded as different elements in $I\sqcup J$); $C_k = A_k$ if $k\in I$ and $C_k = B_k$ if $k\in J$. $(EM,\wedge,\vee)$ is called the *EI* (expending on M) algebra over M.

Axiomatic Fuzzy Set (AFS) Structure

An AFS structure, represented by a triple (M,τ,X), gives rise to membership functions and fuzzy logic operations of the concepts in *EM*.

Definition 2 (Liu, 1998a, 1998b): Let X, M be sets and $\tau: X\times X\to 2^M$. (M,τ,X) is called an AFS structure if τ satisfies the following axioms:

(a_1) $\forall(x_1,x_2)\in X\times X, \tau(x_1,x_2)\subseteq\tau(x_1,x_1)$

(a_2) $\forall(x_1,x_2),(x_2,x_3)\in X\times X, \tau(x_1,x_2)\cap\tau(x_2,x_3)\subseteq\tau(x_1,x_3)$

X is called the universe of discourse, M is called the concept set, and τ is called the structure. In real-world applications, τ can be constructed from a linearly ordered relation $(\geq_m)$ as follows:

$$\tau(x, y) = \{m \mid m \in M, x \geq_m y\} \subseteq 2^M \tag{4}$$

where $x \geq_m y$ implies that the degree of x belonging to the simple concept m is greater than or equal to y.

Definition 3 (Liu, 1998b): Let X and M be sets, (M, τ, X) be an AFS structure, and (M, σ, m) be a measure space, where m is a finite and positive measure, $m(X) \neq 0, A_i^\tau \in \sigma,\ x \in X, i \in I$. For the fuzzy concept $\eta = \sum_{i \in I}\left(\prod_{m \in A_i} m\right) \in EM$, the membership function of n is defined as follows:
For any $x \in X$:

$$\mu_\eta(x) = sup_{i \in I} \frac{m\left(A_i^\tau(x)\right)}{m(X)} \tag{5}$$

where $A_i^\tau(x) = \{y \in X : x \geq_m \text{y}, \text{ for any } m \in A_i\}$. In other words, A_i^τ is the set of all elements in X whose degree of belonging to concept $\prod_{m \in A_i} m$ is less than or equal to that of x.

Simple Additive Weighting (SAW)

SAW, also known as weighted sum model, is one of the most popular and simple MCDM techniques for evaluating a set of alternatives in terms of a set of criteria. In a MCDM problem with m alternatives and n criteria, the performance score of each alternative can be derived using Equation (6):

$$A_i^* = \sum_{j=1}^{n} r_{ij} w_j \tag{6}$$

where r_{ij} (for i = 1,2,...,m and j = 1,2,...,n) represents the normalized rating of alternative i with respect to criterion j, and w_j represents the normalized weight of criterion j. The alternative with maximum performance score (A_i^*) is considered as the best alternative.

The Proposed Methodology: SWOT, AHP, AFS theory, and SAW (SAAS)

The proposed SAAS methodological framework integrates SWOT, AHP, AFS theory, and SAW to provide an effective tool for formulating and ranking the strategies under the MCDM environment. In SWOT analysis, the subjective and qualitative nature of SWOT factors require expressing the strengths or weaknesses of preferences using linguistic terms. The SAAS methodology utilizes the AFS theory to process the linguistic terms and thereby models the fuzziness in human knowledge representation and reasoning process. The SAAS methodology consists of five basic phases.

Phase 1: The identification of SWOT factors and formulation of alternative strategies

Step 1: Identify all possible SWOT factors ($f_j, j = 1,\ldots,n$) and organize them in four SWOT groups ($g_k, k = 1,\ldots,4$): strengths (g_1), weaknesses (g_2), opportunities (g_3), and threats (g_4), respectively.

Step 2: Establish a TOWS matrix and formulate all possible strategies (A_i, i=1,2,...,m).

Phase 2: Calculation of the relative important weights of SWOT factors and linguistic assessments of alternative strategies in terms of SWOT factors

Step 1: Establish pair-wise comparison matrices (using a 9-point scale as given in Table 1) for SWOT groups and their corresponding factors.

Step 2: Calculate the weights for SWOT groups (g_k^w) and their corresponding factors (f_j^w) using eigenvalue calculation framework.

Step 3: Calculate the global weights (w_j) by multiplying (g_k^w) and f_j^w based on the hierarchical structured relationship.

Step 4: Establish a judgment matrix $\left[a_{ij}\right]_{m\times n}$ for linguistic assessment of alternative strategies in terms of SWOT factors. The matrix element a_{ij} represents assessment (performance score) of i^{th} strategy in terms of j^{th} factor using linguistic terms.

Phase 3: Obtain the best fuzzy description (ζ_{A_i}) of each strategy using the AFS theory. Let $F=\{f_1,f_2,\ldots,fn\}$ be the set of SWOT factors and $S = \{A_1, A_2, \ldots, A_n\}$ be the set of strategies. Then, the best fuzzy description of each strategy is determined by the following steps (Liu & Pedrycz, 2009):

Step 1: Find the set of fuzzy attributes in F, defined as follows:

$$B_{A_i}^{\varepsilon} = \left\{ f_j \in F : \mu_{f_j}\left(A_i\right) \geq \mu_{\upsilon}\left(A_i\right) - \epsilon \right\} \tag{7}$$

Step 2: Find the set $\overline{B}_{A_i}^{\varepsilon}$, defined as follows:

$$\overline{B}_{A_i}^{\varepsilon} = \left\{ \prod_{c\in X} c : \mu_{\prod_{c\in X} c}(A_i) \geq \mu_{\upsilon}\left(A_i\right) - \varepsilon, X \subseteq B_{A_i}^{\varepsilon} \right\} \tag{8}$$

Step 3: Select the best fuzzy description $\zeta_{A_i} \in \overline{B}_{A_i}^{\varepsilon}$ for the strategy A_i as follows:

$$\zeta_{A_i} = argmin_{\zeta \in \overline{B}_{A_i}^{\varepsilon}} \left\{ \sum_{s\in S, s\neq A_i} \mu_{\zeta}\left(s\right) \right\} \tag{9}$$

Phase 4: Establish a decision matrix by rating each strategy A_i ($i = 1,2,..., m$) over each SWOT factor f_j ($j = 1,2 ...,n$)

Step 1: Perform pair-wise comparisons (using a 9-point scale) between each pair of strategies according to cost and benefit factors in their best fuzzy descriptions (ζ_{A_i}). For cost factors, the alternatives are compared based on $f_j^{'}$ (factor f_j is not good), and for benefit factor, the comparison process is carried out based on f_j (factor f_j is good).

Step 2: Compute the performance scores of strategies over SWOT factors using AHP and establish a decision matrix $\left[r_{ij}\right]_{m\times n}$ where each element (r_{ij}) represents the performance score of i^{th} strategy over j^{th} factor. Since the performance scores (r_{ij}) are obtained using AHP, these are considered as normalized under AHP calculation framework, and therefore there is no need to further normalize them explicitly. *This is one of the advantages of the SAAS methodology that it does not require normalization process at this stage.*

Phase 5: Rank the strategies

Step 1: Establish a weighted normalized decision matrix $\left[v_{ij}\right]_{m\times n}$, where $v_{ij} = r_{ij} \times w_j$, and evaluate the performance of each alternative strategy using Equation (6), and rank accordingly.

Case Study: Application of SAAS Methodology in Tourism

Agra, a historic city in northern region of India, houses numerous historical monuments including one of the seven wonders 'The Taj Mahal'. Having international importance in tourism, a large number of tourists from all over the world come here every year to savor the different moods of various magnificent edifices. For the scope of the study area, the identification of most important factors (internal as well external to the tourism industry) and then continuously improving the overall performance of these factors are essentially important to provide better services and gain competitive advantages. The application of SAAS methodology in tourism may help the policymakers in formulating effective strategies to utilize the strengths, eliminate the weaknesses, and exploit the opportunities or use them to counter the threats. The following section illustrates the step-by-step process of the SAAS methodology in the formulation and evaluation of Agra tourism-related strategies based on SWOT analysis.

Phase 1: Identification of SWOT Factors and Formation of Strategies

This phase begins with forming a team of experts of tourism industry (12 members) responsible for identifying various factors relevant to tourism's internal and external environment. The experts' opinion together with self-observations, past industry experience, and literature review helped in identifying 15 main factors (f_j,j = 1,..., 15) which are categorized into four SWOT groups (g_k,k = 1,..., 4) to form a SWOT matrix (Table 2).

Table 2. SWOT Matrix

Strengths (g_1)	**Weaknesses (g_2)**
(f_1) *Destination characteristics:* cultural, religious, and splendid heritage destinations; museums and beautiful nature parks; varied culture and hospitality; international recognition; cosmopolitan culture; distinct local foods (variety of cuisines) (f_2) *Geographical location and historic value:* proximity to religious city (Mathura) and birds' city (Bharatpur); famous capital during Mughal Empire (f_3) *Profile and status of tourism industry:* foreign exchange earning contributions to Indian economy; diverse and unique tourism products such as leatherware, handicraft made of marble, zari embroidery, and inlay work (f_4) *Cultural and religious events:* religious festivals and cultural events around the year	(f_5) *Limited infrastructure:* lack of modern technologies and facilities (like information centers and directional signs); no international airport; traffic congestion; no proper parking and sanitary conditions (f_6) *Lack of professionalism in tourism services:* lack of professionalism of individual workers; untrained service providers (f_7) *Poor coordination among tourism authorities*: no government tourism policy; lack of public–private involvement in decision-making (f_8) *Inadequate marketing promotions:* absence of proper marketing promotion strategies; lack of proper information sources
Opportunities (g_2)	**Threats (g_4)**
(f_9) *Potential for tourism development:* ecotourism (Keetham Lake); health tourism (a wide range of hospitals and medical services); meetings, incentives, conferences, exhibitions (MICE); tourism; heritage tourism; to get familiar with the culture of three neighboring states (Uttar Pradesh, Madhya Pradesh, and Rajasthan) (f_{10}) *International business opportunities*: good market for foreign direct investment (FDI); shopping avenues (f_{11}) *Geographic settings*: not a disaster zone; close to national capital (New Delhi)	(f_{12}) *Lack of active tourism controlling authorities*: lack of tourism development plan; outdated tourism law (f_{13}) *Regional competitive destinations*: aggressive marketing by competitive destinations; closeness to competitive tourism destinations (like Jaipur and Gwalior) (f_{14}) *Lack of tourism friendly environment*: harassment and cheating with tourists by touts; lack of safety and security; and deteriorating law and order (f_{15}) *Price hike during tourism season*: considerable increase in the prices of various services such as local food, transportation, etc.

Source: The authors.

Next, the expert team formulated six strategies (A_i, $i = 1,..., 6$) under four conceptually distinct strategic groups (SO, WO, ST, WT) of TOWS matrix (Table 3). The TOWS matrix, developed by Weihrich (1982), is the next step of SWOT to develop strategies based on logical combinations of factors related to internal strengths (or weaknesses) with factors related to external opportunities (or threats). The strategies identified as SO concerns making good use of opportunities by using the existing strengths. The WO strategies seek to reduce internal weaknesses by taking advantage of external opportunities. The ST strategies are related to utilize the strengths in order to avoid or reduce the effects of threats. Finally, the WT strategies aim to reduce the effects of threats and weaknesses. The SWOT groups, factors, and developed strategies are organized in a hierarchical structure as shown in Figure 1.

Phase 2: Prioritization of SWOT Groups (g_i) and Factors (f_i)

Under this phase, the prioritization of SWOT groups and factors were achieved from the study presented by Singh et al. (2015). Figure 2 presents the weights of SWOT groups and their corresponding factors. Next, the experts were asked to rate each alternative strategy with respect to factors. This rating process resulted in establishment of a judgment matrix $\left[a_{ij}\right]_{m\times n}$, as shown in Table 4. The matrix element a_{ij} represents assessment of i^{th} strategy in terms of j^{th} factor using linguistic terms.

Phase 3: Fuzzy Description (ζ_{A_i}) of Each Alternative Strategy (A_i) Using AFS Theory

By considering the data in Table 4, let $S = \{A_1,A_2,A_3,A_4,A_5,A_6\}$ be the set of six alternative strategies, as defined in Table 3; let $\epsilon = 0$, $F = \left\{f_1, f_1^{'}, f_2, f_2^{'}, \ldots f_{15}, f_{15}^{'}\right\}$ be the set of factors on S (defined in Table 2), and $v = f_1 + f_1^{'} + f_2 + f_2^{'} + \ldots f_{15} + f_{15}^{'}$.

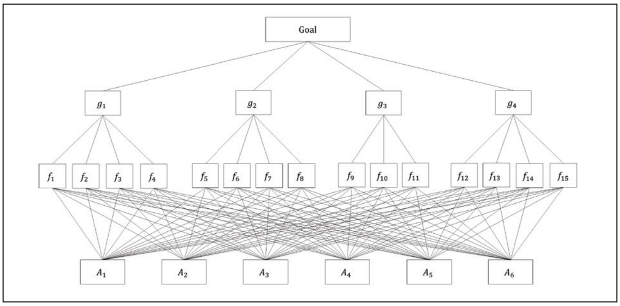

Figure 1. Hierarchical Structure of SWOT Factors and Alternative Strategies
source: The authors.

Table 3. TOWS Matrix for Strategy Formulation

	Strengths	**Weaknesses**
Opportunities	SO: 'Maxi-Maxi' Strategies A_1: *Strategy of discerned approach*: Marketing in a different way than competitive destinations; advantage should be taken of the area's ancient culture, language, and dialects; area's handicraft, zari embroidery, and inlay work should be presented and marketed	WO: 'Mini-Maxi' Strategies A_2: *Strategy of stakeholder inclusion*: Involvement of private–public stakeholders for decision-making; enhance services and products quality; reform new policies to develop tourism; environmental education and culture building through public media, academic conferences, and NGOs A_3: *Distribution channel divarication strategy*: Travel intermediaries have the power to influence 'when', 'where', and 'how' people travel; developing attractions and accommodations for overnight and/or long stays; planning and fund provision in order to establish travel agencies to attract tourists
Threats	ST: 'Maxi-Mini' Strategies A_4: *Strategy of proactive communication*: Obviate the negative image created in the minds of prospective travelers; customer care culture (helpline)	WT: 'Mini-Mini' Strategies A_5: *Strategy of organizational interrelationship and team work*: Tourism is an asset of a variety of services which includes many parties; therefore, it is necessary to develop a network among them; informing tourists by local guides and hand out brochures; develop infrastructure harmonized with population increase caused by tourist visits A_6: *Effective marketing promotional strategies*: Creating confidence in target market through special events, trade shows, TV programs, public relations, and advertising

Source: The authors.

By Table 4 and semantic meaning of the factors in F, we have the following linearly ordered relations:

$$f_1 : A_5 < A_2 = A_3 < A_6 < A_4 < A_1 \qquad f_1^{'} : A_5 > A_2 = A_3 > A_6 > A_4 > A_1$$

$$f_2 : A_2 = A_3 = A_6 < A_5 < A_1 = A_4 \qquad f_2^{'} : A_2 = A_3 = A_6 > A_5 > A_1 = A_4$$

$f_3 : A_5 < A_1 < A_2 = A_3 = A_6 < A_4$ $\qquad f_3^{'} : A_5 > A_1 > A_2 = A_3 = A_6 > A_4$

$f_4 : A_5 < A_2 < A_4 = A_6 < A_1 = A_3$ $\qquad f_4^{'} : A_5 > A_2 > A_4 = A_6 > A_1 = A_3$

$f_5 : A_4 < A_1 < A_6 < A_3 = A_5 < A_2$ $\qquad f_5^{'} : A_4 > A_1 > A_6 > A_3 = A_5 > A_2$

$f_6 : A_1 = A_4 < A_5 = A_6 < A_3 < A_2$ $\qquad f_6^{'} : A_1 = A_4 > A_5 = A_6 > A_3 > A_2$

$f_7 : A_1 < A_3 = A_4 = A_6 < A_5 < A_2$ $\qquad f_7^{'} : A_1 > A_3 = A_4 = A_6 > A_5 > A_2$

$f_8 : A_1 < A_4 < A_2 < A_3 = A_5 < A_6$ $\qquad f_8^{'} : A_1 > A_4 > A_2 > A_3 = A_5 > A_6$

$f_9 : A_6 < A_4 = A_5 < A_2 < A_3 < A_1$ $\qquad f_9^{'} : A_6 > A_4 = A_5 > A_2 > A_3 > A_1$

$f_{10} : A_4 = A_5 < A_6 < A_3 < A_2 < A_1$ $\qquad f_{10}^{'} : A_4 = A_5 > A_6 > A_3 > A_2 > A_1$

$f_{11} : A_5 < A_1 = A_2 = A_4 = A_6 < A_3$ $\qquad f_{11}^{'} : A_5 > A_1 = A_2 = A_4 = A_6 > A_3$

$f_{12} : A_1 = A_2 < A_3 < A_4 < A_6 < A_5$ $\qquad f_{12}^{'} : A_1 = A_2 > A_3 > A_4 > A_6 > A_5$

$f_{13} : A_4 < A_3 = A_6 < A_2 = A_5 < A_1$ $\qquad f_{13}^{'} : A_4 > A_3 = A_6 > A_2 = A_5 > A_1$

$f_{14} : A_1 = A_2 = A_3 < A_6 < A_4 = A_5$ $\qquad f_{14}^{'} : A_1 = A_2 = A_3 > A_6 > A_4 = A_5$

$f_{15} : A_1 = A_3 = A_6 < A_5 < A_2 < A_4$ $\qquad f_{15}^{'} : A_1 = A_3 = A_6 > A_5 > A_2 > A_4$.

Using Equation (9), we can obtain:

$$\mu_\upsilon(A_1) = \mu_\upsilon(A_2) = \mu_\upsilon(A_3) = \mu_\upsilon(A_4) = \mu_\upsilon(A_5) = \mu_\upsilon(A_6) = 1.0$$

For A_1:

$$\mu_{f_1}(A_1) = \mu_{f_2}(A_1) = \mu_{f_4}(A_1) = \mu_{f_9}(A_1) = \mu_{f_{10}}(A_1) = \mu_{f_{13}}(A_1) = \mu_{f_6^{'}}(A_1) = \mu_{f_7^{'}}(A_1) = \mu_{f_8^{'}}(A_1) = \mu_{f_{12}^{'}}(A_1) = \mu_{f_{14}^{'}}(A_1) = \mu_{f_{15}^{'}}(A_1) = 1.0$$

Table 4. Rating of Strategies (Judgment Matrix)

Strategy	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}
A_1	VH	H	ML	M	L	L	VL	L	VH	MH	L	L	M	L	VL
A_2	L	L	M	L	VH	H	H	MH	MH	M	L	L	ML	L	ML
A_3	L	L	M	M	H	MH	M	H	H	ML	H	ML	L	L	VL
A_4	H	H	MH	ML	VL	L	M	ML	L	VL	L	M	VL	H	ML
A_5	VL	ML	L	VL	H	M	MH	H	L	VL	VL	H	ML	H	L
A_6	ML	L	M	ML	ML	ML	M	VH	VL	L	L	MH	L	MH	VL

Source: The authors.

Note: Expansion of Table Values: VL = Very Low, L = Low, ML = Medium Low, M = Medium, MH = Medium High, H = High, VH = Very High.

We obtained $B_{A_1}^0 = \left\{ f_1, f_2, f_4, f_9, f_{10}, f_{13}, f_6^{'}, f_7^{'}, f_8^{'}, f_{12}^{'}, f_{14}^{'}, f_{15}^{'} \right\}$ and $\mu_{f_1 f_2 f_4 f_9 f_{10} f_{13} f_6^{'} f_7^{'} f_8^{'} f_{12}^{'} f_{14}^{'} f_{15}^{'}}$ as the minimal element in $\overline{B}_{A_1}^{\varepsilon}$.

Thus, $\zeta_{A_1} = f_1 f_2 f_4 f_9 f_{10} f_{13} f_6^{'} f_7^{'} f_8^{'} f_{12}^{'} f_{14}^{'} f_{15}^{'}$, that is, the best fuzzy description of A_1 is such that: 'destination characteristics (f_1), geographical location and historical value (f_2), cultural and religious events (f_4), potential for tourism development (f_9), international business opportunities (f_{10}), and regional competitive destinations (f_{13}) are strong' while 'lack of professionalism in tourism services ($f_6^{'}$), poor coordination among tourism authorities ($f_7^{'}$), inadequate marketing promotions ($f_8^{'}$), lack of active tourism controlling authorities ($f_{12}^{'}$), lack of tourism friendly environment ($f_{14}^{'}$), and price hike during tourism season are not strong ($f_{15}^{'}$)'.

Similarly, we can obtain the best fuzzy descriptions of A_2, A_3, A_4, A_5, and A_6:

$$B_{A_2}^0 = \left\{ f_5, f_6, f_7, f_2^{'}, f_{12}^{'}, f_{14}^{'} \right\}, \qquad \zeta_{A_2} = f_5 f_6 f_7 f_2^{'} f_{12}^{'} f_{14}^{'}$$

$$B_{A_3}^0 = \left\{ f_4, f_{11}, f_2^{'}, f_{14}^{'}, f_{15}^{'} \right\}, \qquad \zeta_{A_3} = f_4 f_{11} f_2^{'} f_{14}^{'} f_{15}^{'}$$

$$B_{A_4}^0 = \left\{ f_2, f_3, f_{14}, f_{15}, f_5^{'}, f_6^{'}, f_{13}^{'} \right\}, \qquad \zeta_{A_4} = f_2 f_3 f_{14} f_{15} f_5^{'} f_6^{'} f_{13}^{'}$$

$$B_{A_5}^0 = \left\{ f_{12}, f_{14}, f_1^{'}, f_3^{'}, f_4^{'}, f_{10}^{'}, f_{11}^{'} \right\}, \qquad \zeta_{A_5} = f_{12} f_{14} f_1^{'} f_3^{'} f_4^{'} f_{10}^{'} f_{11}^{'}$$

$$B_{A_6}^0 = \left\{ f_8, f_2^{'}, f_9^{'}, f_{15}^{'} \right\}, \qquad \zeta_{A_6} = f_8 f_2^{'} f_9^{'} f_{15}^{'}$$

Phase 4: Establish a Decision Matrix by Rating Each Strategy A_i ($i = 1, 2, \ldots, m$) over Each SWOT Factor, f_j ($j = 1, 2 \ldots, n$)

In this phase, a decision matrix (normalized under the AHP framework) $\left[r_{ij} \right]_{m \times n}$ is established based on pair-wise comparisons between each pair of transportation modes according to attributes in their ζ_{A_i}. In this comparison process, the factors under strengths and opportunities are considered as positive (benefit) factors while the factors under weaknesses and threats are considered as negative (cost) factors. For benefit factors, the comparison process is carried out based on f_j (factor f_j is good), and for cost factors, the comparison is performed with $f_j^{'}$ (factor $f_j^{'}$ is not good).

Table 5. Rating of Strategies over f_1

f_1	A_1	A_1	A_3	A_4	A_5	A_6	*Weight*
A_1	1	9	9	9	9	9	0.643
A_2		1	1	1	1	1	0.071
A_3			1	1	1	1	0.071
A_4				1	1	1	0.071
A_5					1	1	0.071
A_6						1	0.071

Source: The authors.

The performance scores of strategies over SWOT factors are determined using AHP, as shown in Table 5, where each element (r_{ij}) represents the performance score of i^{th} strategy over j^{th} factor. For illustration, The factor f_1 appears in the description of strategy A_1 and strategy A_5; hence, the alternative strategies A_1 and A_5 are extremely preferred over A_2, A_3, A_4, and A_6. Similarly, the decision weights of all alternative strategies over the factors f_j (j = 1, 2,...,15) are obtained and are presented in Table 6 as the decision matrix.

Phase 5: Ranking the Strategies

The decision matrix (Table 6) is combined with the factor weights (w_j), given in Figure 2, to form a weighted decision matrix (Table 7).

Next, the concept of SAW is applied to the weighted decision matrix obtained in Table 7. The performance of alternative strategies is evaluated using Equation (6) and is presented in Table 8. The graphical representation of overall performance scores of strategies is shown in Figure 3. The result shows that the strategy of the discerned approach (A_1) is the top-ranked strategy.

Results and Discussion

The presented study examines the strengths, weaknesses, opportunities, and threats of tourism development in Agra. The main issues which influence the tourism development are identified by SWOT analysis, and alternative strategies

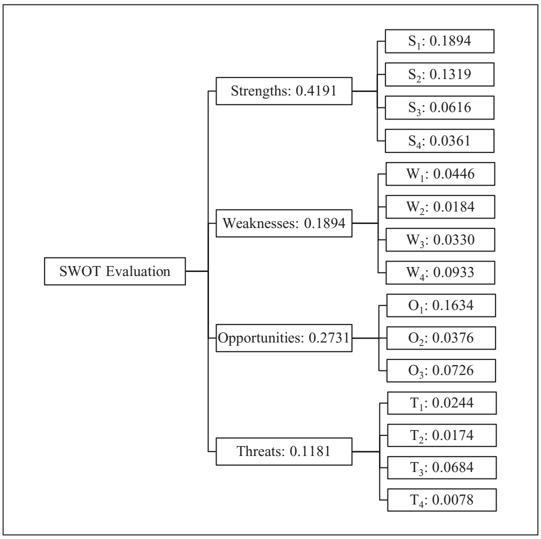

Figure 2. Weights of SWOT Groups and Their Corresponding Factors

Source: Singh, Chauhan and Singh (2015).

Table 6. Decision Matrix (*N*)

Strategy	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}
A_1	0.6429	0.4091	0.0714	0.4091	0.0714	0.4091	0.6429	0.6429	0.6429	0.6429	0.0714	0.4091	0.0714	0.3000	0.3000
A_2	0.0714	0.0455	0.0714	0.0455	0.0714	0.0455	0.0714	0.0714	0.0714	0.0714	0.0714	0.4091	0.0714	0.3000	0.0333
A_3	0.0714	0.0455	0.0714	0.4091	0.0714	0.0455	0.0714	0.0714	0.0714	0.0714	0.6429	0.0455	0.0714	0.3000	0.3000
A_4	0.0714	0.4091	0.6429	0.0455	0.6429	0.4091	0.0714	0.0714	0.0714	0.0714	0.0714	0.0455	0.6429	0.0333	0.0333
A_5	0.0714	0.0455	0.0714	0.0455	0.0714	0.0455	0.0714	0.0714	0.0714	0.0714	0.0714	0.0455	0.0714	0.0333	0.0333
A_6	0.0714	0.0455	0.0714	0.0455	0.0714	0.0455	0.0714	0.0714	0.0714	0.0714	0.0714	0.0455	0.0714	0.0333	0.3000

Source: The authors.

Table 7. Weighted Decision Matrix (*W*)

Strategy	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}
A_1	0.1218	0.0540	0.0044	0.0148	0.0032	0.0075	0.0212	0.0600	0.1050	0.0242	0.0052	0.0100	0.0012	0.0205	0.0023
A_2	0.0135	0.0060	0.0044	0.0016	0.0032	0.0008	0.0024	0.0067	0.0117	0.0027	0.0052	0.0100	0.0012	0.0205	0.0003
A_3	0.0135	0.0060	0.0044	0.0148	0.0032	0.0008	0.0024	0.0067	0.0117	0.0027	0.0467	0.0011	0.0012	0.0205	0.0023
A_4	0.0135	0.0540	0.0396	0.0016	0.0287	0.0075	0.0024	0.0067	0.0117	0.0027	0.0052	0.0011	0.0112	0.0023	0.0003
A_5	0.0135	0.0060	0.0044	0.0016	0.0032	0.0008	0.0024	0.0067	0.0117	0.0027	0.0052	0.0011	0.0012	0.0023	0.0003
A_6	0.0135	0.0060	0.0044	0.0016	0.0032	0.0008	0.0024	0.0067	0.0117	0.0027	0.0052	0.0011	0.0012	0.0023	0.0023

Source: The authors.

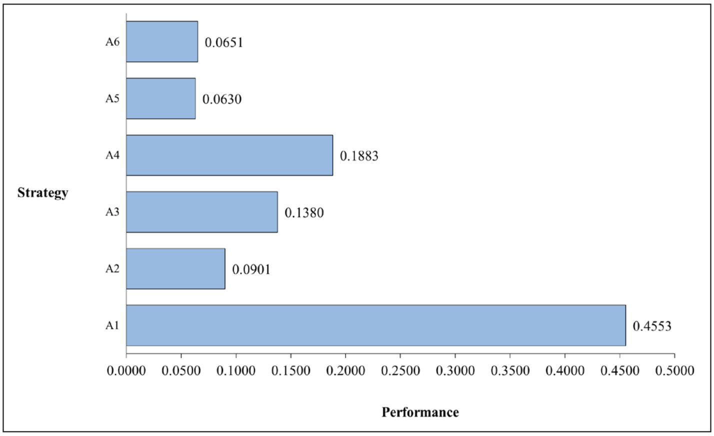

Figure 3. Performance of Strategies

Source: The authors.

are formed in order to develop this industry. The results indicate that the strategy of discerned approach (A_1)is the most effective strategy followed by the strategy of proactive communication (A_4), the distribution channel divarication strategy (A_3), the strategy of stakeholder inclusion (A_2), effective marketing promotional strategies (A_6), and strategy of organizational interrelationship and teamwork (A_5) for tourism development in the study area. In the AHP computation of SWOT factors (Figure 2), we can see that the factors which are internal to tourism development are more important than the external factors. With AHP weights of factors/subfactors (as shown in Figure 2) and the performance scores of strategies (as shown in Table 8), it is observed that the weights of subfactors f_1, f_3, and f_9 of strength and opportunity groups, respectively, are more important than other subfactors in other groups. The involvement of these higher-weighted subfactors in strength and opportunity groups testifies the rank of SO: 'maxi-maxi' strategy turned out to be the best one, hence the consistency of the proposed approach.

Table 8. Performance Scores of Strategies

Strategy	A_i^*	Rank
A_1	0.4553	1
A_2	0.0901	4
A_3	0.1380	3
A_4	0.1883	2
A_5	0.0630	6
A_6	0.0651	5

Source: The authors.

Conclusion

This article presents a hybrid methodology aimed to help the policymakers in evaluation and ranking of strategies. The proposed methodology integrates the AFS theory for determining best fuzzy description of each alternative strategy and AHP and the concept of SAW to evaluate/rank the strategies' alternatives by SWOT analysis. The advantage of the developed model is that it processes the linguistic values using axiomatic fuzzy logic that overcomes the ambiguity in the human decision-making process and copes with the inconsistency caused by the different types of fuzzy numbers used to process linguistic values. The proposed methodology is supported by a case study of the tourism industry in Agra, a historic city in the northern region of India. This presented study provides an important contribution for organizational strategic planning by suggesting a decision-making approach to enhance policymakers' discussion related to internal and external factors, as well as in developing effective strategies to utilize the strengths, eliminate the weaknesses, and exploit the opportunities or use them to counter the threats. As a result of the study, it is found that the proposed model is practical for ranking alternatives with respect to multiple conflicting criteria.

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