Determination Weight Prioritized of Multi-attribute Decision-Making for Diversification Product in Pangasius Agro-industry

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Abstract

The pangasius agroindustry has significant potential to boost added value, build economic processes, raise the commercial community, offer jobs, generate economic opportunities, and strengthen the national economy. The base value of the pangasius agroindustry is due to the need for more innovative product development, which is essential to sustainable agroindustry. Making the appropriate option when selecting a new product development concept is crucial to generating a successful new product. The selection of concepts is crucial for mitigating risk in a variety of market and uncertainty settings. AHP is appropriate for dealing with decision-making challenges involving multiple connected aspects. Combining AHP with fuzzy set theory has created a recent offshoot known as fuzzy AHP. This innovative method widens the decision-making application scope much further. Despite the widespread use of fuzzy AHP, only some studies have compared the priority weight vectors generated by fuzzy AHP with those of classical AHP. This research compares the two AHP techniques by examining the weight vectors derived from real-world case studies. Four distinct fuzzy AHP techniques were derived from past research and tested using a variety of fuzzy fundamental scales and weight aggregation to determine which produces the most equivalent outcomes to standard AHP. The principal findings and outcomes from the four methodologies are presented and thoroughly explored.

Keywords
diversification product, F-AHP, pangasius agroindustry, weight prioritized.

1. Introduction
The creation of innovative goods in the fish agroindustry is called downstream fish agroindustry. Downstream fish agroindustry, in this case, pangasius sp agroindustry, has the potential to flourish because pangasius sp commodities play a significant role in the national economy, and fish farmers control the fishery sector; therefore, pangasius sp commodities are commodities that can benefit farmers' (Kaminski et al., 2018). Downstream in the agroindustry can boost Product value-added, reinforce the industrial structure, create jobs, and create commercial prospects (Joffre et al., 2017). Agroindustry downstream can be developed by boosting product development. New product development and innovation are frequently cited as the keys to a company's success (Bstieler, 2012; McKenzie et al., 2022). Today's market wants high-quality, high-performance, low-cost items (Yusuf and Suyanto, 2019).

As a prospective commodity in the world, Pangasius has become a substitute for other white meat fish fillets, such as catfish (*Ictalurus punctatus*) (Hayandani S, Firdaus M, 2014; Rimmer et al., 2013; Yuwono B, Zakaria FR, 2012). Pangasius is a freshwater fish commodity with great development potential and a high selling price. This causes Pangasius sp to receive attention and interest from entrepreneurs to cultivate it. Some of the advantages of catfish, such as the rearing area, do not require running water, and in just six months of maintenance, it can reach a length of 35-40 cm (Prihatman, 2000).

In the downstream product process, there are several points to be noticed, and they are: 1)Innovative Product Approaches: Integrating the process of generating new goods with company goals can serve as a target for generating ideas/concepts and rules for setting filtering criteria. 2) Idea generation: Developing innovative products that suit the company's goals, 3) Screening: Initial analysis to evaluate which concepts are appropriate and merit further investigation. 4) Business Analysis: Review concepts using quantitative parameters such as profits, ROI, and sold units. 5) Developments: transforming ideas on paper into items that can be presented and manufactured, 6) Testing entails carrying out commercial tests in order to validate earlier business judgments; and 7) Commercialization: The introduction of a product (Fish, 2016).

The decision to select the best alternative or idea for producing new products is a crucial phase in the creation of new products. F-AHP (Kafa et al., 2014) is a method that can be used to choose fresh product development concepts. This research aims to create the Fuzzy Analytic Hierarchy Process (F-AHP) approach for selecting new product innovation ideas in the downstream pangasius sp agroindustry.

2. Background

A Hierarchical Process (AHP) is a decision-making process that considers both intangible and tangible criteria. It has been demonstrated to be effective in various complicated problems in engineering, management, economics, and sociology. Two phases must be completed to apply AHP to such issues: hierarchical design and evaluation. The subjective assessment of decision-makers also impacts evaluation (Saaty, 2002; Sayyadi and Awasthi, 2013).

Decomposition, comparison judgment, and priority synthesis are the three principles of AHP (Saaty, 2002). The decomposition principle, to capture the fundamental aspects of the problem, necessitates the creation of a hierarchy. The comparative judgment principle necessitates the creation of a matrix in order to perform a pairwise comparison to a common goal.

Although AHP has many great elements and uses (Saaty, 2002), there are certain limitations or obstacles in implementing this technique in reality. AHP typically tolerates variation of up to 10%. Therefore the results should be used with caution. A high consistency ratio restriction can be applied whenever a matrix has a complicated pattern and is confidently evaluated by experts. Saaty (1986) developed the significance scale for assessments (Table 1).

Table 1. Fundamental Scale (Saaty, 1986)

Intensity of importance	Definition	Explanation
1	Equal importance	Two actions each contribute equally to the goal.
3	Little more significant than the other	Knowledge and judgments are slightly more significant than others.
5	Important or very important	Knowledge and judgments prefer one activity over the other.
7	Very strong importance	Activity is highly preferred, and its domination is manifest in practice.
9	Significant	The evidence supporting one activity over another is at the highest confirmation level.
2, 4, 6, 8	Intermediate values	When a tradeoff is required
Reciprocals	When compared to activity *j*, activity *i* has a common value, and *j* has a similar value to *i*.	

3. Research Methodology

At this stage, we first carry out the classical AHP stage, then follow it with calculations using the Fuzzy AHP method. The results are then compared with examples of calculations. From the results of the sample calculations, recommendations will be generated.

3.1 Fuzzy AHP Approach

The fuzzy AHP methodology is founded on Zadeh's fuzzy set theory (Zadeh, 1965). Fuzzy membership functions may represent any real integer in the interval [0, 1] as fuzzy numbers. When such a fuzzy number is near 1, the number's degree of membership is greater. Triangular fuzzy numbers were utilized in several applications due to their computational simplicity and capacity to facilitate a fuzzy environment, representation, and information processing.

$$\mu_{\bar{A}(x)} = \begin{cases} 0, x \leq l \\ \frac{x-l}{m-l}, l \leq x \leq m \\ \frac{x-u}{m-u}, m \leq x \leq u \\ 0, otherwise \end{cases} \quad \ldots\ldots (1)$$

When two triangular fuzzy integers are present, $\tilde{A} = (a_1, a_2, a_3)$ and $\tilde{B} = (b_1, b_2, b_3)$, their operating regulations are as follows:

$$\tilde{A} \oplus \tilde{B} = (a_1, a_2, a_3) \oplus (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \ldots\ldots (2)$$

$$\tilde{A} \otimes \tilde{B} = (a_1, a_2, a_3) \otimes (b_1, b_2, b_3) = = (a_1 b_1, a_2 b_2, a_3 b_3) \ldots\ldots (3)$$

$$\tilde{A}^{-1} = \left(1/a_3, 1/a_2, 1/a_1\right) \ldots\ldots (4)$$

$$\lambda \otimes \tilde{A} = \lambda \otimes (a_1, a_2, a_3) = (\lambda a_1, \lambda a_2, \lambda a_3)\ (\lambda > 0, \lambda \epsilon R) \ldots\ldots (5)$$

The importance weight of the choice criteria is evaluated in fuzzy AHP utilizing a modified basic scale expressed as a linguistic term. Tables 2 and 3 indicate that two categories of fuzzy fundamental scales were created for evaluating criteria. The fuzzy AHP uses a modified fundamental scale stated in linguistic terms to assess the weight relevance of choice factors. Although certain broad notions are identical, there are differences in the specific application components.

Table 2. Fuzzy Fundamental Scale 1 (Suroor et al., 2012)

Linguistic term	Fuzzy number	Triangular fuzzy scale	Reciprocal fuzzy scale
Equally important	$\tilde{1}$	(1,1,1)	(1,1,1)
Intermediate Value	$\tilde{2}$	(1,2,3,)	$(1/3, 1/2, 1)$
Moderately important	$\tilde{3}$	(2,3,4)	$(1/4, 1/3, 1/2)$
Intermediate Value	$\tilde{4}$	(3,4,5)	$(1/5, 1/4, 1/3)$
Strongly Important	$\tilde{5}$	(4,5,6)	$(1/6, 1/5, 1/4)$
Intermediate Value	$\tilde{6}$	(5,6,7)	$(1/7, 1/6, 1/5)$
Very Strongly important	$\tilde{7}$	(6,7,8)	$(1/8, 1/7, 1/6)$
Intermediate_value	$\tilde{8}$	(7,8,9)	$(1/9, 1/8, 1/7)$
Extremely important	$\tilde{9}$	(8,9,10)	$(1/10, 1/9, 1/8)$

Table 3. Fuzzy Fundamental Scale 2 (Khazaeni et al., 2012)

Linguistic term	Fuzzy number	Triangular fuzzy scale	Reciprocal fuzzy scale
Equally important	$\tilde{1}$	(1,1,1)	(1,1,1)
Moderately important	$\tilde{3}$	(1,3,5)	$\left(1/5, 1/3, 1/1\right)$
Strongly Important	$\tilde{5}$	(3,5,7)	$\left(1/7, 1/5, 1/3\right)$
Very Strongly important	$\tilde{7}$	(5,7,9)	$\left(1/9, 1/7, 1/5\right)$
Extremely important	$\tilde{9}$	(7,9,9)	$\left(1/9, 1/9, 1/7\right)$

The primary goal of this research study is to compare weight results obtained by classical AHP through case studies. The first approach (Subulan et al., 2015) is as follows:

1. Weight aggregation 1 (WA1)

$$\widetilde{w}_{ij} = \left(Lw_{ij}, Mw_{ij}, Uw_{ij}\right) \quad \ldots\ldots (6)$$

$$Lw_{ij} = min_t \left\{Lw_{ijt}\right\}, Mw_{ij} = \frac{1}{T}\sum_{t=1}^{T} Mw_{ij}, Uw_{ij} = max_t \left\{Uw_{ijt}\right\} \quad \ldots\ldots (7)$$

Where $\widetilde{w}_{ij}$= the i-th criterion's triangular fuzzy weight with the *j*-th criterion

The following describes the second strategy, which is based on fuzzy arithmetic operations (Khazaeni et al., 2012):

$$Lw_{ij} = \frac{1}{T}\sum_{t=1}^{T} Lw_{ij}, Mw_{ij} = \frac{1}{T}\sum_{t=1}^{T} Mw_{ij}, Uw_{ij} = \frac{1}{T}\sum_{t=1}^{T} Uw_{ij} \quad \ldots\ldots (8)$$

3.2 Fuzzy AHP Weights Calculation

A fuzzy AHP weights calculation approach is demonstrated here with a paired comparison (Zhu et al., 1999).

Let X= {X_1, X_2, ... X_n }be an object set, and U = { U_1, U_2, … U_m} be a goal set. An extent analysis for each goal, follow the method by Chang (Chang, 1996; Zhu et al., 1999), is performed for each object (Step 1). Therefore, m extent analysis values for each object can be acquired with the following signs: $M_{gi}^{1}, M_{gi}^{2}, M_{gi}^{3}, \ldots M_{gi}^{1m}$, (j = 1, 2, … m and i = 1,2, …. n). All extent analysis values are fuzzy triangular numbers.

Then the value of fuzzy synthetic extent to the i^{th} object can be defined as follows:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad \ldots\ldots (9)$$

Step 2: Calculate the degree of possibility of two fuzzy synthetic extent values. The degree of possibility (as shown in Fig.1) of $S_2 = (l_2, m_2, u_2) \geq S_1 = (l_1, m_1, u_1)$ is defined as:

$$V(S_2 \geq S_1) = hgt((S_2 \cap S_1)) = \mu(d)$$

$$= \begin{cases} = 1, if\ m_2 \geq m_1 \\ = 0, if\ l_1 \geq u_2 \\ = \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)},\ otherwise \end{cases} \quad \text{.............................. (10)}$$

Where d = ordinate of highest intersection point D between two fuzzy numbers. To compare S1 and S2, we need both values, V ($S_2 \geq S_1$) and V ($S_1 \geq S_2$) (Figure 1).

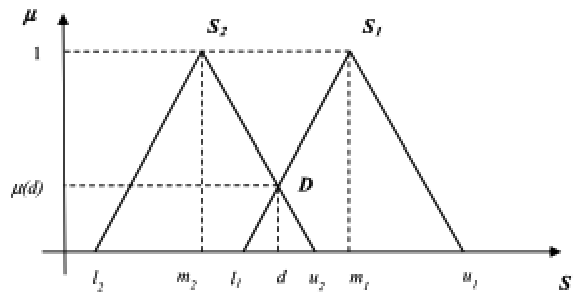

Figure 1. Intersection between S_1 and S_2

Step 3: e degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers can be defined as follows:

V ($S \geq S_1, S_2, \ldots, S_k$)

$$= \text{V}\ [(S \geq S_1) and\ (S \geq S_2)\ and \ldots and\ (S \geq S_k)]$$
$$= \min \text{V}\ (S \geq S_1)\ (i = 1,2, \ldots, k) \text{ ....(11)}$$

Step 4:

assume that $d'\ (C_i)$ = min V (Si ≥ Sk) for k = 1,2, … , n (i ≠ k).

Then the weight vector is given by :

$W' = [d'\ (C_1), d'\ (C_2), \ldots, d'\ (C_n)\ ]^T$ ………………. (12)

Step 5 :

The normalized weight vector needs to be obtained through normalization

$$W \quad = \left[d \quad (C_1), d \quad (C_2), \ldots, d \quad (C_n)\ \right] T \text{ ………………. (13)}$$

Table 4 shows a pairwise comparison matrix that illustrates the calculation of priority weights by the fuzzy AHP. There are three factors— Pangasius Fish Fillet, Frozen Product, and Surimi-based Product — in the matrix, and four decision makers are involved in evaluating the matrix.

Table 4. Fuzzy Pairwise Comparison Matrix

Criteria	Pangasius Fish Fillet	Frozen Product	Surimi-based Product
	(1, 1, 1)	(2, 3, 4)	(1, 1, 1)

Pangasius Fish Fillet		(2, 3, 4)	(1, 1, 1)
		$(^1/_4, ^1/_3, ^1/_2)$	$(^1/_4, ^1/_3, ^1/_2)$
		(1, 1, 1)	(1, 1, 1)
Frozen Product	$(^1/_4, ^1/_3, ^1/_2)$	(1, 1, 1)	$(^1/_4, ^1/_3, ^1/_2)$
	$(^1/_4, ^1/_3, ^1/_2)$		(1, 1, 1)
	(2, 3, 4)		(2, 3, 4)
	(1, 1, 1)		(1, 1, 1)
Surimi-based Product	(1, 1, 1)	(2, 3, 4)	(1, 1, 1)
	(1, 1, 1)	(1, 1, 1)	
	(2, 3, 4)	$(^1/_4, ^1/_3, ^1/_2)$	
	(1, 1, 1)	(1, 1, 1)	

First, fuzzy numbers evaluated by multiple experts have to be aggregated by an appropriate method. Table 5 shows the resulting pairwise comparison matrix prepared by the first weight aggregation (WA1) method. Then the value of fuzzy synthetic extent to the ith object (i = 1,2; 3) can be computed by Eq. (9).

S_1 = (1.5, 3.66, 6.0) x (0.0417, 0,0909, 0.1905)
= (0.06, 0.33, 1,14)

S_2 = (1.5, 3.5, 9.0) x (0.0417, 0,0909, 0.1905)
= (0.06, 0.32, 1,71)

S_3 = (2.25, 3.83, 9.0) x (0.0417, 0,0909, 0.1905)
= (0.09, 0.35, 1,71)

Table 5. Final Pairwise Comparison Matrix

Criteria	Pangasius Fish Fillet	Frozen Product	Surimi-based Product
Pangasius Fish Fillet	(1, 1, 1)	(0.25, 1.83, 4.0)	(0.25, 0.83, 1.0)
Frozen Product	(0.25, 1.17, 4.0)	(1, 1, 1)	(0.25, 1.33, 4.0)
Surimi-based Product	(1.0, 1.5, 4.0)	(0.25, 1.33, 4.0)	(1, 1, 1)

Then the degree of possibility (V values) can be calculated by Eq. (10). Table 6 presents the results of the values. Then priority weights can be computed using Eq. (11)

Table 6. Degree of Possibility

V	S_1	S_2	S_3
$V (S_1 \geq \dots)$	-----	1.0	0.981
$V (S_2 \geq \dots)$	0.994	-----	0.982
$V (S_3 \geq \dots)$	1.0	1.0	----

$$d'(C_1) = \min(1.0, 0.981) = 0.981$$
$$d'(C_2) = \min(0.994, 0.982) = 0.982$$
$$d'(C_3) = \min(1.0, 1.0) = 1.0$$

As a result, priority weights form a vector of W'= $(0.981;\ 0.982;\ 1.000)^T$. This vector goes through a normalization process to make the sum of weights equal to 1. Finally, final priority weights can be obtained as W= $(0.331;\ 0.332;\ 0.337)^T$.

As previously stated, there are several ways to use the AHP fuzzy approach to determine priority weights, and the resulting weights may vary based on the variable used. Based on the literature analysis, two types of fuzzy fundamental scales and two forms of weight aggregation were found. In this study, four distinct AHP fuzzy techniques are investigated by combining fuzzy fundamental scales and weight aggregation. This means that for a comprehensive comparison, priority weights are calculated using a total of five approaches, including the usual AHP (Table 7). Data was gathered by giving questionnaires to respondents who worked directly in the pangasius fish industry. The classic AHP approach is used to identify the priority weight among the choice criteria that influence derivative product determination. Figure 2 depicts a decision hierarchy in which the bidding criteria are classified and subclassified at two levels.

Table 7. Five Comparison Methods

Method	Approach
Method 1 (M.1)	Classical_AHP
Method 2 (M.2)	Fuzzy-AHP (FFS_1 and WA_1 mixture)
Method 3 (M.3)	Fuzzy-AHP (FFS_1 and WA_2 mixture)
Method 4 (M.4)	Fuzzy-AHP (FFS_2 and WA_1 mixture)
Method 5 (M.5)	Fuzzy-AHP (FFS_2 and WA_2 mixture)

Note: FFS = Fuzzy Fundamental Scale

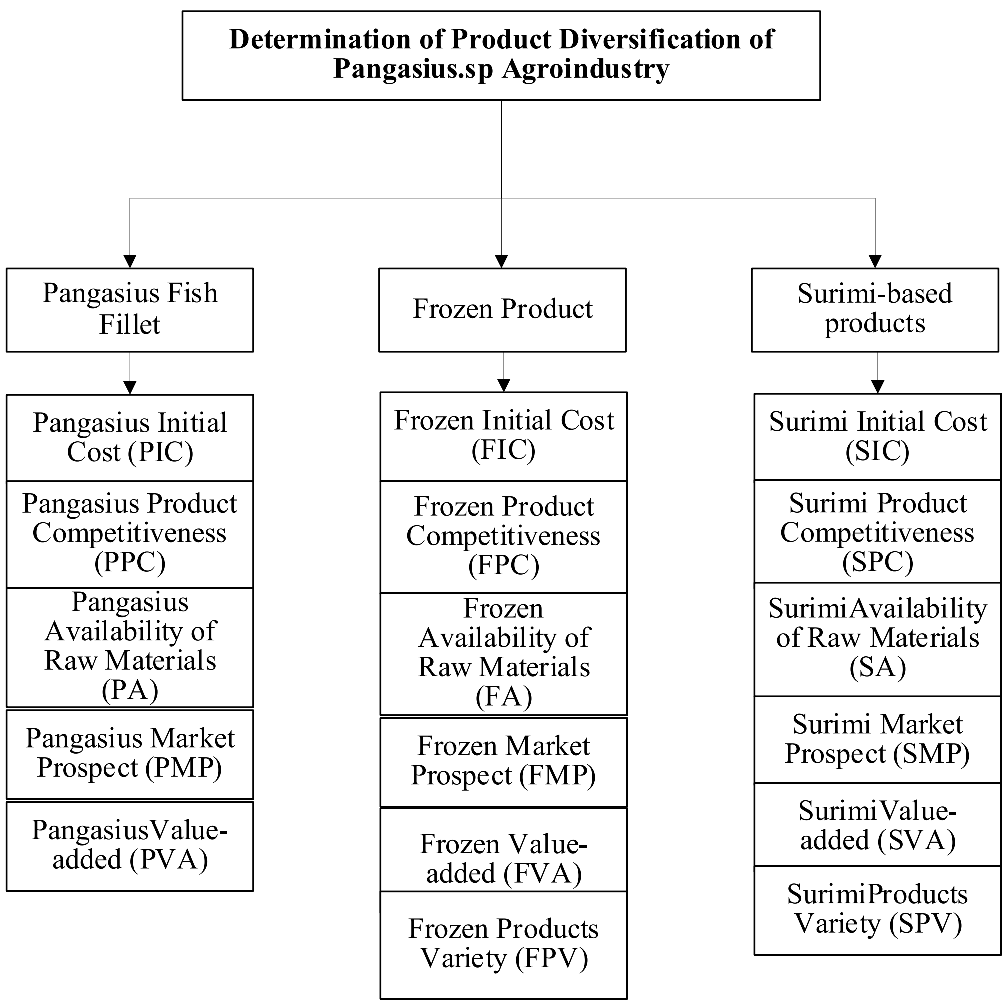

Figure 2. Structure of Product Decision Hierarchy

There are various subclassification factors for each classification factor. The classification levels are Pangasius fillet factor, frozen Product, and Surimi Based Product. The Pangasius fillet factor has five subclassification factors, and the frozen Product and Surimi Based Product factors each have six subclassification factors. Based on Miller's figure, each subclassification can only have a maximum of seven members (Miller, 1956).

When calculating the weight vector, four pairwise comparison matrices were assessed using five techniques, M1-M5, either on the fundamental scale or the fuzzy fundamental scale. Matrix comparisons between pairs containing strong values are turned into fuzzy pairwise comparison matrices with the relevant fuzzy membership functions. For example, if factor A is three times more favorable (a little more significant than the other) than component B, the first fuzzy basic scale assigns the fuzzy scale (2, 3, 4) instead of three.

4. Results and Discussion

The estimated weight vectors from classic AHP and fuzzy AHP are shown in this section. A complete comparison, particularly based on priority weights and ranking order, can reveal the degree of similarity or difference between various methodologies.

4.1 Priority Weights

Normative Weights Four paired comparisons at the category, and subclassification levels were used to determine priority weights.

Table 8-11 presents the product determination priority weights, Pangasius fillet, Frozen Product, and Surimi Based Product matrices. The fuzzy AHP weights were obtained following the previously described computational procedure.

Table 8. Priority Weights of Product Determination Level

	Criteria			
Method	Pangasius Fillet	Frozen Product	Surimi Based Product	Sum
M1	0.332	0.304	0.364	1
M2	0.331	0.332	0.337	1
M3	0.328	0.309	0.363	1
M4	0.332	0.331	0.337	1
M5	0.331	0.324	0.345	1

Tabel 9. Priority Weights of Pangasius Fillet Level

	Criteria					
Method	PIC	PPC	PA	PMP	PVA	SUM
M1	0.218	0.160	0.234	0.109	0.279	1
M2	0.205	0.188	0.209	0.191	0.207	1
M3	0.282	0.067	0.321	0.026	0.304	1
M4	0.203	0.193	0.207	0.193	0.205	1
M5	0.222	0.161	0.242	0.138	0.237	1
Note: PVA= Pangasisus Value Added; PA = Pangasius Availability of raw material; PIC= Pangasius Initial Cost; PMP = Pangasius Market Prospect; PPC = Pangasius Product Competitiveness						

Table 10. Priority Frozen Product Level

				Criteria			
Method	FIC	FPC	FA	FMP	FAVA	FPV	Sum
M1	0.043	0.067	0.372	0.218	0.134	0.166	1
M2	0.086	0.146	0.211	0.196	0.173	0.188	1

M3	0	0	0.563	0.31	0.003	0.124	1
M4	0.117	0.154	0.195	0.185	0.17	0.179	1
M5	0	0.006	0.347	0.264	0.174	0.209	1

Table 11. Priority Weights of Surimi-Based Product Level

				Criteria			
Method	SIC	SPC	SA	SMP	SVA	SPV	Sum
M1	0.25	0.184	0.133	0.13	0.133	0.17	1
M2	0.2	0.17	0.13	0.166	0.159	0.17	1
M3	0.66	0.191	0	0.052	0	0.1	1
M4	0.19	0.172	0.137	0.166	0.16	0.17	1
M5	0.28	0.183	0.073	0.161	0.132	0.17	1

Additionally, the degree of departure from the target data, or the data produced through the traditional AHP, is determined using the root mean square error (RMSE). RMSE may be determined for each decision factor with all fuzzy approaches using Eq. (14).

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(X_i - X_i'\right)^2}{n}} \quad \ldots\ldots (14)$$

Where X_i= weight with fuzzy AHP, X_i' = weight with classical AHP, and n = number of factors in the matrix.

The RMSE values of the four fuzzy techniques are presented in Table 12, and their error rate patterns are depicted graphically in Figure 3. Although there is some variation in the number of deviations among the fuzzy AHP algorithms, M5 has the lowest RMSE value among the four.

Table 12. RMSE Values of Fuzzy AHP

Method	Determination Product	Pangasius Fish Fillet	Frozen Product	Surimi Based Product	Sum
M2	0.0225	0.0519	0.0779	0.0259	0.1782
M3	0.0037	0.0746	0.1082	0.1901	0.3766
M4	0.0220	0.0538	0.0884	0.0295	0.1937
M5	0.0159	0.0232	0.0443	0.0313	0.1147

In addition, M2 and M4 follow M5 while showing similar performance in matrix evaluation. In contrast to the other three methods, the M3 number of factors in a matrix affects the error rate., as shown in Figure 3.

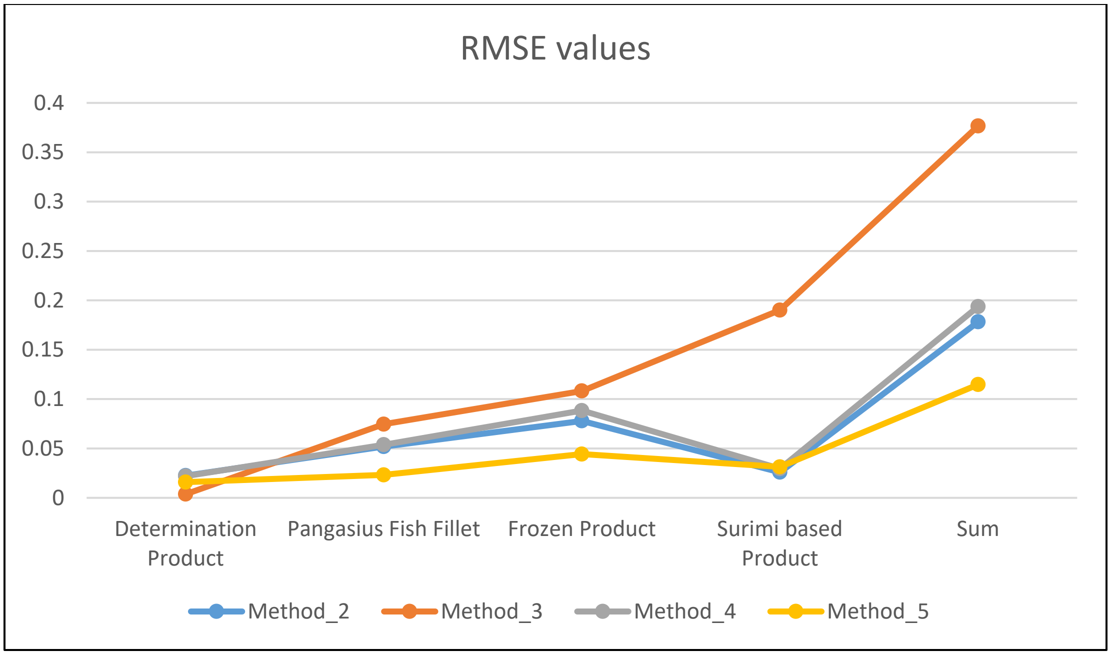

Figure 3. RMSE values

Three elements make up the categorization matrix at the first level, while five factors make up the matrix at the second level for Pangasius fish fillets. The third and fourth products—frozen goods and products made with surimi—require a comparison of six variables.

M3 has the worst performance in the remaining paired matrices, despite having the best performance in the three-factor evaluation. It is important to realize that priority weights can occasionally be severely affected. When M3 was used, it was found that zero weights were given to four components, two from the level of frozen products and two from the level of surimi-based products. Tables 10 and 11 show that M3 substantially underestimates some parameters while omitting some crucial ones. For instance, M1 calculates the FA (Frozen Availability of Raw Material) factor value to be 0.372, while M3 calculates the factor value to be 0.563. Even worse, the SIC component (Surimi Initial Cost) had M1 values of 0.246 and M3 values of 0.658. The attribute displayed by M3 is undesirable since it significantly impacts the selection of suitable priority weights and can alter how the decision hierarchy was initially intended to be formed. This characteristic is closely associated with WA2, which averages all TFN components.

A comparison of the probability values obtained from M2 and M3 at the level of frozen products is shown in Table 13.

Table 13. Degree of Possibility of MT2 and MT3 in the Frozen Product Level

Criteria	M2	M3
FIC	(0.01, 0.05, 0.25)	(0.03, 0.05, 0.07)
FPC	(0.01, 0.07, 0.61)	(0.05, 0.07, 0.10)
FA	(0.06, 0.32, 1.81)	(0.22, 0.32, 0.44)
FMP	(0.03, 0.23, 1.33)	(0.16, 0.23, 0.33)
FAVA	(0.03, 0.15, 0.83)	(0.10, 0.15, 0.22)
FPV	(0.02, 0.18, 1.18)	(0.13, 0.18, 0.26)

The fuzzy numbers in M2 are created using WA1, and while they partially overlap, they have a far greater range than their counterparts in M3. The FPC (Frozen Product Competitiveness) and FIC (Frozen Initial Cost) factors in M3 exhibit much lower numbers than the others, and their ranges do not overlap with those of the other factors in the group. Zero weight results from a lack of or a minor overlap.

4.2 Ordering by rank

When fuzzy AHP is used, rank order is examined to see if rank reversal happens. The complete ranking of the five approaches is shown in Table 14. A few ranking reversals were seen in numerous matrices, particularly at Pangasius fillet and Surimi Based Product levels.

Table 14. Five Methods Rank Ordering

Category	Method	Rank
Classification	M1	Surimi-Based Product> Pangasius Fillet > Frozen Product
	M2	Surimi-Based Product> Frozen Product > Pangasius Fillet
	M3	Surimi-Based Product> Pangasius Fillet > Frozen Product
	M4	Surimi-Based Product> Pangasius Fillet > Frozen Product
	M5	Surimi-Based Product> Pangasius Fillet > Frozen Product
Pangasius Fillet	M1	PVA> PA > PIC > PPC > PMP
	M2	PA > PVA > PIC > PMP > PPC
	M3	PA > PVA > PIC > PPC > PMP
	M4	PA > PVA > PIC > PPC = PMP
	M5	PA > PVA > PIC > PPC > PMP
Frozen Product	M1	FA > FMP > FPV > FVA > FPC > FIC
	M2	FA > FMP > FPV > FVA > FPC > FIC
	M3	FA > FMP > FPV > FVA > FPC = FIC (= 0.0)
	M4	FA > FMP > FPV > FVA > FPC > FIC
	M5	FA > FMP > FPV > FVA > FPC > FIC
Surimi Based Product	M1	SC=SI > SPC > SPV > SA = SVA > SMP
	M2	SC=SI > SPV > SPC > SMP > SVA > SA
	M3	SC=SI > SPC > SPV > SMP > SA = SVA (= 0.0)
	M4	SC=SI > SPV > SPC > SMP > SVA > SA
	M5	SC=SI > SPC > SPV > SMP > SVA > SA

Note:
PVA = Pangasius fish fillet Value Added;
PA = Pangasius Availability of raw material;
SVA = Surimi Value Added;
PIC = Pangasius Initial Cost;
PMP = Pangasius Market Prospect;
SA = Surimi Availability of raw material;
SPC = Surimi Product Competitiveness;
FVA = Frozen Value Added;
FMP = Frozen Market Prospect;
PPC = Pangasius Product Competitiveness;
FPV = Frozen Products Variety.
FPC = Frozen Product Competitiveness.
SMP = Surimi Market Prospect;
FA = Frozen Availability of raw material;
FIC = Frozen Initial Cost;
SIC = Surimi Initial Cost;
SPV = Surimi Product Variety.

In many instances, reversing ranks may be undesirable, especially when determining the ranking order of choice variables is one of the essential research objectives since it might undermine the legitimacy of decisions produced using classical AHP or fuzzy AHP. At the Pangasius fillet level, all AHP fuzzy techniques identify PA (Pangasius Availability of raw materials) as the most relevant element, whereas conventional AHP prioritizes PVA (Pangasius Value Added).

PA $[S_{PA}]$ values are indicated: (0.03, 0.25, 1.68) for M2, (0.18, 0.25, 0.36) for M3, (0.02, 0.25, 1.83) for M4, and (0.13, 0.25, 0.48) for M5. The enlarged values of PVA $[S_{PVA}]$ are (0.04, 0.24, 1.38) for M2, (0.16, 0.24,0.36) for M3, (0.03, 0.24, 1.67) for M4, and (0.11, 0.24, 0.53) for M5. These numbers indicate that the PA intermediate fuzzy number for all instances is somewhat more than the PVA number for all cases. This implies that, according to Equation (10), the possible level of PA is always greater than that of PVA. However, the difference between the fuzzy numbers of the two variables appears to be minor. A comparison chart was created as a practical reference for either strategy to solve their difficulties. Table 15 presents a list of significant factors to consider while selecting the best approach for a specific situation. It is based on the findings of two studies and their application processes.

Table 15. Fuzzy and Classical AHP comparison

Consideration point	Remarks
Uncertainty	When ambiguity in identifying the scale number is minimal, AHP fuzzy scales may be preferable to regular AHPH scales. Flexible scales, such as those that are not impacted by AHP fuzziness or have a range of potential values, must be considered when using AHP fuzzy.
Ease of use	Fuzzy numbers are represented by several numbers, such as three for fuzzy triangular numbers and four for trapezoidal fuzzy numbers. Classical AHP is easier because it only works simultaneously with one number. Readers unfamiliar with fuzzy number operations, such as multiplication or reciprocity, may make a mathematical error.
Design of hierarchy	The number of elements must be considered while creating a decision hierarchy. Too many criteria in the same category cause decision-makers to make inconsistent decisions. The comparison of two fuzzy numbers, in particular, is a time-consuming procedure. Ten elements need 90 comparisons, whereas 15 factors need 210 comparisons.
Pairwise comparisons	To decrease evaluation error in AHP fuzzy, employing linguistic phrases is highly significant and is preferable to fuzzy numbers (e.g., 3, 5, 7). Numbers or linguistic concepts might be utilized in comparison to classical AHP. Both AHP approaches need expert pairwise comparisons of components.
Applicability	Classical AHP and fuzzy AHP may be utilized efficiently in various decision-making circumstances, such as determining an individual's fitness for a specific position or task. The computed weight vectors may change depending on the core fuzzy scale design and aggregation mechanism.

When there is a relatively modest variance between several parameters, say more than five, the fuzzy AHP approach may be prone to rank reversal. In this situation, the final PVA weight vector cannot be greater than the PA weight vector. Overall, rank reversals were discovered in the three matrices for M2 and M3 and the two for M4 and M5.

5. Conclusions and Recommendation

Classical and fuzzy AHP has been actively used for various objectives, including assessing technology and equipment. Four distinct techniques were studied by altering the basic fuzzy scales and weight aggregations. Fuzzy AHP approaches were evaluated to determine which delivers the most equivalent outcomes to standard AHP.
The following are the primary conclusions from this extensive study:

1. The priority weights were generated on a given decision hierarchy using four alternative fuzzy AHP techniques. The results showed that the weights might change greatly depending on the design of the fuzzy membership functions. The mistake rate rose when more elements were included in an assessment matrix.
2. The rank reversal was detected in all fuzzy AHP techniques examined and was most prevalent in the Pangasius Fillet and Surimi Based Product categories. Small discrepancies in ranking factors are unavoidable, owing to how they handle pairwise comparison matrices.
3. It is important to consider the fuzzy basic scale to employ with whatever weight aggregation.
4. Overall, M5 performed the best compared to a classical AHP method, while M3 performed the worst.

The recommendation is that the fuzzy AHP technique necessitates extra calculations, owing to comparing two fuzzy integers' degrees of possibility (V values). More comparisons are made with more elements, and this growth is exponential. Six comparisons are needed for a matrix with three components, whereas thirty are needed for a matrix with six factors.

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