Sustainable Supplier Selection for Agro-Food Industry of an Emerging Economy: A Fuzzy Topsis Approach

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Abstract

In order to make a manufacturing system sustainable, it is crucial to integrate sustainability practices across the whole supply chain and the production process. It is a demand in today's industrial sector, especially in developing nations like Bangladesh which has an emerging economy. The most important economic, environmental, and social assessment criteria for choosing sustainable suppliers will be identified through a thorough literature analysis and expert input. The Stepwise Weight Assessment Ratio Analysis (SWARA) method will be used to determine the weights of the selected evaluation criteria. The ultimate ranking of suppliers in the Agro-food industry will then be determined using the Fuzzy Topsis approach utilizing the criterion weight from the SWARA method. This study is anticipated to help decision-makers in the Agro-food sectors of developing nations choose suppliers who are both long-term economically and ecologically sustainable.

Keywords
SWARA, Fuzzy Topsis, Supplier selection, Agro-food, Sustainability

1. Introduction
The Agro-food processing sector is a significant industry, especially for the countries which has an emerging economy like Bangladesh. This industry is a significant component of Bangladesh's manufacturing sector, which today contributes around 20% of the nation's GDP and the industry is growing day by day. Due to increasing environmental and economic worries, sustainability has been a top issue for enterprises globally since the United Nations (UN) announced the Sustainable Development Goals (SDG) in 2015. The Bangladeshi government has chosen the Agro-food sector as one of its priority sectors for sustainable development. For organizations to operate effectively and produce high-quality products, supplier selection is a crucial process. In Bangladesh, the growth of the Agro-processing industry is severely constrained. There are some critical problems with the availability of the market, huge transportation costs, inadequate post-harvesting procedures knowledge, and packaging to Bangladesh's Agro-processing industry's expansion. It is crucial to create a sustainable supplier selection framework to address these issues. The research's innovation is the creation of a hybrid model in SSS that can simulate the decision-making process, take into account a wide range of factors, and produce more precise findings. This will help managers identify potential areas for development and boost competitive advantage, ensuring that the most sustainable provider is chosen from a pool of suppliers. Additionally, this will help to improve the effectiveness of the supply chain.

1.1 Objectives

The objectives of this study encompass a comprehensive examination of the economic, environmental, and social factors influencing the selection of sustainable suppliers in the agro-food sector of Bangladesh. This research aims to establish a Fuzzy TOPSIS framework for supplier sustainability evaluation, leveraging the SWARA approach to determine the ultimate ranking of these suppliers. Additionally, it seeks to introduce a range of supplier alternatives, along with a blend of subjective and objective sustainability parameters to enhance the selection process, thereby contributing to the advancement of sustainable practices in the agro-food industry of Bangladesh.

2. Literature Review

For choosing appropriate suppliers for green and sustainable approaches using a variety of methods, various models were presented. These techniques can be divided into two primary groups: single models (such as artificial intelligence, mathematical programming, qualitative methods, and Multi-Criteria Decision Making (MCDM) methodologies) and hybrid models. Since this decision inherently requires several goals incorporating criteria in an uncertain environment, integrated methodologies have been widely used in the supplier selection process. Problems with supplier selection have been examined by a number of researchers recently. Combining two or more strategies is advised in order to strengthen multi-criteria optimization models. Hence, to identify the most sustainable suppliers in the agro-food sector, two MCDM techniques—SWARA and FUZZY TOPSIS—were integrated in this study. SWARA is easier to use and less complex than other MCDMs, allowing experts to convey ideas conveniently(Stanujkic et al. 2020). Experts can score the criteria in SWARA without taking into account any specific most favourable or least favourable criterion, which makes it easier for them to provide feedback and enables them to contribute more(Zolfani and Chatterjee 2019). The process of choosing a supplier is complex and can include a number of different criteria, a mix of selection models, group decision-making, and different kinds of uncertainty. One of the well-known traditional MCDM techniques, Techniques for order performance by similarity to ideal solution (TOPSIS), may serve as the foundation for supplier selection models that can successfully address these uncertainties(Cakar and Çavuş 2021).Sustainable supplier selection is a novel idea for agro-food sector, but it is standard practice in other sectors such as chemicals, leather, pharmaceuticals, textile dyeing, and so on. Some previous works on sustainable supplier selection are listed below.

Table 1. Some previous work on sustainable supplier selection in different industries:

Author Name	Work	Methodology
[I. J. Orji and S. Wei,2015]	Manufacturing Industry	TOPSIS
[S. A. Hoseini, A. Fallahpour, K. Y. Wong,A. Mahdiyar, M. Saberi, and S. Durdyev,2021]	Construction Industry	Fuzzy Inference System (FIS)
[M. O. Okwu and L. K. Tartibu,2020]	Retail Industry	TOPSIS and ANFIS
[Ž.Stević,D.Pamučar, A.Puška,andP. Chatterjee,2020]	Healthcare Industry	MARCOS
[C. Wu, Y. Lin, and D. Barnes,2021]	Chemical Industry	GRA and FUZZY TOPSIS
[M. R. Sarker, F. Ahmed, A. K. Deb, andM.Chowdhury,2018]	Footwear Industry	Delphi
[Yu and Hou, 2016]	Automobile Manufacturing Industry	MMAHP

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[R. Chattopadhyay, S. Chakraborty, and S. Chakraborty,2020]	Steel Industry	D-MARCOS
[R. K. Singh and S. Modgil,2020]	Cement Industry	SWARA and WASPAS(Rabbani and Sarkar 2015)

For this study, seven experts with extensive backgrounds in the agro-food supply chain have been chosen. First, a review of the literature and feedback from experts led to the identification of ten crucial evaluation criteria. Four of the criteria have to do with the economy, three with the environment, and the remaining three with society.

3. Methods

A multi-criteria problem, supplier selection takes into account both tangible and intangible elements. The approach of this study consists of two parts, namely the collecting of expert data for the SWARA technique and the analysis of the driving forces behind the development of a sustainable supplier. The second stage is gathering information from experts for the fuzzy TOPSIS technique, which will aid in choosing the most environmentally friendly supplier in the context of Bangladesh.
Supplier selection process:

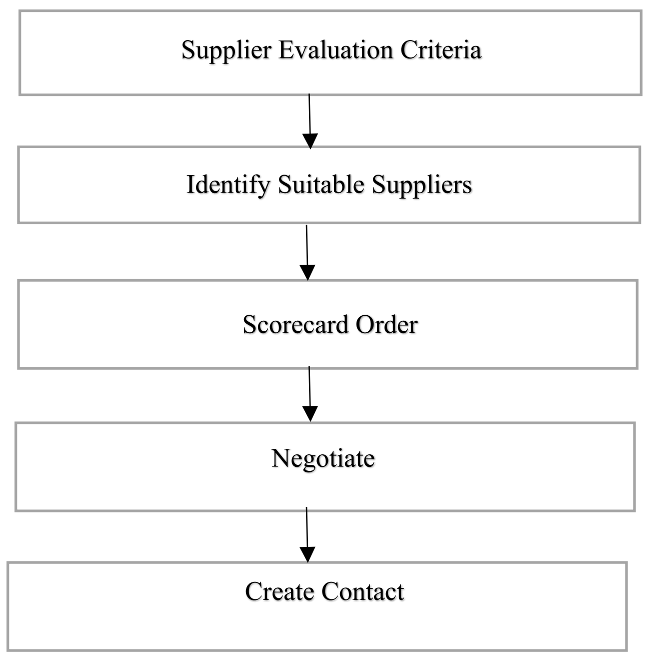

Figure 1. General process of supplier selection

3.1 Supplier Selection Criteria

In the Agro-food processing sector, suppliers are essential since they offer the machinery, equipment, after-sales maintenance services, and most importantly, the raw ingredients. To choose a competent supplier, the selection process needs a proper framework or sufficient scope of provider requirements. Companies may identify suppliers that are dedicated to sustainable practices, lower their environmental effect, and contribute to a more environmentally conscious supply chain by supplying against these criteria. There are three major criteria for supplier selection with some sub criteria. Supplier selection framework:

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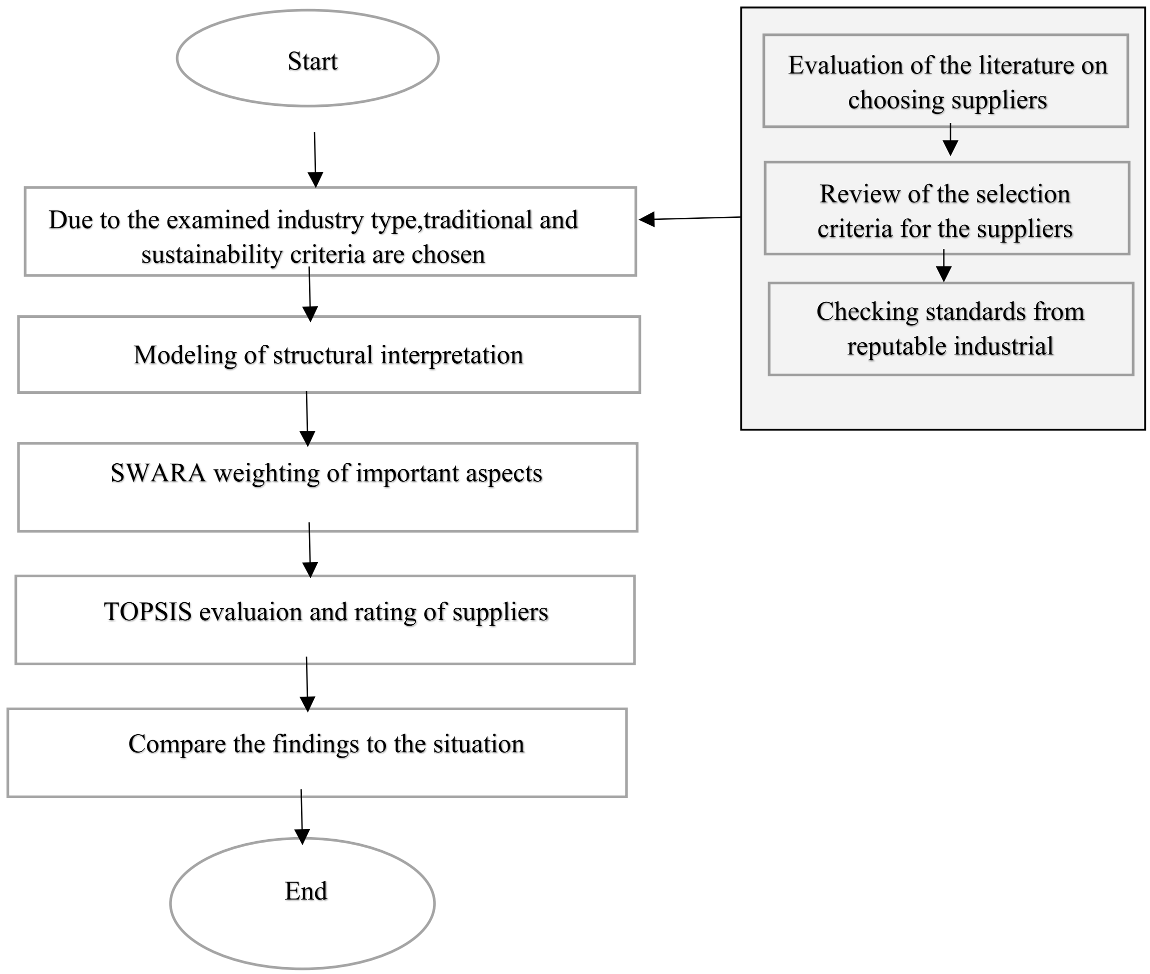

Figure 2. Framework of supplier selection

1.Economic Criteria

i. Purchase cost(c1)
ii. Quality(c2)
iii. Delivery and service(c3)
iv. Technological capability(C10)

2. Environmental Criteria

i. Environment Management (c7)
ii. Pollution regulation(c9)
iii. Recycling(c8)

3. Social Criteria

i. Work safety and labor health(c4)
ii. Information disclosure(C6)
iii. Reputation(C5)

3.2 SWARA Method

The fundamental advantage of the SWARA approach for solving decision-making difficulties is that it does not require evaluation in order to organize the criteria and determine the priorities and weights of those criteria in accordance with organizational goals or plans. SWARA Method's phases are given below:

Phase 1: Compiling a list of criteria.

The qualities (criteria) are decided by literature research and/or professional judgment.

Phase 2: Survey of experts and decision makers.

Experts and decision-makers are now requested to rate the finalized list of criteria and qualities. Typically, in this stage, the less important criteria are eliminated. As a result, the final list still includes the comparatively most relevant criteria. From most crucial to least significant, the final list of criteria is arranged.

Phase 3: Determining the comparative importance of the average value (sj).

The relevance of the j-th criterion in relation to the prior criterion (j-1)th is assessed by experts through pair-wise comparisons starting with the second criterion.

Phase 4: Calculating the coefficient values(kj):

$$K_j=\begin{cases} 1 & j=1 \\ Sj+1 & j>1 \end{cases}$$

Phase 5: Choosing the recalculated weight in phase five (qj):

$$Q_i=\frac{Kj}{Kj-1}$$

Phase 6: Relative weights are calculated (wj):

$$W_j=\frac{Qj}{\sum_{j=1}^{n} Qj}$$

From a questionnaire pertaining to the issue, the authors calculated the preference for each criterion and excluded those that were unsuccessful. Following that, they ranked the desired criteria in accordance with the information from the same questionnaire. And they used the technique by mathematically subtracting from each other the preference values, which represented the relative significance of the average value (sj).

The second method involves asking each participant to rate a set of criteria according to their own preferences, and then average those rankings to get a new (final) rating.

The third application resembles the second application. Once more, the criterion important order was determined as in the second usage form by decision makers' pairwise comparisons, but this time, the procedure was carried out by averaging the pairwise comparisons rather than the weight values at the conclusion of the SWARA Method (sj).

SWARA employed these procedures to establish the weights of the primary criterion and sub-criteria.

Table 2. Determination of the merged RI scores

Criteria	Merged RI score	Comparative Importance S_j	Coefficient Value K_j	Corrected Weight Value Q_j	Final Weight Value
C2	0.992857143		1	1	0.129835752
C1	0.935714286	0.057142857	1.057142857	0.945945946	0.122817603
C3	0.9	0.035714286	1.035714286	0.91332712	0.118582513
C4	0.807142857	0.092857143	1.092857143	0.835724162	0.108506875
C5	0.642857143	0.164285714	1.164285714	0.717799894	0.093196089
C7	0.635758134	0.007099009	1.007099009	0.712740145	0.092539153
C10	0.542857143	0.092900991	1.092900991	0.652154359	0.084672951
C8	0.535714286	0.007142857	1.007142857	0.647529151	0.084072434
C9	0.528571429	0.007142857	1.007142857	0.642936746	0.083476176
C6	0.514285714	0.014285715	1.014285715	0.633881298	0.082300455

Table 3. Calculating final criterion weights using SWARA

Criteria	Individual Evaluations of decision makers (DMs)							Merged relative Importance Score (RI score)
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	
C1	0.9	0.95	.9	.95	.95	.95	.95	0.935714286
C2	1	1	.95	1	1	1	1	0.992857143
C3	0.95	0.9	.85	.9	.9	.9	.9	0.9
C4	0.85	0.85	.75	.7	.85	.85	.8	0.807142857
C5	0.8	0.75	.5	.6	.75	.7	.4	0.642857143
C6	0.75	0.8	.35	.2	.70	.45	.35	0.514285714
C7	0.7	0.7	.3	.65	.65	.75	.75	0.642857143
C8	0.55	0.55	.4	.55	.6	.6	.5	0.535714286
C9	0.6	0.6	.15	.5	.55	.65	.65	0.528571429
C10	0.65	0.65	.45	.45	.5	.55	.55	0.542857143

Table 4. Ranking of the Criteria

Criteria	Rank
Purchase cost(C1)	2
Quality(C2)	1
Delivery and service(C3)	3
Work safety and labor health(C4)	4
Reputation(C5)	5
Information disclosure(C6)	10
Environment Management system(C7)	6
Recycling(C8)	8
Pollution regulation(C9)	9
Technological capability(C10)	7

3.3 Fuzzy Topsis Method

FuzzyαTopsis is the most well-known method for resolving MCDM issues. This approach is predicated on the idea that the selected option should be closest to the Positive Ideal Solution (PIS), or the solution that minimizes costs and maximizes benefits, and the furthest from the Negative Ideal Solution (NIS). Here, Triangular fuzzy numbers will be implemented for the fuzzy TOPSIS algorithm. The following are the steps in the fuzzy TOPSIS method.
Step 1: Decide how much each criterion and sub-criterion should weight.
Using triangular fuzzy numbers, the significance of each criterion is established in this case.

Table 5. Fuzzy ratings for linguistic variables

Fuzzy number	Alternative Assessment	QA Weights
(1,1,3)	Very Poor (VP)	Very Low (VL)
(1,3,5)	Poor (P)	Low (L)
(3,5,7)	Fair (F)	Medium (M)
(5,7,9)	Good (G)	High (H)
(7,9,9)	Very Good (VG)	Very High (VH)

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Step 2: Criteria weightage by Decision makers

Table 6. Criteria Weightage

Criteria	Individual Evaluations of decision makers (DMs)						
	DM1	DM2	DM3	DM4	DM5	DM6	DM7
C1	H	VH	VH	H	VH	H	H
C2	VH	VH	VH	VH	VH	VH	VH
C3	VH	H	H	H	H	H	H
C4	H	H	H	M	M	H	M
C5	M	M	M	M	L	L	L
C6	M	M	H	M	M	M	VL
C7	M	M	L	H	H	M	M
C8	VL	VL	M	M	M	L	L
C9	L	L	L	L	M	M	M
C10	M	M	L	M	L	L	M

Step 3: Apply the fuzzy numbers

Table 7. Fuzzy numbers for Criteria Weightage

Criteria	Individual Evaluations of decision makers (DMs)						
	DM1	DM2	DM3	DM4	DM5	DM6	DM7
C1	H (5,7,9)	VH (7,9,9)	VH (7,9,9)	H (5,7,9)	VH (7,9,9)	H (5,7,9)	H (5,7,9)
C2	VH (7,9,9)	VH (7,9,9)	VH (7,9,9)	VH (7,9,9)	VH (7,9,9)	VH (7,9,9)	VH (7,9,9)
C3	VH (7,9,9)	H (5,7,9)	H (5,7,9)	H (5,7,9)	H (5,7,9)	H (5,7,9)	H (5,7,9)
C4	H (5,7,9)	H (5,7,9)	H (5,7,9)	M (3,5,7)	M (3,5,7)	H (5,7,9)	M (3,5,7)
C5	M (3,5,7)	M (3,5,7)	M (3,5,7)	M (3,5,7)	L (1,3,5)	L (1,3,5)	L (1,3,5)
C6	M (3,5,7)	M (3,5,7)	H (5,7,9)	M (3,5,7)	M (3,5,7)	M (3,5,7)	VL (1,1,3)
C7	M (3,5,7)	M (3,5,7)	L (1,3,5)	H (5,7,9)	H (5,7,9)	M (3,5,7)	M (3,5,7)
C8	VL (1,1,3)	VL (1,1,3)	M (3,5,7)	M (3,5,7)	M (3,5,7)	L (1,3,5)	L (1,3,5)
C9	L (1,3,5)	L (1,3,5)	L (1,3,5)	L (1,3,5)	M (3,5,7)	M (3,5,7)	M (3,5,7)
C10	M (3,5,7)	M (3,5,7)	L (1,3,5)	M (3,5,7)	L (1,3,5)	L (1,3,5)	M (3,5,7)

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Step 4: Aggregated criteria weightage fuzzy decision matrix

$$a_{Ij} = \min\{a_{ij}^{k}\}$$
$$b_{Ij} = \frac{1}{k}\sum b^{k}_{ij}$$
$$c_{ij} = \max\{c^{k}_{Ij}\}$$

Table 8. Aggregated fuzzy decision matrix for criteria weightage

Criteria	Aggregated weightage
C1	5,7.871,9
C2	7,9,9
C3	5,8.286,9
C4	3,6.143,9
C5	1,4.143,7
C6	1,4.714,9
C7	1,5.286,9
C8	1,3.286,7
C9	1,3.857,7
C10	1,4.143,7

Step 5: Fuzzy multi criteria group decision making (gdm) and process of normalizing
rij = (aij /c*j, bij / c*j, cij/ c*j) and c*j = max cij (benefit criteria)
rij = (aj /cij , aj /bij , aj /aij) and aj = min aij (cost criteria)

Table 9. Aggregated fuzzy decision matrix for alternative

Supplier	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
S1	1/1,1/ 5.857, 1/9	1/9,5. 571/9, 9/9	1/9,4. 714/9, 9/9	3/9,5. 268/9, 9/9	1/9,5. 268/9, 9/9	1/9,5. 857/9, 9/9	3/9,7. 2/9,9/ 9	1/9,1. 571/9, 5/9	3/9,6. 43/9,9 /9	1/9,5. 571/9, 9/9
S2	1/1,1/ 5.571, 1/9	1,5.28 6/9,9/ 9	3/9,7. 286/9, 9/9	1/9,4. 43/9,9 /9	3/9,6. 142/9, 9/9	1/9, 5.286/ 9,9/9	1/9,6. 43/9,9 /9	5/9,6. 571/9, 9/9	1/9,5. 571/9, 9/9	1/9,6. 142/9, 9/9
S3	1/3,1/ 6.142, 1/9	5/9,7. 857/9, 9/9	1/9,6. 714/9, 9/9	1/9,4. 714/9, 9/9	5/9,7/ 9,9/9	1/9,5. 285/9, 9/9	3/9,5. 571/9, 9/9	1/9,4. 43/9,9 /9	3/9,6. 142/9, 9/9	1/9,4. 714/9, 9/9
Supplier	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
S1	1.000, 0.171, 0.111	0.111, 0.619, 1	0.111, 0.524, 1	0.333, 0.585, 1	0.111, 0.585, 1	0.111, 0.651, 1	0.333, 0.800, 1	0.111, 0.175,. 556	0.333, 0.714, 1	0.111, 0.619, 1
S2	1.000, 0.180, 0.111	0.111, 0.587, 1	0.333, 0.810, 1	0.111, 0.492, 1	0.333, 0.682, 1	0.111, 0.587, 1	0.111, 0.714, 1	0.556, 0.730, 1	0.111, 0.619, 1	0.111, 0.682, 1
S3	0.333, 0.163, 0.111	0.556, 0.873, 1	0.111, 0.746, 1	0.111, 0.524, 1	0.556, 0.778, 1	0.111, 0.587, 1	0.333, 0.619, 1	0.111, 0.492, 1	0.333, 0.682, 1	0.111, 0.524, 1

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Step 6: Weighted Normalized Fuzzy Decision Matrix

Weighted Normalized Fuzzy Decision Matrix,

P=[pij] where pij= rij× w_j

Table 10. Weighted Normalized Fuzzy Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
S1	5,1.328,1	.778,5.571,9	0.556, 4.340, 9	1.000, 3.654, 9	0.111, 2.425, 9	0.111, 3.068, 9	0.333, 4.229, 9	0.111, 0.574, 3.889	0.333, 2.756, 7	.111,2.565,7
S2	5,1.397,1	.778,5.286,9	1.667, 6.708, 9	0.333, 3.073, 9	0.333, 2.827, 9	0.111, 2.769, 9	0.111, 3.777, 9	0.556, 2.399, 7	0.111, 2.387, 7	.111,2.827,7
S3	1.667,1.267,1	3.889, 7.857, 9	0.556, 6.181, 9	0.333, 3.270, 9	0.556, 3.222, 9	0.111, 2.768, 9	0.333, 3.272, 9	0.111, 1.617, 7	0.333, 2.170, 7	.111,2.170,7
FPIS (A+)	5,1.397,1	3.889, 7.857, 9	1.667, 6.708, 9	1.000, 3.654, 9	0.556, 3.222, 9	0.111, 3.068, 9	0.333, 4.229, 9	0.556, 2.399, 7	0.333, 2.756, 7	.111,2.827,7
FNIS (A-)	1.667,1.267,1	.778,5.286,9	0.556, 4.340, 9	0.333, 3.073, 9	0.111, 2.425, 9	0.111, 2.768, 9	0.111, 3.777, 9	0.111, 0.574, 3.889	0.111, 2.387, 7	.111,2.170,7

Step 7: FPIS and FNIS

$A^+ = (p^+_1, p^+_2, \dots p^+_n)$ where

$p^+_j = \max\{p_{ij3}\}$, i=1,2….m; j=1, 2..….n

$A^- = (p^-_1, p^-_2, \dots p^-_n)$ where

$p^-_j = \min\{p_{ij}1\}$, i=1,2….m; j=1,2……n

Table 11. Distance of Criteria from each supplier to FPIS (Positive ideal solution)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Distance of each weighted supplier(d_i^+)
S1	.04	2.22	1.51	0	0.526	0	0	2.098	0	0.151	6.545
S2	0	2.33	0	0.51	0.26	0.173	0.291	0	0.25	0	3.814
S3	1.93	0	.71	.44	0	0.168	.552	0.52	0.338	0.38	5.038

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Table 12. Distance of Criteria from each supplier to FNIS (Fuzzy negative ideal solution)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Distance of each weighted supplier(di^-)
S1	1.92	0.165	0	0.51	0	0.173	.290	0	0.25	0.288	3.596
S2	1.93	0	1.51	0	0.265	0.04	0	2.098	0	0	5.843
S3	0	2.33	1.062	0.11	0.527	0	.276	1.89	.243	0.38	6.818

Step 8: FPIS and FNIS for each criterion

FPIS (A1) = d (pij, p1+) and
FNIS (A1) = d (pij, p1-) where,
d (a,b) = $\sqrt{1/3\,[(a1 - b1)\,2 + (a2 - b2)\,2 + (a3 - b3)\,2]}$
$di += \sum_{j=1}^{n} d(\text{pij}, \text{pj}+)$
$di -= \sum_{j=1}^{n} d(\text{pij}, \text{pj}-)$
$CC_{i} = \frac{\text{di}-}{\text{di}- + \text{di}+}$

Table 13. Determination of closeness coefficient

Suppliers	FPIS	FNIS	Closeness Coefficient of each supplier (CC_i)	Rank
S1	6.545	3.596	0.354600138	3
S2	3.814	5.843	0.605053329	1
S3	5.038	6.818	0.575067476	2

Table 14. Final ranking of supplier

Suppliers	Final Supplier Ranking
Supplier 1	3
Supplier 2	1
Supplier 3	2

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4. Result

With the help of this thesis, we intend to identify a suitable supplier for the Argo-food sector based on their various requirements. How to choose a sustainable supplier is something we learn. Decision-makers may learn from this study how important various economic, geographical, and social factors are in relation to one another. Rank of the criteria according to the importance is shown below:

Table 15. ranking of the Criteria

Criteria	**Rank**
Purchase Cost (C1)	2
Quality (C2)	1
Delivery and Service (C3)	3
Work Safety and Labor Health (C4)	4
Reputation (C5)	5
Information Disclosure (C6)	10
Environment Management System (C7)	6
Recycling (C8)	8
Pollution Regulation (C9)	9
Technological Capability (C10)	7

Table 16. Ranking of the alternative

Suppliers	Final Supplier Ranking
Supplier 1	3
Supplier 2	1
Supplier 3	2

5. Conclusion and Discussion

Sustainable Supplier Selection is presented as one of the sustainable practices that affect all operational operations inside a corporation in the context of sustainable supply chain management. It might be difficult to choose the best supplier(s) who can obtain materials or components while taking organizational requirements and predefined sustainable standards into account. Therefore, providing Decision makers with precise decision-making support would be advantageous for an effective organizational movement towards putting sustainable sourcing practices in place. This study looked at the SSS issue in the Argo-food industry with the hope of offering a useful method for SSS decision-making. The relationships between and the criteria and sub-criteria were not taken into account, which is a weakness of this study. The outcomes may be affected by taking into account the dependencies between the criterion and sub-criteria. Further research might use the Analytic Network Process to evaluate the relationships between the criterion and sub-criteria (ANP).

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Biographies

Mohaddis Hossain is an accomplished individual with a passion for education and a keen interest in the field of Mechatronics and Industrial Engineering. Born and raised in Rajshahi, Bangladesh, he began his academic journey at the prestigious Rajshahi Collegiate School, where he excelled academically. After completing his secondary education, Mohaddis continued his educational journey at New Govt. Degree College, Rajshahi, where he continued to excel in his studies. His dedication and commitment to his studies were evident as he achieved a perfect GPA of 5.00 in both his Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) exams, reflecting his outstanding academic prowess. His academic journey reached new heights when he gained admission to the Chittagong University of Engineering and Technology (CUET), where he pursued a degree in Mechatronics and Industrial Engineering. Not only has Mohaddis Hossain demonstrated exceptional academic performance, but he has also actively engaged in various extracurricular activities. His leadership skills have been recognized as he served as the Vice President of the CUET SPORTS Club and took on the role of Financial Secretary in both the IEOM CUET Student Club and the Rajshahi Divisional Association. His field of interest in research revolves around industrial engineering, showcasing his commitment to applying his knowledge and skills to real-world challenges and innovations in the industrial sector.

Fatin Ihsan Hredoy also a fresh graduate from the Department of Mechatronics and Industrial Engineering. He completed his high school from Natural Gas Fertilizer School and college from Notre Dame College Mymensingh.

He acted as a President in IEOM CUET Student Chapter. He is now pursuing his M.Sc from Chittagong University of Engineering and Technology (CUET) in Mechanical Engineering. His field of interest is in computational fluid dynamics, automation, sustainability, Heat transfer etc.

Dr. Jamal Uddin Ahamed is a Professor and Head of Department of Mechatronics and Industrial Engineering, Faculty of Mechanical Engineering at Chittagong University of Engineering and Technology (CUET), Chittagong, Bangladesh. Dr. Ahamed was EX-Dean, Faculty of ME, CUET. He received his B.Sc. from Chittagong University of Engineering and Technology (CUET), M.Sc. from Bangladesh University of Engineering and Technology (BUET) and Ph.D. from University of Malaya, Malaysia. His field of interest is in Heat transfer, Thermal engineering, Fluid Dynamics, Automotive air conditioning, Energy, exergy analysis of vapor compression system, Nano technology in Refrigeration and air conditioning system, Effect of nano fluid in refrigeration heat transfer performance. He has supervised many under-graduate and post-graduate students in these areas. Moreover, he has published many journal papers, book chapters and conference articles in these areas.

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