Neutrosophic Sets and Systems

Volume 57 Article 18

8-20-2023

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Mahmoud Ismail

Ahmed M. Ali

Ahmed Abdelhafeez

Ahmed Abdel-Rahim El-Douh

Mahmoud Ibrahim

See next page for additional authors

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NSS

Neutrosophic Sets and Systems, Vol. 57, 2023

University of New Mexico

Neutrosophic Multi-Criteria Decision Making for Sustainable Procurement in Food Business

Mahmoud Ismail[1], Ahmed M.Ali[2,*], Ahmed Abdelhafeez[3], Ahmed Abdel-Rahim EI-Douh [4], Mahmoud Ibrahim[5] Ayman H. Abdel-aziem[6]

[1]Department of Operations Research, Faculty of Computers and Informatics, Zagazig University, Egypt; mahsabe@yahoo.com

[2,*]Faculty of Computers and Informatics, Zagazig University, Zagazig 44519, Sharqiyah, Egypt; aabdelmonem@zu.edu.eg

[3]Faculty of Information Systems and Computer Science, October 6th University, Cairo, Egypt; aahafeez.scis@o6u.edu.eg

[4]Faculty of Information Systems and Computer Science, October 6th University, Cairo, Egypt; ahmed.eldouh.csis@o6u.edu.eg

[5]Faculty of computers and Informatics, Zagazig University, Zagazig, 44519, Egypt; mmsba@zu.edu.eg

[6]Faculty of Information Systems and Computer Science, October 6th University, Cairo, Egypt; Ayman.Hasanein.comp@o6u.edu.eg

Abstract: Purchasing food in a way that minimizes negative effects on the environment, society, and the economy is a growing trend in the food industry. Sustainable procurement is discussed in this study, along with its significance, important criteria, and advantages in the food business. Businesses may aid sustainable development, lessen their impact on the environment, provide aid to local communities, and keep up with shifting consumer expectations for sustainably and ethically produced food when they prioritize responsible sourcing practices. To effectively implement sustainable procurement in the food sector, this article stresses the need for teamwork, openness, and a long-term commitment to sustainability. So, this paper ranks the best supplier in sustainable procurement in the food business to achieve sustainability. The concept of multi-criteria decision-making (MCDM) is used in this paper to deal with the various criteria. This paper used the TOPSIS method as an MCDM tool to compute the weights of criteria and rank the suppliers. The TOPSIS method is integrated with the single-valued neutrosophic set to deal with uncertain and vague information. There are seven criteria and 10 suppliers in the food business are evaluated and ranked in this study. We obtained the environmental impacts as the best criteria in seven criteria. The goal of environmental impact prioritizing suppliers and products that minimize negative environmental impact.

Keywords: Neutrosophic Set, MCDM, TOPSIS, Procurement, Sustainability

1. Introduction

As businesses become more aware of the environmental, social, and financial consequences of their supply chains, they are beginning to prioritize sustainable procurement practices within the food industry.

Businesses in the food industry, such as restaurants, caterers, and grocery stores, may have a significant impact on global sustainability by shifting to ethical purchasing policies. Sustainable food procurement involves making ethical and ecologically sound decisions throughout the manufacturing, distribution, consumption, and disposal of food items. This article delves into the topic of sustainable procurement in the food sector, discussing its value, obstacles, and recommendations for moving forward. Businesses in the food industry may improve their environmental impact, give back to their communities, and satisfy customer demand for sustainably and ethically sourced products by giving sustainable procurement first priority[1], [2].

Deforestation, greenhouse gas emissions, and water pollution are just some of the ways in which the food business is damaging the environment. Sustainable and sustainably sourced food items are in high demand as consumer knowledge of the environmental and social implications of food production increases. The key to environmentally, socially, and economically responsible food procurement is to take into account all stages of the supply chain, from raw material sourcing through final retail packaging. The focus is on long-term viability rather than short-term gains in efficiency or quality[3], [4].

The mitigation of negative effects on the environment is a major advantage of sustainable procurement in the food business. Organic farming and regenerative agriculture are two examples of sustainable agriculture that help companies reduce their chemical footprint, save biodiversity, and preserve scarce natural resources. Waste is reduced and landfill contributions are decreased because of sustainable procurement's emphasis on responsible waste management and the promotion of environmentally friendly packaging materials[5], [6].

The importance of social responsibility in sustainable food purchases cannot be overstated. Businesses may aid in the growth of their communities by investing in the agricultural sector. Farmers may be protected from exploitation and paid fairly for their goods with the help of fair trade practices and ethical sourcing. In addition, by prioritizing universal access to safe, healthy, and reasonably priced food, sustainable procurement may contribute to solving problems of food security and food justice[7], [8].

There are a number of obstacles that must be overcome before the food business can adopt sustainable buying practices. One major challenge is the proliferation of middlemen and international sourcing networks that characterize modern supply chains. It might be difficult to ensure traceability and transparency across the supply chain, but new tools like blockchain and digital tracking systems are making it easier than ever. It is important for firms to weigh the long-term advantages against the potential additional expenses of obtaining sustainable goods, and to explore opportunities for cooperation and partnership to take advantage of economies of scale[9], [10].

There are a variety of approaches that companies may take to sustainable buying in the food sector. Establishing connections with certified sustainable suppliers, developing explicit sustainability standards for suppliers, and performing frequent audits and evaluations are all crucial. Sustainable practices across the supply chain can only be driven by encouraging supplier participation and cooperation. Moreover, companies may guarantee that procurement choices are consistent with sustainable values by investing in staff training and education[11], [12].

Sustainable food procurement practices are mostly driven by consumer demand. Sustainable food enterprises may gain an advantage as consumers grow more aware of the ecological and social

consequences of their purchases. Increased brand reputation and customer satisfaction may result from open communication regarding sustainable sourcing practices and certifications that have been earned by the company[13], [14].

In this paper, we improve the supply chain by selecting the best suppliers in sustainable procurement in the food business. There are various criteria for sustainable procurement in the food business so, we used the concept of multi-criteria decision-making (MCDM) to deal with various criteria[15], [16].

In light of these considerations, the proper handling of uncertainties or imprecision has emerged as a critical problem in MCDM analysis. The single-valued neutrosophic set (SVNS) suggested by Smarandache and Wang et al. is one such tool for capturing such uncertainties or imprecision information[17], [18]. The SVNS, a novel and practical extension of fuzzy sets, is distinguished by the strength of the relationships between its truth-member, indeterminacy-member, and falsity-member. The SVNS seems to be more successful at dealing with uncertain information than other fuzzy tools like the intuitionistic fuzzy set (IFS) and the Pythagorean fuzzy set (PFS), as it can deal with indeterminate information that IFS and PFS cannot. According to this new line of inquiry, SVNS theory may be used to MCDM issues even while facing ambiguity and complexity[19], [20].

The paper is organized as follows: section 2 provides the challenges in the food business. The proposed method in the neutrosophic TOPSIS method is organized in section 3. The results and discussion of the proposed method are presented in section 4. Section 5 presented the conclusions of this study.

2. Challenges in Food Business

Many obstacles might arise when companies strive to practice sustainable buying in the food sector. Some typical difficulties encountered by the food industry are listed below.

Tracing the origin and viability of food items may be difficult because of the food industry's notoriously complicated and worldwide supply networks, which sometimes include several middlemen. When working with several suppliers with different data availability, it may be challenging to maintain supply chain transparency and traceability[21], [22].

Consequences on Expenditures Sustainable product sourcing and working with certified suppliers may cost more than traditional product procurement in certain cases. Some organizations, particularly those with slim profit margins, may be put off by the initial investment or additional expenditures associated with sustainable buying practices.

Supply Chain Challenges It may be difficult for businesses to locate suppliers who match the requirements for sustainable procurement, especially if they need a big quantity of a certain product. An obstacle to implementation may be the scarcity of sustainable suppliers in a certain area or for a given component[23], [24].

The tastes and expectations of consumers change with time, and businesses must be prepared to respond by offering more and more sustainably and ethically based goods. Successfully navigating customers' ever-evolving expectations and communicating the company's commitment to sustainable sourcing is essential for gaining their confidence and loyalty.

Sustainable buying necessitates weighing several variables, including the effect on the environment, the impact on society, and the profitability of the business. It might be difficult to strike a balance between competing needs. Environmental concerns about transportation emissions, for instance, may collide to prioritize local sources[24], [25].

It might be difficult to get suppliers on board with adopting sustainable procedures and standards for both production and business. It calls for establishing reliable connections, inspecting suppliers, and encouraging cooperation for ongoing improvement. However, not all vendors can easily adapt to new conditions or fulfill stringent environmental standards.

The process of verifying and certifying a company's sustainability claims may be time-consuming and costly. Additional time, money, and knowledge may be needed to ensure that all sustainable practices and certifications are being adhered to.

The value of sustainability, the criteria for sustainable sourcing, and the advantages of sustainable procurement can only be fully realized if all personnel in an organization are educated and trained in these areas. In bigger organizations with more varied teams and stakeholders, it may be difficult to ensure that everyone has the same knowledge of and commitment to sustainability.

Collaboration among stakeholders, utilizing technology for traceability and transparency, seeking partnerships and collaborations, and incorporating sustainability concerns into the core business plan are just some of the avenues that may be pursued to address these difficulties. Food companies may set the path for good change in the food sector by overcoming these challenges to sustainable procurement[10], [13].

3. Neutrosophic TOPSIS Method

To deal with the MCDM difficulties precisely, the traditional TOPSIS developed by Hwang and Yoon has been widely used. Distance from the negative ideal solution (NIS) to the positive ideal solution (PIS) is used in this method to evaluate alternatives (and ultimately choose the best one). The optimal option(s) will be those that both minimize the travel time to the PIS and maximize the travel time to the NIS[26], [27] [28],[29]. The following steps explain how Ye modified the traditional TOPSIS approach to work in an SVNLS setting as shown in Figure 1.

Step 1. Build the decision matrix

$$X^e = \begin{bmatrix} x_{11}^{(e)} & \cdots & x_{1n}^{(e)} \\ \vdots & \ddots & \vdots \\ x_{m1}^{(e)} & \cdots & x_{mn}^{(e)} \end{bmatrix} \quad (1)$$

Where $x_{ij}^{(e)} = < \left(T_{x_{ij}}^{\ e}, I_{x_{ij}}^{\ e}, F_{x_{ij}}^{\ e}\right) > , i = 1,2,3 \ldots m\ (alternatives); j = 1,2,3, \ldots n\ (criteria)$

Step 2. Normalize the decision matrix

The normalization matrix is built based on positive and negative criteria.

$$L = \begin{bmatrix} l_{11}^{(e)} & \cdots & l_{1n}^{(e)} \\ \vdots & \ddots & \vdots \\ l_{m1}^{(e)} & \cdots & l_{mn}^{(e)} \end{bmatrix} \quad (2)$$

Step 3. Combined the decision matrix

$$L = \begin{bmatrix} l_{11} & \cdots & l_{1n} \\ \vdots & \ddots & \vdots \\ l_{m1} & \cdots & l_{mn} \end{bmatrix} \quad (3)$$

Where $l_{11} = \sum_{e=1}^{d} w_e * l_{ij}^{(e)}$, d refers to the number of decision makers.

Step 4. Compute the weights of criteria

Step 5. Compute the weighted decision matrix

$$G = \begin{bmatrix} w_1 l_{11} & \cdots & w_n l_{1n} \\ \vdots & \ddots & \vdots \\ w_1 l_{m1} & \cdots & w_n l_{mn} \end{bmatrix} \quad (4)$$

Step 6. Compute the distance between alternatives ($S_i (i = 1,2,3, \ldots . m)$) and positive and negative criteria

$$T(S_i, S^+) = \sum_{j=1}^{n} t\left(g_{ij}, g_i^+\right) \quad (5)$$

$$T(S_i, S^-) = \sum_{j=1}^{n} t\left(g_{ij}, g_i^-\right) \quad (6)$$

Step 7. Calculate the coefficient of closeness value

$$F(S_i) = \frac{T(S_i, S^-)}{T(S_i, S^+) + T(S_i, S^-)} \quad (7)$$

Step 8. Order the suppliers

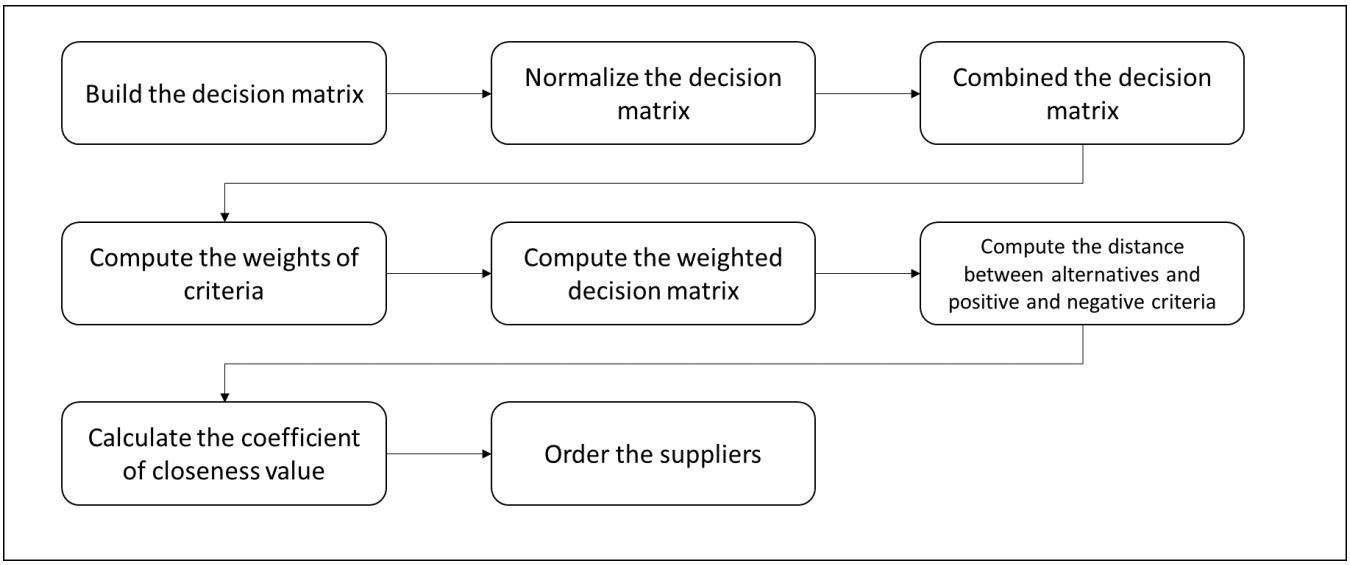

Figure 1. The Steps of the single valued neutrosophic TOPSIS method.

4. Results

This section introduces the results of the proposed method. This paper used single-valued neutrosophic numbers to evaluate the criteria and suppliers. There are various experts in the field of supply chain in the food business to evaluate the criteria and suppliers. This study gathered seven criteria from previous studies to evaluate it and ten suppliers. First, we compute the weights of these criteria, then rank and select suppliers in the food business to achieve sustainable procurement. There are seven criteria organized as:

Organic and regenerative farming practices have a positive effect on the environment because they improve soil quality, increase biodiversity, and reduce the need for synthetic chemicals.

You may help protect marine habitats and support local economies by purchasing seafood from sustainable fisheries and aquaculture businesses.

Favor vendors that have integrated water and energy-saving practices throughout their whole manufacturing operations.

Accountability to Society:

If you care about things like fair salaries, safe working conditions, and the absence of child labor, you should support businesses that source their goods ethically.

Priorities purchasing from regional farmers and manufacturers to bolster regional economies, cut down on carbon emissions from transportation, and foster growth in existing communities.

Support vendors that value diversity and inclusion in their workforce, and who seek to ensure that all of their workers are afforded the same respect and opportunity.

Purchase meat, dairy, and eggs from farms that place a premium on animal welfare and adhere to established industry guidelines for humane animal care.

Favor vendors that raise their animals without confining them in cages and instead provide them access to outdoor areas where they may forage and engage in other natural behaviors.

Sustainable packaging is selecting vendors whose packaging is either fully or partially recyclable, compostable, or biodegradable. This helps reduce landfill trash and supports the circular economy.

Reduce your impact on the environment by supporting businesses that recycle and compost food scraps and other organic waste, as well as packaging and other items.

Look for vendors that have supplier certifications like USDA Organic, Fair Trade, MSC (Marine Stewardship Council), or Rainforest Alliance to know that they engage in ethical and sustainable practices.

Make that your suppliers are abiding by all applicable laws and regulations about food quality and safety, as well as the environment and workers' rights.

Transparency and tractability

Seeing the whole supply chain: If you want to know where your food came from and how it was made, you need to find a supplier that can tell you.

Regular audits and inspections of suppliers are necessary to guarantee compliance with sustainability standards and maintain supply chain transparency.

Effortless Updating:

Inspire your suppliers to work together on sustainability projects and to brainstorm new ways to solve environmental and social problems so that everyone benefits.

To ensure ongoing development and accountability, it is important to set up systems for tracking supplier performance and encouraging frequent reporting on sustainability measures.

To motivate real change and advance sustainability in the food sector, organizations must set their sustainable procurement criteria, communicate them clearly to suppliers, and periodically analyze and evaluate supplier compliance.

Then we applied the SVNS TOPSIS method to show the weights of the criteria and rank the suppliers. There are seven criteria and ten suppliers in this study.

Step 1. Build the decision matrix

We used three decision-makers who have expertise in the food business to rank the criteria of sustainable procurement in the food business and suppliers. Then we built the decision matrix between criteria and suppliers based on the opinions of three decision-makers by using Eq. (1).

Step 2. Normalize the decision matrix

Then we normalized the decision matrix by using Eq. (2) as shown in Table 1.

Table 1. Normalized decision matrix

	$SPFB_1$	$SPFB_2$	$SPFB_3$	$SPFB_4$	$SPFB_5$	$SPFB_6$	$SPFB_7$
$SPFBS_1$	0.19916	0.412945	0.581344	0.550445	0.355256	0.455857	0.161866
$SPFBS_2$	0.216038	0.141239	0.357227	0.341767	0.332499	0.221326	0.248287
$SPFBS_3$	0.19916	0.216647	0.307107	0.152471	0.149182	0.14429	0.175584
$SPFBS_4$	0.533344	0.153209	0.160277	0.169914	0.149182	0.149792	0.312759
$SPFBS_5$	0.381442	0.372847	0.451764	0.152471	0.162014	0.14429	0.587109
$SPFBS_6$	0.44389	0.270868	0.17223	0.339829	0.233255	0.14429	0.508233
$SPFBS_7$	0.311398	0.512291	0.17386	0.402174	0.437433	0.523355	0.161866
$SPFBS_8$	0.105487	0.378234	0.17386	0.152471	0.610003	0.462338	0.253088
$SPFBS_9$	0.213506	0.128073	0.245849	0.421233	0.22883	0.382306	0.161866
$SPFBS_{10}$	0.305491	0.323773	0.24449	0.1641	0.149182	0.156517	0.253088

Step 3. Combined the decision matrix

We combined the decision matrix into one matrix by using Eq. (3)

Step 4. Compute the weights of criteria

Then the weights of criteria are computed as shown in Figure 2. The environmental impacts have the largest weight in all criteria.

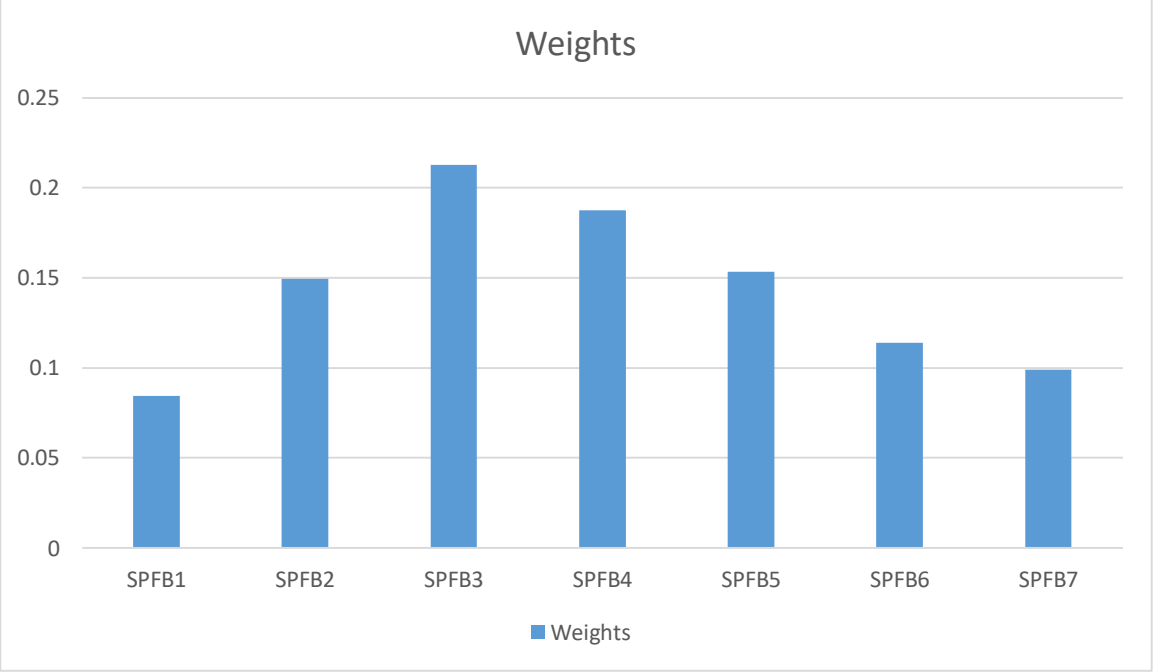

Figure 2. Weights of the criteria of sustainable procurement in food business.

Step 5. Compute the weighted decision matrix

Then we used Eq. (4) to compute the weighted decision matrix by multiplying the weights of criteria by the normalization matrix as shown in Table 2.

Table 2. Weighted normalized decision matrix

	$SPFB_1$	$SPFB_2$	$SPFB_3$	$SPFB_4$	$SPFB_5$	$SPFB_6$	$SPFB_7$
$SPFBS_1$	0.016807	0.061654	0.123603	0.103175	0.054523	0.05187	0.016024
$SPFBS_2$	0.018231	0.021087	0.075952	0.06406	0.05103	0.025184	0.024579
$SPFBS_3$	0.016807	0.032346	0.065296	0.028579	0.022896	0.016418	0.017382
$SPFBS_4$	0.045008	0.022874	0.034078	0.031849	0.022896	0.017044	0.030961
$SPFBS_5$	0.032189	0.055667	0.096052	0.028579	0.024865	0.016418	0.05812
$SPFBS_6$	0.037459	0.040441	0.036619	0.063697	0.035799	0.016418	0.050312
$SPFBS_7$	0.026278	0.076486	0.036965	0.075383	0.067135	0.05955	0.016024
$SPFBS_8$	0.008902	0.056471	0.036965	0.028579	0.09362	0.052607	0.025054
$SPFBS_9$	0.018017	0.019122	0.052271	0.078955	0.03512	0.043501	0.016024
$SPFBS_{10}$	0.02578	0.04834	0.051983	0.030759	0.022896	0.017809	0.025054

Step 6. Compute the distance between alternatives ($S_i(i = 1,2,3, \dots . m)$) and positive and negative criteria.

All criteria are positive criteria, so we compute the distance of each suppliers and positive criteria as shown in Eq. (5).

Step 7. Calculate the coefficient of closeness value

Then compute the closeness value by using Eq. (7).

Step 8. Order the suppliers

The suppliers are ranked according to the largest value in closeness coefficient. The supplier 1 is the best and supplier 4 is the worst as shown in figure 3.

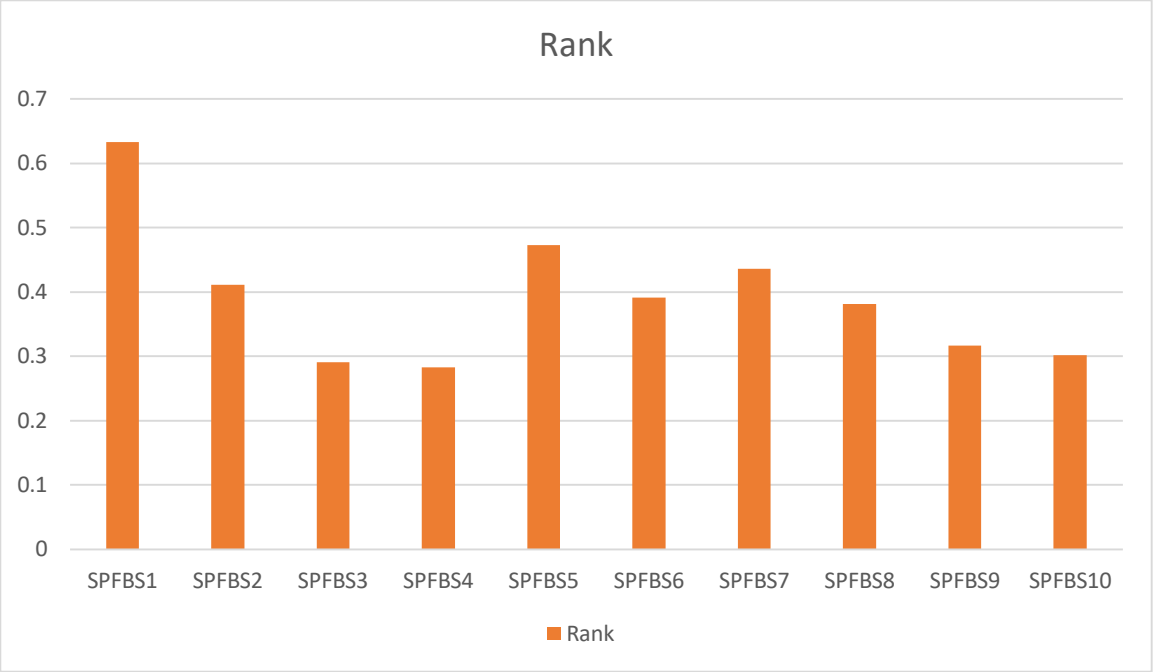

Figure 3. The rank of suppliers in food business.

5. Conclusions

Fostering a more sustainable and resilient food system requires a focus on sustainable procurement in the food industry. Sustainable development may be greatly aided by the food industry if it takes into account environmental implications, social responsibility, animal welfare, packaging and waste management, certifications and standards, traceability and transparency, and the need for continual improvement. Reduced environmental degradation, greater community development, enhanced brand reputation, and the satisfaction of customer expectations are all possible thanks to sustainable procurement practices. However, sustainable procurement isn't without its obstacles, such as convoluted supply networks and unknown financial consequences. Overcoming these challenges, this paper introduces the framework to show the importance of sustainable procurement in food business criteria and select the best supplier in the food business. This paper used the TOPSIS MCDM method to rank these suppliers. The TOPSIS is integrated with a single valued neutrosophic set to deal with uncertain data. The main results show that environmental impacts have the highest importance in all criteria. Food companies may play a crucial role in ensuring the long-term viability of the food industry and society at large by adopting sustainable procurement practices.

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Received: April 30, 2023. Accepted: Aug 18, 2023