# A Multi-Criteria Decision Making Model for Sustainable and Resilient Supplier Selection and Management

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**Abstract:** Sustainable and resilient supplier selection and management are essential to building environmentally responsible and resilient supply chains. Selecting sustainable and resilient suppliers enables organizations to ensure the long-term viability of the supply chain. To do that, there is a need to identify suitable suppliers that align with sustainability and resilience goals. This study aims to provide an overview of the requirements and criteria for selecting and managing sustainable and resilient suppliers and emphasizes the significance of integrating sustainability and resilience principles throughout the supply chain. Multi-criteria decision-making (MCDM) is used to deal with various criteria. The double normalization-based multi-aggregation (DNMA) method ranks the alternatives. This study used 18 criteria and 12 alternatives to select the best one. By employing these criteria, organizations can identify suppliers that align with sustainability and resilience goals. The results show that alternative 3 is the best and alternative 11 is the worst. Also, the results show that the proposed method can provide a new method to rank alternatives. Moreover, the proposed method can introduce a more simple and flexible method for selecting a suitable supplier and ensuring the long-term viability of the supply chain.

**Keywords:** Double Normalization Based Multi-Aggregation Method; MCDM; Resilient Supplier Selection; Supply Chain.

## 1. Introduction

In today's rapidly changing business landscape, organizations increasingly recognize the importance of sustainability and resilience in their supply chains. A key aspect of achieving sustainability and resilience is selecting and managing suppliers who share the same values and commitment to these principles. Sustainable and resilient suppliers play a critical role in ensuring the long-term viability of supply chains, minimizing environmental impact, promoting social responsibility, and effectively managing risks and disruptions [1]. Sustainable suppliers are those that prioritize environmentally friendly practices, resource conservation, and the reduction of carbon footprints [2]. They seek to minimize waste, adopt renewable energy sources, and implement sustainable manufacturing processes. On the other hand, resilient suppliers demonstrate the ability to withstand and recover from disruptions such as natural disasters, geopolitical instability, or supply chain breakdowns. They have robust business continuity plans, diversified sourcing strategies, and proactive risk management practices [3].

Organizations must identify and assess suppliers based on specific criteria that align with their sustainability and resilience goals. These criteria encompass various dimensions, including environmental sustainability, social responsibility, supply chain transparency, resilience and business continuity, innovation and adaptability, financial stability, collaboration and communication, compliance and certifications, risk management, ethical practices, energy efficiency, water management, circular economy practices, community engagement, reporting and

transparency, innovation and collaboration, and supplier diversity [4]. The selection and management of sustainable and resilient suppliers require a comprehensive and strategic approach. So, this study aims to provide an overview of the requirements and criteria for selecting and managing sustainable and resilient suppliers and emphasizes the significance of integrating sustainability and resilience principles throughout the supply chain. Multi-criteria decision-making (MCDM) is used to deal with various criteria. The double normalization-based multi-aggregation (DNMA) method ranks the alternatives. This study used 18 criteria and 12 alternatives to select the best one. The results show that alternative 3 is the best and alternative 11 is the worst. By employing these criteria, organizations can identify suppliers that align with sustainability and resilience goals, ensuring the long-term viability of the supply chain

This work is arranged as follows: the first section gives the introduction; the second section introduces motivations for evaluating suppliers; the third section introduces the concept of sustainable and resilient supplier; the fourth section represents the requirements for evaluating and selecting a suitable supplier. The fifth section gives the proposed Double Normalization Based Multi-Aggregation (DNMA) Method; the sixth section applies the proposed method with a numerical example; the seventh section discusses the results; the eighth section gives the conclusion of this work; and finally, it gives references.

## 2.   Motivations for Evaluating Suppliers

By carefully evaluating suppliers against these criteria, organizations can make informed decisions that support their sustainability and resilience objectives. Sustainable and resilient suppliers contribute to the overall sustainability and resilience of the supply chain by reducing environmental impacts, promoting fair labour practices, ensuring a stable supply of goods and services, and actively managing risks. They also foster collaboration, innovation, and knowledge sharing, driving continuous improvement and the development of more sustainable and resilient practices [5].

Furthermore, selecting and managing sustainable and resilient suppliers are not isolated activities but require continuous monitoring and evaluation. Organizations should maintain open lines of communication with suppliers, engage in regular performance assessments, and collaborate on sustainability initiatives. This ongoing relationship-building and collaboration contribute to developing a robust and dynamic supply chain that can adapt to changing market conditions, regulatory requirements, and societal expectations. By integrating sustainability and resilience principles into supplier selection processes, organizations can ensure that their supply chains are profitable, environmentally sustainable, socially responsible, and equipped to withstand disruptions [6]. This proactive approach to supplier selection and management can support the organization's overall sustainability goals and help create a more sustainable and resilient future.

## 3.   The Concept of Sustainable and Resilient Supplier

The concept of sustainability and sustainable development was introduced by the World Commission on Environment and Development (WCED) in 1987 [7]. Sustainable and resilience concepts can improve the overall performance of organizations and can decrease disruption propagation in the form of supply chain quantity downscaling [8]. Sustainable and resilient can be defined as follows in Table 1:

**Table 1.** Sustainable and resilient.

| | |
|---|---|
| Sustainable | Sustainable suppliers are those that prioritize environmentally friendly practices, resource conservation, and the reduction of carbon footprints [2]. |
| Resilient | Resilience is defined as the intrinsic ability of an organization to return to or recover from a steady state facing a disruptive event [9]. Can be defined as the ability to resist disruptions and to recover operational capability after disruptions have occurred [10]. Suppliers have robust business continuity plans, diversified sourcing strategies, and proactive risk management practices [3]. |

## 4. The Requirements for Evaluating and Selecting the Suitable Supplier

Supplier selection is a complex process that needs to evaluate different types of criteria in order to select consistent suppliers [11]. Supplier selection is divided into two main types, as shown in the following Figure 1 [12]:
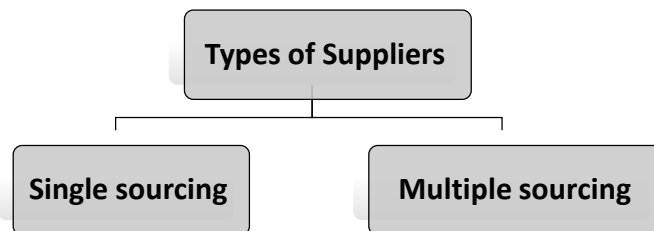


**Figure 1.** Types of suppliers.

- Single sourcing only one supplier is able to fulfill an organization's demands. The decision makers need to select only one supplier
- Multiple sourcing more than one supplier is selected as no one supplier is single-handedly capable of meeting the demand requirements of the enterprise. The decision makers face more challenges as they need to allocate optimal quantities to each supplier in order to create an environment of fair play and genuine competition, while maximizing returns for their own organization at the same time.

The requirements and criteria include environmental sustainability, social responsibility, supply chain transparency, resilience and business continuity, innovation and adaptability, financial stability, collaboration and communication, compliance and certifications, risk management, ethical practices, energy efficiency, water management, circular economy practices, community engagement, reporting and transparency, innovation and collaboration, and supplier diversity. By employing these criteria, organizations can identify suppliers that align with sustainability and resilience goals, ensuring the long-term viability of the supply chain. The criteria used in this study are organized as [13]:

- *Environmental Sustainability*: Assess the supplier's environmental practices and policies. Look for suppliers who demonstrate a commitment to environmental sustainability by implementing eco-friendly practices such as resource conservation, waste reduction, recycling, and pollution prevention. Consider their track record in minimizing carbon footprint and adherence to relevant environmental certifications or standards.
- *Social Responsibility:* Evaluate the supplier's social responsibility practices. This includes assessing their labour practices, human rights policies, and commitment to fair and ethical treatment of employees. Look for suppliers that promote diversity and inclusion, provide safe working conditions, and ensure fair wages and benefits for their workers.
- *Supply Chain Transparency:* Consider the supplier's level of transparency in their supply chain. Suppliers should be able to provide information on the origin of their materials, their supply

chain partners, and any potential risks or vulnerabilities in their supply chain. Transparency helps identify potential environmental and social risks and enables proactive risk management.

- *Resilience and Business Continuity:* Evaluate the supplier's resilience and business continuity plans. Assess their ability to mitigate and respond to disruptions such as natural disasters, supply chain disruptions, or other unforeseen events. Look for suppliers who have implemented measures to ensure continuity of supply, such as backup manufacturing facilities, diversified sourcing, or robust risk management strategies.

- *Innovation and Adaptability*: Consider the supplier's commitment to innovation and adaptability. Look for suppliers who invest in research and development, embrace new technologies, and continuously improve their processes to enhance sustainability and resilience. Suppliers demonstrating a forward-thinking approach and agility adapting to changing market demands are more likely to contribute to long-term sustainability and resilience goals.

- *Financial Stability:* Assess the financial stability of the supplier. A financially stable supplier is better positioned to invest in sustainable and resilient practices, maintain high-quality standards, and provide consistent supply. Financial stability ensures that the supplier can withstand economic fluctuations and continue to deliver products and services without compromising sustainability and resilience commitments.

- *Collaboration and Communication:* Evaluate the supplier's willingness to collaborate and communicate openly. Look for suppliers who are proactive in engaging in sustainability discussions, participate in industry collaborations, and are responsive to inquiries and feedback. Effective communication channels and cooperation foster a strong partnership and facilitate shared sustainability and resilience goals.

- *Compliance and Certifications:* Consider the supplier's compliance with relevant regulations and certifications. Look for suppliers who comply with environmental, social, and labour laws and regulations.

- *Long-Term Relationship Potential:* Assess the long-term relationship potential with the supplier. Look for suppliers who align with your organization's values, goals, and sustainability strategies. Building long-term partnerships allows for collaborative efforts in driving sustainable and resilient practices throughout the supply chain.

- *Risk Management:* Evaluate the supplier's risk management practices. Assess their ability to identify and mitigate potential risks and disruptions to their operations and supply chain. Look for suppliers with robust risk management strategies, including contingency plans, supply chain mapping, and proactive monitoring of potential risks such as climate change impacts, geopolitical instability, or regulatory changes.

- *Ethical Practices:* Consider the supplier's commitment to ethical practices. This includes evaluating their stance on anti-corruption, anti-bribery, and fair trade issues. Look for suppliers with clear policies and procedures to ensure ethical behaviour throughout their operations and supply chain.

- *Energy Efficiency:* Assess the supplier's energy efficiency initiatives. Look for suppliers seeking to reduce energy consumption, implement energy-efficient technologies, and invest in renewable energy sources. Energy-efficient practices contribute to sustainability while enhancing resilience by reducing reliance on fossil fuels and mitigating the impact of energy price fluctuations.

- *Water Management:* Consider the supplier's water management practices. Suppliers prioritising responsible water usage, implementing water conservation measures, and addressing water pollution concerns demonstrate a commitment to environmental sustainability. Effective water management is crucial for ensuring the availability of this vital resource and minimizing water-related risks.

- *Circular Economy Practices:* Assess the supplier's adoption of circular economy principles. Look for suppliers who embrace product lifecycle extension, recycling, reusing, and waste reduction practices. Suppliers promoting circularity contribute to resource conservation, waste reduction, and a more sustainable and resilient economy.
- *Community Engagement:* Evaluate the supplier's involvement in local communities. Look for suppliers who actively engage with local communities, support social initiatives, and contribute to local economic development. Suppliers with strong community relationships are more likely to positively impact the social resilience of the communities in which they operate.
- *Reporting and Transparency:* Assess the supplier's reporting and transparency practices. Look for suppliers who provide comprehensive sustainability reports, disclose their environmental and social impacts, and engage in third-party audits or certifications. Transparent reporting allows for accountability and facilitates better understanding and monitoring of the supplier's sustainability and resilience performance.
- *Innovation and Collaboration:* Consider the supplier's ability to innovate and collaborate on sustainability and resilience initiatives. Look for suppliers who actively seek opportunities for joint projects, knowledge sharing, and innovation in sustainable practices. Collaborative partnerships foster continuous improvement and the exchange of best practices, driving sustainability and resilience efforts forward.
- *Supplier Diversity:* Assess the supplier's commitment to supplier diversity and inclusion. Look for suppliers who promote diversity in their supply chain by engaging with minority-owned, women-owned, and small businesses. Supplier diversity enhances social resilience, fosters economic development, and promotes a more inclusive and equitable business environment.

## 5. The proposed Double Normalization Based Multi-Aggregation (DNMA) Method

This section introduces the steps of the DNMA method to rank the alternatives [14]. The MCDM can be used in this section [15]. The proposed DNMA method includes seven steps that are organized as Figure 2:

**Step 1**. Build the decision matrix.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{1}$$

**Step 2.** Compute the target based linear normalization.

$$r_{ij}^1 = 1 - \frac{\left|a_{ij} - \max_i a_{ij}\right|}{\max\left\{\max_i a_{ij} \max_i a_{ij}\right\} - \min\left\{\min_i a_{ij} \max_i a_{ij}\right\}} \tag{2}$$

**Step 3.** Compute the target based vector normalization.

$$r_{ij}^2 = 1 - \frac{\left|a_{ij} - \max_i a_{ij}\right|}{\sqrt{\sum_{i=1}^m \left(a_{ij}\right)^2 + \left(\max_i a_{ij}\right)^2}} \tag{3}$$

**Step 4.** Compute the adjusted criteria weights.

$$d_j = \sqrt{\frac{\sum_{i=1}^m \left(\frac{a_{ij}}{\max_i a_{ij}} - \frac{1}{m}\sum_{i=1}^m \left(\frac{a_{ij}}{\max_i a_{ij}}\right)\right)^2}{m}} \tag{4}$$

$$w_j^d = \frac{d_j}{\sum_{j=1}^n dj} \tag{5}$$

$$w_j = \frac{\sqrt{w_j^d w_j}}{\sum_{j=1}^n \sqrt{w_j^d w_j}} \tag{6}$$

**Step 5.** Compute the values of complete compensatory, and incomplete compensatory.

$$q_1 = \sum_{j=1}^n w_j r_{ij}^1 / \max_i r_{ij}^1 \tag{7}$$

$$q_2 = \max_j w_j \left(1 - r_{ij}^1 / \max_i r_{ij}^1 \right) \tag{8}$$

$$q_3 = \prod_j \left(r_{ij}^2 / \max_i r_{ij}^2 \right)^{w_j} \tag{9}$$

**Step 6.** Compute the value of $S_i$.

$$S_i = \left\{ \begin{array}{l} \frac{1}{3}\sqrt{\beta \left(\frac{q_1}{\max_i q_1}\right)^2 - (1-\beta)\left(\frac{m-q_1+1}{m}\right)^2} + \\ \quad \frac{1}{3}\sqrt{\beta \left(\frac{q_2}{\max_i q_2}\right)^2 - (1-\beta)\left(\frac{q_2}{m}\right)^2} \\ + \frac{1}{3}\sqrt{\beta \left(\frac{q_3}{\max_i q_3}\right)^2 - (1-\beta)\left(\frac{m-q_3+1}{m}\right)^2} \end{array} \right\} \tag{10}$$

**Step 7.** Rank the alternatives based on the largest value in $S_i$.
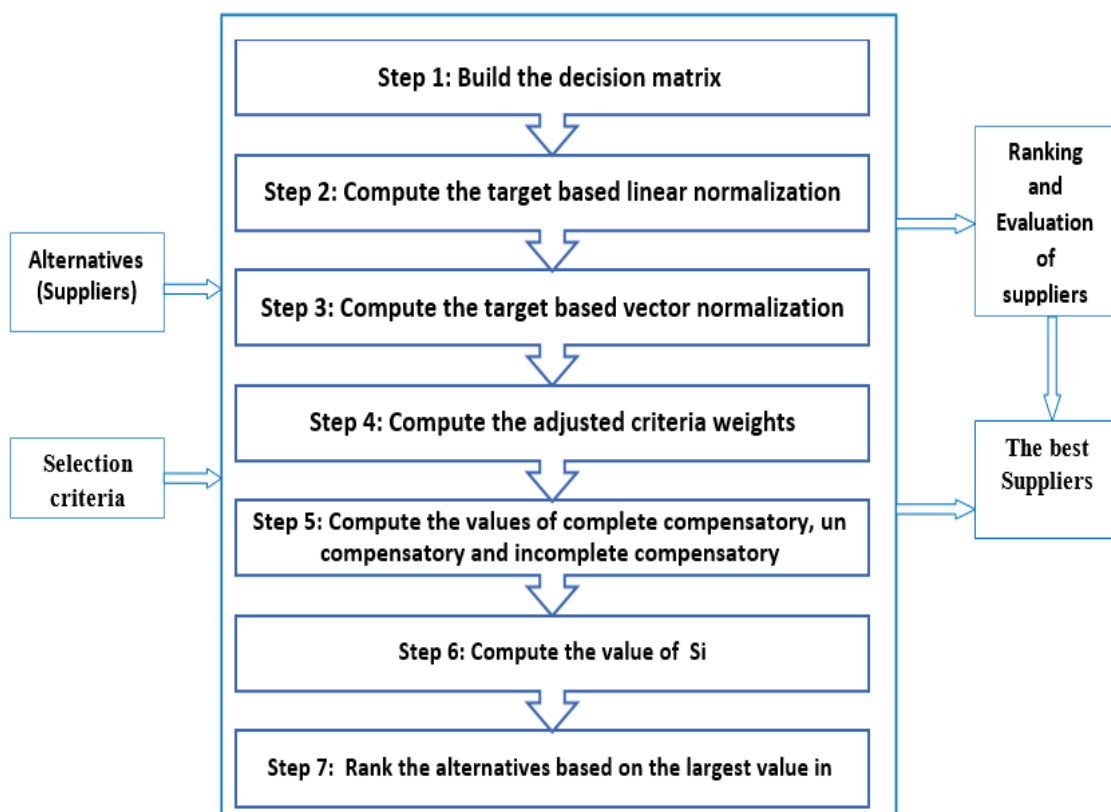


**Figure 2.** The proposed double normalization-based multi-aggregation (DNMA) method.

## 6. Applying the Proposed Method with Numerical Example

This section provides the application of the proposed method. We suggested this method for selecting the best supplier. We used the 18 criteria and 15 alternatives in this section. The criteria used in this study are organized as [13]:

- Environmental Sustainability
- Social Responsibility
- Supply Chain Transparency
- Resilience and Business Continuity
- Innovation and Adaptability
- Financial Stability
- Collaboration and Communication
- Compliance and Certifications
- Long-Term Relationship Potential
- Risk Management
- Ethical Practices
- Energy Efficiency
- Water Management
- Circular Economy Practices
- Community Engagement
- Reporting and Transparency
- Innovation and Collaboration
- Supplier Diversity

**Step 1.** Build the decision matrix between factors and suppliers by Eq. (1). The experts used the scale between 1 and 9 to evaluate the criteria and alternatives.

**Step 2.** Compute the target based linear normalization by Eq. (2) as shown in Table 2.

**Step 3.** Compute the target based vector normalization by Eq. (3) as shown in Table 3.

**Step 4**: Compute the adjusted criteria weights by Eqs. (4-6) as shown in Figure 3.

**Step 5.** Compute the values of complete compensatory, uncompensatory and incomplete compensatory by Eqs. (7-9)

**Step 6.** Compute the value of $S_i$ by Eq. (10)

**Step 7.** Rank the alternatives based on the largest value in $S_i$ as shown in Figure 4. We show the alternative 3 is the best and alternative 11 is the worst.

We change the value in $\beta$ parameter to ensure the stable of the results. Figure 5 shows the different ranks under different value between 0.1 and 1 in $\beta$ parameter.

**Table 2.** The target based linear normalization.

| | TLC1 | TLC2 | TLC3 | TLC4 | TLC5 | TLC6 | TLC7 | TLC8 | TLC9 | TLC10 | TLC11 | TLC12 | TLC13 | TLC14 | TLC15 | TLC16 | TLC17 | TLC18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLA1 | 1.047619 | 1 | 1.015873 | 1.027778 | 1.083333 | 1.0625 | 1.047619 | 1.111111 | 1.095238 | 1.047619 | 1.088889 | 1.079365 | 1.013889 | 1 | 1.097222 | 1.095238 | 1.111111 | 1.055556 |
| TLA2 | 1.031746 | 1.063492 | 1.079365 | 1.111111 | 1.166667 | 1.104167 | 1.047619 | 1.111111 | 1.063492 | 1 | 1.022222 | 1.047619 | 1.055556 | 1.079365 | 1.111111 | 1.111111 | 1.095238 | 1.041667 |
| TLA3 | 1.015873 | 1.015873 | 1.079365 | 1.055556 | 1 | 1.125 | 1.095238 | 1 | 1.063492 | 1.031746 | 1.111111 | 1.015873 | 1 | 1.047619 | 1.097222 | 1.063492 | 1.047619 | 1 |
| TLA4 | 1 | 1 | 1.047619 | 1.097222 | 1.041667 | 1.041667 | 1.111111 | 1.095238 | 1.047619 | 1.063492 | 1 | 1.015873 | 1.055556 | 1.111111 | 1.041667 | 1.047619 | 1 | 1.013889 |
| TLA5 | 1.047619 | 1.063492 | 1.079365 | 1.055556 | 1.041667 | 1.125 | 1.095238 | 1.047619 | 1.015873 | 1.031746 | 1.088889 | 1.047619 | 1.097222 | 1.047619 | 1.041667 | 1.063492 | 1.063492 | 1.055556 |
| TLA6 | 1.095238 | 1.015873 | 1.063492 | 1.013889 | 1 | 1.104167 | 1.063492 | 1.111111 | 1.047619 | 1 | 1.088889 | 1.111111 | 1.097222 | 1.095238 | 1.055556 | 1.095238 | 1.047619 | 1.083333 |
| TLA7 | 1.111111 | 1 | 1.031746 | 1 | 1.125 | 1.104167 | 1.047619 | 1.063492 | 1.031746 | 1.015873 | 1.088889 | 1 | 1.041667 | 1.095238 | 1.097222 | 1.111111 | 1.063492 | 1.097222 |
| TLA8 | 1.063492 | 1.063492 | 1.015873 | 1.041667 | 1.166667 | 1 | 1 | 1.079365 | 1.111111 | 1.063492 | 1.066667 | 1 | 1.041667 | 1.047619 | 1.083333 | 1.047619 | 1.111111 | 1.055556 |
| TLA9 | 1.015873 | 1.047619 | 1 | 1.041667 | 1.041667 | 1.083333 | 1.015873 | 1.047619 | 1.095238 | 1.111111 | 1.066667 | 1.063492 | 1.027778 | 1.015873 | 1.041667 | 1 | 1.095238 | 1.069444 |
| TLA10 | 1 | 1.063492 | 1.047619 | 1.041667 | 1.041667 | 1.125 | 1.063492 | 1 | 1.047619 | 1.063492 | 1.044444 | 1.015873 | 1.041667 | 1.111111 | 1 | 1.015873 | 1.111111 | 1.111111 |
| TLA11 | 1.047619 | 1.111111 | 1.063492 | 1.041667 | 1.166667 | 1.104167 | 1.063492 | 1.015873 | 1 | 1.047619 | 1.088889 | 1.111111 | 1.111111 | 1.079365 | 1.097222 | 1.015873 | 1 | 1.041667 |
| TLA12 | 1.095238 | 1.063492 | 1.111111 | 1.041667 | 1.041667 | 1.083333 | 1.031746 | 1.015873 | 1 | 1.047619 | 1.088889 | 1 | 1.013889 | 1.079365 | 1.041667 | 1.063492 | 1.111111 | 1.083333 |

**Table 3.** The target based vector normalization.

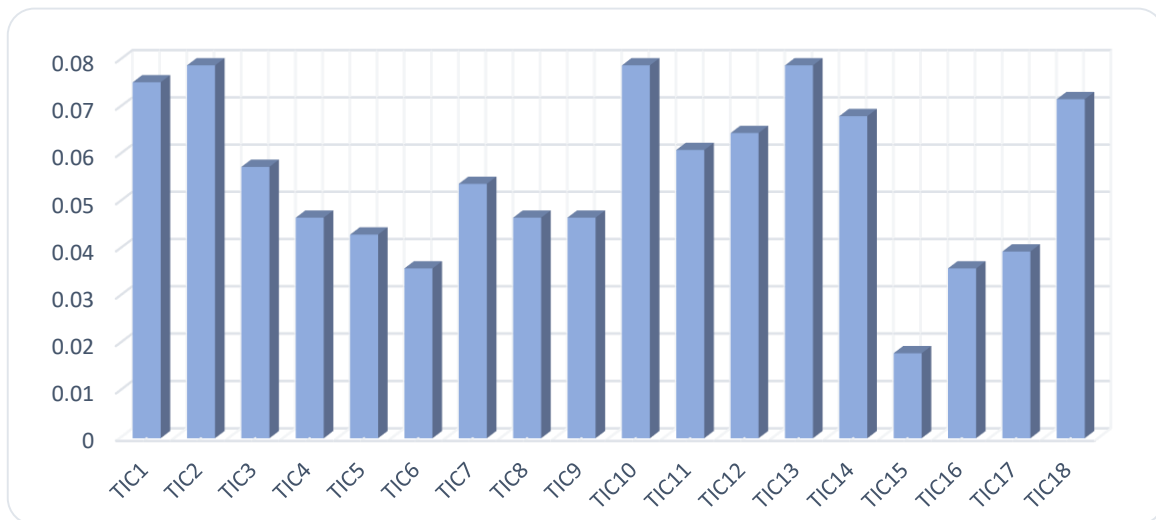| | TLC1 | TLC2 | TLC3 | TLC4 | TLC5 | TLC6 | TLC7 | TLC8 | TLC9 | TLC10 | TLC11 | TLC12 | TLC13 | TLC14 | TLC15 | TLC16 | TLC17 | TLC18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TLA1** | 0.974359 | 1 | 0.993103 | 0.984615 | 0.961538 | 0.966292 | 0.974359 | 0.917647 | 0.933333 | 0.974359 | 0.962264 | 0.948454 | 0.993103 | 1 | 0.917647 | 0.933333 | 0.917647 | 0.962264 |
| **TLA2** | 0.984615 | 0.962264 | 0.948454 | 0.902439 | 0.9 | 0.931507 | 0.974359 | 0.917647 | 0.962264 | 1 | 0.993103 | 0.974359 | 0.962264 | 0.948454 | 0.902439 | 0.917647 | 0.933333 | 0.974359 |
| **TLA3** | 0.993103 | 0.993103 | 0.948454 | 0.962264 | 1 | 0.911765 | 0.933333 | 1 | 0.962264 | 0.984615 | 0.948454 | 0.993103 | 1 | 0.974359 | 0.917647 | 0.962264 | 0.974359 | 1 |
| **TLA4** | 1 | 1 | 0.974359 | 0.917647 | 0.983607 | 0.98 | 0.917647 | 0.933333 | 0.974359 | 0.962264 | 1 | 0.993103 | 0.962264 | 0.917647 | 0.974359 | 0.974359 | 1 | 0.993103 |
| **TLA5** | 0.974359 | 0.962264 | 0.948454 | 0.962264 | 0.983607 | 0.911765 | 0.933333 | 0.974359 | 0.993103 | 0.984615 | 0.962264 | 0.974359 | 0.917647 | 0.974359 | 0.974359 | 0.962264 | 0.962264 | 0.962264 |
| **TLA6** | 0.933333 | 0.993103 | 0.962264 | 0.993103 | 1 | 0.931507 | 0.962264 | 0.917647 | 0.974359 | 1 | 0.962264 | 0.917647 | 0.917647 | 0.933333 | 0.962264 | 0.933333 | 0.974359 | 0.933333 |
| **TLA7** | 0.917647 | 1 | 0.984615 | 1 | 0.933333 | 0.931507 | 0.974359 | 0.962264 | 0.984615 | 0.993103 | 0.962264 | 1 | 0.974359 | 0.933333 | 0.917647 | 0.917647 | 0.962264 | 0.917647 |
| **TLA8** | 0.962264 | 0.962264 | 0.993103 | 0.974359 | 0.9 | 1 | 1 | 0.948454 | 0.917647 | 0.962264 | 0.974359 | 1 | 0.974359 | 0.974359 | 0.933333 | 0.974359 | 0.917647 | 0.962264 |
| **TLA9** | 0.993103 | 0.974359 | 1 | 0.974359 | 0.983607 | 0.95 | 0.993103 | 0.974359 | 0.933333 | 0.917647 | 0.974359 | 0.962264 | 0.984615 | 0.993103 | 0.974359 | 1 | 0.933333 | 0.948454 |
| **TLA10** | 1 | 0.962264 | 0.974359 | 0.974359 | 0.983607 | 0.911765 | 0.962264 | 1 | 0.974359 | 0.962264 | 0.984615 | 0.993103 | 0.974359 | 0.917647 | 1 | 0.993103 | 0.917647 | 0.902439 |
| **TLA11** | 0.974359 | 0.917647 | 0.962264 | 0.974359 | 0.9 | 0.931507 | 0.962264 | 0.993103 | 1 | 0.974359 | 0.962264 | 0.917647 | 0.902439 | 0.948454 | 0.917647 | 0.993103 | 1 | 0.974359 |
| **TLA12** | 0.933333 | 0.962264 | 0.917647 | 0.974359 | 0.983607 | 0.95 | 0.984615 | 0.993103 | 1 | 0.974359 | 0.962264 | 1 | 0.993103 | 0.948454 | 0.974359 | 0.962264 | 0.917647 | 0.933333 |

**Figure 3.** The weights of supplier selection criteria.
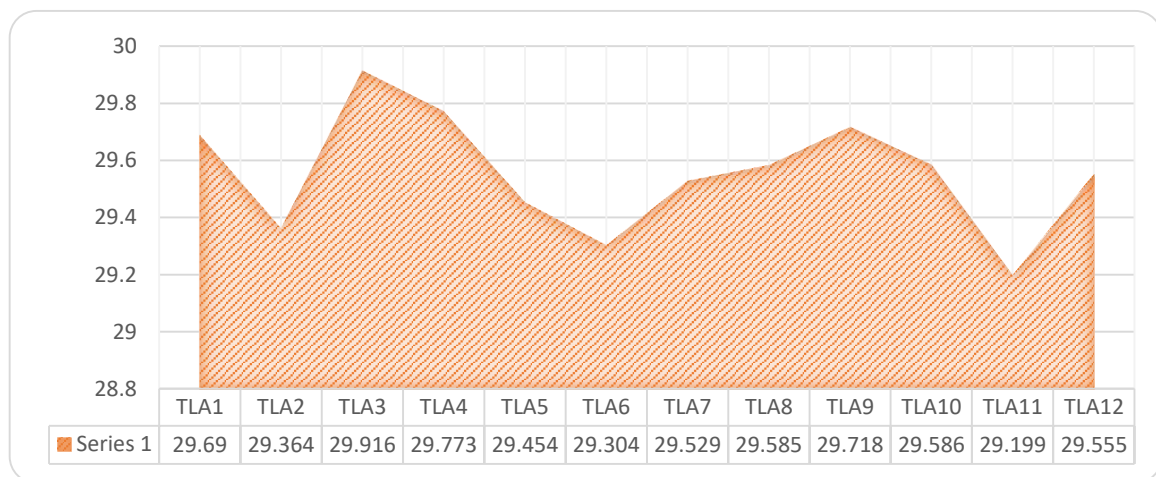


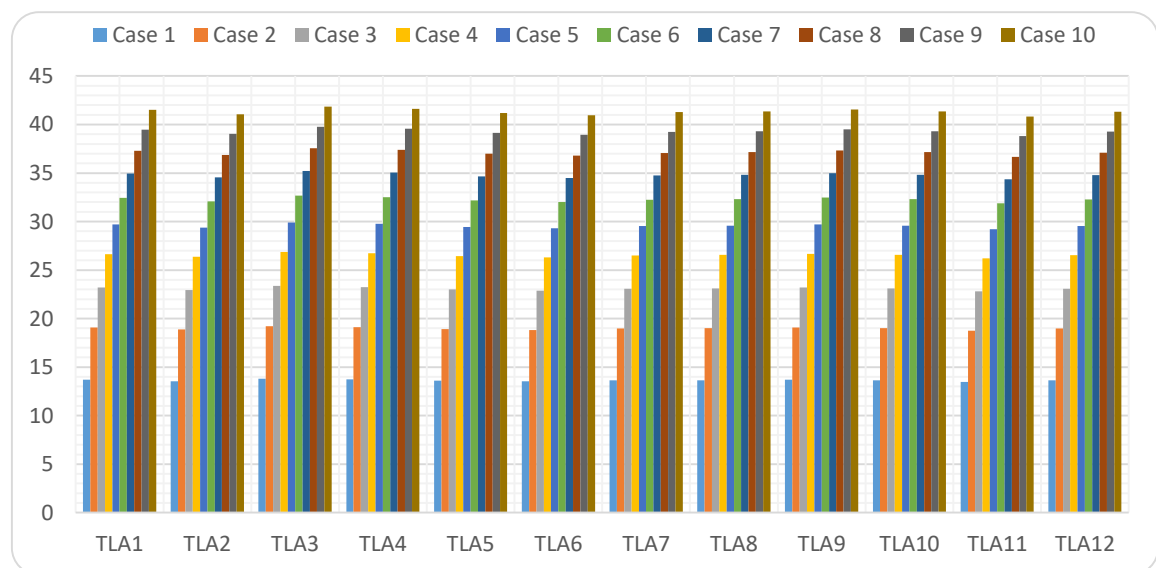**Figure 4.** The value of $S_i$.



**Figure 5.** The rank of alternatives under $\beta$ values.

## 7. Results Discussion

Selecting and managing sustainable and resilient suppliers are crucial in creating resilient and environmentally responsible supply chains. By considering the criteria discussed in this paper, organizations can make informed decisions that promote sustainability, mitigate risks, and enhance overall supply chain resilience. Environmental sustainability is a fundamental criterion, emphasizing the importance of suppliers' eco-friendly practices and commitment to reducing their ecological footprint. Social responsibility criteria ensure that suppliers uphold fair labour practices, human rights, and ethical treatment of employees, contributing to a socially sustainable supply chain. Supply chain transparency enables organizations to identify potential risks, vulnerabilities, and opportunities for improvement, fostering proactive risk management and resilience. By applying the proposed model the results show that:

- Integrating sustainability and resilience criteria into the selection and management processes, organizations can identify suppliers that align with their goals and contribute to long-term sustainability and resilience. The findings from these processes guide decision-making, facilitate risk management, and promote collaboration, ultimately leading to more sustainable, resilient, and responsible supply chains.
- The weights of the criteria are computed. Then, the alternatives are ranked. The results show that alternative 3 is the best and alternative 11 is the worst.
- By applying the MCDM to deal with various criteria and DNMA method to rank the alternatives; the proposed method can give more accurate results.
- The proposed method can introduce more simple and flexible method.
- The proposed method can handle any number of criteria and alternatives that give more reliability for results.

## 8. Conclusions

Sustainable and resilient supplier selection and management are essential for organizations striving to build environmentally responsible and resilient supply chains. This study aims to provide an overview of the requirements and criteria for selecting and managing sustainable and resilient suppliers and emphasizes the significance of integrating sustainability and resilience principles throughout the supply chain. Multi-criteria decision-making (MCDM) is used to deal with various criteria. The double normalization-based multi-aggregation (DNMA) method ranks the alternatives. This study used 18 criteria and 12 alternatives to select the best one. The weights of the criteria are computed. Then, the alternatives are ranked. The results show that alternative 3 is the best and alternative 11 is the worst. By employing these criteria, organizations can identify suppliers that align with sustainability and resilience goals, ensuring the long-term viability of the supply chain.

**Conflict of interest**

The authors declare that there is no conflict of interest in the research.

**Ethical approval**

This article does not contain any studies with human participants or animals performed by any of the authors.

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