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Sustainable Supplier Selection and Order allocation using Integrating AHP-TOPSIS and Goal Programming

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ABSTRACT

Increased awareness of environmental and social aspects has become an urgent global issue, especially in ensuring supply chain sustainability. In addition, optimizing sustainable supplier selection and order allocation is also crucial for companies to encourage sustainable industries. This research aims to determine the best potential sustainable suppliers and determine order allocation by considering economic, social, and environmental dimensions. This research proposes an approach that integrates AHP-Topsis and goal programming to solve the problem of sustainable supplier selection and order allocation. The AHP-Topsis procedure is proposed for weighting the criteria and sub-criteria of sustainable supplier selection. Meanwhile, Topsis is offered for supplier ranking. This study offers a goal programming procedure for order allocation. Order allocation is based on three goals: minimizing total procurement cost, maximizing total purchase value, and reducing carbon emissions. A case study is presented on the plastic bean processing industry in Indonesia involving three criteria (Economic, social, and environmental) and 17 sub-criteria. The analysis results show that economic criteria have the highest weight, followed by environmental and social criteria. Furthermore, the TOPSIS method selected the three best suppliers out of 5 alternative suppliers to receive order allocation. The order allocation process for three periods was carried out using the Goal Programming method on suppliers C, E, and A. This research contributes to improving supply chain sustainability. It provides practical guidance for companies in selecting suppliers and allocating orders efficiently.

1. Introduction

In the era of globalization, sustainability has become a significant focus in companies' operational strategies [1]. The supply chain sector ensures that sustainability principles are integrated into business activities. Sustainable supplier selection and wise order allocation are key aspects that require in-depth attention [2]. Sustainable Supplier Selection and Order Allocation significantly impact the sustainability and competitiveness

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of companies in today's global economy [3, 4]. This process significantly influences the company's efficiency, profitability, flexibility, and speed. Successfully selecting suppliers by assessing their performance will result in company savings and impact customer satisfaction [5]. Industries need to try to reduce their negative impact on the environment by applying the concept of sustainability to the supply chain [6]. The concept of sustainability in supplier selection integrates economic and social with environmental awareness [7, 8]. Sustainable suppliers help improve sustainability throughout the supply chain [9]. Therefore, many leading companies have considered sustainability in supplier selection [10]. However, decision-making during this process is often complex due to the limited availability of materials from suppliers and supplier performance [11]. Thus, it is important to realize that sustainable supplier selection and order allocation are key to ensuring supply chain and overall company sustainability.

Various procedures have been proposed for supplier selection. The Multi-Criteria Decision Making (MCDM) procedure is the most popularly used one as it comprehensively evaluates various criteria [12, 13]. In addition, this method allows stakeholders to consider various important aspects simultaneously based on priorities and preferences [14, 15]. Various supplier selection procedures have been proposed, including a Technique for Order of Preference by Similarity to Ideal Solution (Topsis) [16], SWARA and WASPAS [17], Analytic Hierarchy Process (AHP) and Topsis [9]. Other MCDM procedures are also offered, such as AHP and SUR [18] and fuzzy AHP and Topsis [19]. Meanwhile, some studies on supplier selection and order allocation apply integrated procedures of MCDM and mathematical optimization to solve the problem [20, 21]. Mathematical optimization procedures are applied in order allocation because they allow companies to allocate resources efficiently, minimize production costs, and maximize profits. Combining these two procedures can help companies select optimal suppliers and optimize order allocation to achieve the best business results [22]. In the Green supplier selection and order allocation problem, some of the proposed procedures integrate the best-worst method (BWM), modified fuzzy Topsis, and fuzzy multi-objective linear programming (MOLP) [23], the combination of linguistic Z-numbers, alternative queuing method (AQM) and MOLP [24], and Fuzzy TOPSIS) -MOLP [25].

Many methodologies have been suggested throughout the previous research on selecting sustainable suppliers and allocating orders. Cheraghalipour and Farsad [26] developed a sustainable supplier procedure using the BWM method and goal programming. In addition, different procedures have been proposed, such as Robust goal programming [27], multi-objective optimization combined with a fuzzy approach [28], a Fuzzy approach [29], Fuzzy AHP-Fuzzy TOPSIS and MOLP [30], MOLP [31], goal programming [11], a multi-objective mixed-integer non-linear programming coupled with data envelopment analysis [32], the BWM, and MOLP [33]. Additionally, a multi-attribute and multi-objective decision-making approach [34] and the integration of the language entropy weight method and MOLP [35] have been investigated. In addition, researchers have looked into the weighted sum approach and the augmented ε-constraint method [36], the fuzzy AHP-Topsis, and a multi-objective programming model [37]. A BWM-Goal Programming approach has been proposed to minimize the total cost while simultaneously optimizing the total score achieved by all suppliers with regard to three aspects of sustainability [26].

Based on previous research on sustainable supplier selection and order allocation, most studies utilize the AHP-Topsis MCDM procedure for supplier selection and MOLP for order allocation. The AHP-Topsis procedure is widely applied in supplier selection because it has several advantages [9]. AHP allows the assessment of criteria hierarchically and based on their importance [19]. This can help avoid subjective judgments and ensure

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proper prioritization in supplier selection [37]. Meanwhile, the Topsis procedure allows companies to holistically consider several criteria to find the best supplier close to the ideal solution [16]. In order allocation, MOLP requires proper weighting of each objective, which is difficult to determine objectively. In addition, MOLP produces solutions that are complex and difficult to interpret. This can make it difficult for decision-makers to determine each objective's priority or weight [31]. As a result, goal programming is often considered more flexible and intuitive in handling situations with multiple competing objectives [11]. In addition, goal programming can handle more than one objective without the need to transform the problem into a weighted sum form, thus allowing the accommodation of conflicting objectives directly [27]. We note that very few studies utilize the AHP-Topsis and goal programming procedures, as investigated by Chi and Trinh [38]. Unfortunately, these studies only focus on the economic dimension. The environmental and social dimensions were ignored.

Therefore, the research aims to propose a supplier selection procedure with sustainability in mind using AHP-TOPSIS integration and perform order allocation with goal programming. This research significantly improves supply chain sustainability by proposing a supplier selection procedure integrating the AHP-TOPSIS method. This approach enables supplier assessment based on sustainability criteria, such as environmental, social, and economic dimensions. In addition, this research also performs order allocation using the goal programming method, ensuring efficient and optimal use of resources. The results of this research are expected to provide practical guidance for companies in selecting suppliers that prioritize sustainability and allocating orders by considering diverse multi-criteria goals.

2. Methods

2.1 Proposed Method

To solve the challenges of sustainable supplier selection and order allocation, this study introduces an integrated method of AHP-Topsis and goal programming. The draft framework of the proposed method can be found in Fig. 1. AHP is proposed for weighting the sustainable supplier selection criteria and sub-criteria. Meanwhile, Topsis is proposed to rank the best suppliers based on sustainability criteria and sub-criteria. Furthermore, Goal Programming is proposed to determine the supplier ranking order allocation and the goal of order allocation.

In the sustainable supplier selection and order allocation framework, stage (1) includes identifying criteria and sub-criteria along with the goals of order allocation. At this stage, the decision maker identifies the criteria for sustainable supplier selection and order allocation problems. Each sub-criteria should also be identified based on the classification of criteria based on the classification of benefits and costs to ensure that the supplier selection and order allocation process is more comprehensive.

At stage (2), the weighting of criteria and subcriteria with AHP begins with a pairwise comparison of each criterion and subcriteria for selecting sustainable suppliers by the decision maker. In this stage, the pairwise comparison method compares each criterion and subcriteria of sustainable supplier selection. It is important to detail the scale of importance used in the pairwise comparison process for the sustainable supplier selection criteria, and sub-criteria are detailed in Table 1. Each criterion and sub-criteria is expressed in the pairwise comparison results matrix according to Equation (1). The process of determining the level of importance of pairwise comparisons on criteria p and q is described through Equation (2), which shows the a_{pq} function. Furthermore, the

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normalization of matrix A is done by dividing the value by the total amount in each column. The principle of eigenvector AHP is illustrated through Equation (3). The AHP method analyses each pairwise comparison matrix to calculate the Consistency Ratio (CR) as listed in Equation (5). This value is based on the comparison of the Consistency Index (CI) value as described in Equation (4), divided by the Random Index (RI) proposed by Saaty [39]. The RI value in the AHP procedure is shown in Table 2. If the consistency ratio value ≤ 0.1, then the consistency value is good. Meanwhile, the judgment data assessment must be corrected if the consistency ratio value is > 0.1. Finally, the global weight of sub-criteria is calculated by multiplying the weight of the comparison results between criteria and sub-criteria.

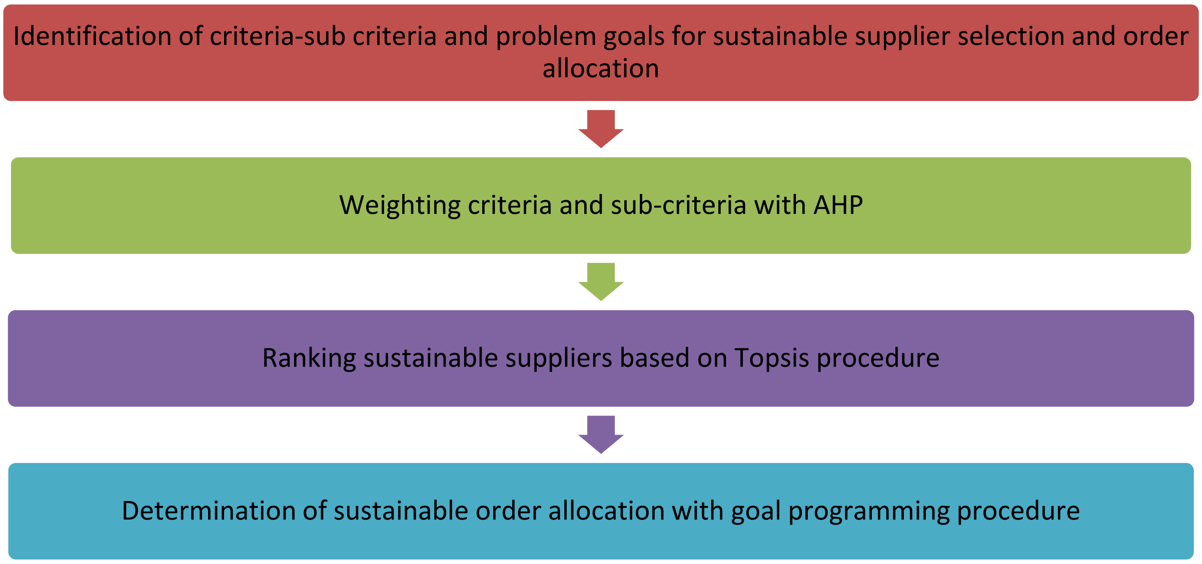

Fig. 1. Framework for sustainable supplier selection and order allocation

Table 1. AHP level of importance

Importance Level	Description
1	Equally important
3	Medium importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate scale

Table 2. Random index (RI) value

Number of Criteria	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

$$A = \begin{bmatrix} a_{11} & \dots & a_{1k} \\ a_{21} & \dots & a_{2k} \\ a_{k1} & \dots & a_{kk} \end{bmatrix} \tag{1}$$

$$a_{pq} \neq 0, a_{pp} = 1 \tag{2}$$

$$A.w = \lambda_{max}.w \tag{3}$$

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$$CI = \frac{\lambda_{max} - k}{k-1} \tag{4}$$

$$CR = \frac{CI}{RI} \tag{5}$$

In ranking suppliers based on the Topsis procedure, several key steps exist in stage (3). The stage starts with the decision matrix created, which consists of m suppliers and n criteria. The decision maker's assessment of each supplier (i) on each criterion (j) is represented as aij. In sub-criteria with benefit categories, the supplier assessment for each sub-criterion is based on a Likert scale, as presented in Table 3. Furthermore, based on the assessment of each supplier and sub-criteria, the decision matrix is normalized using Equation (6). Next, the weight of the decision matrix (V_{ij}) is calculated based on Equation (7), where the weight for each criterion j is obtained through the AHP method. Positive and negative ideal solutions are then calculated according to Equations (8) and (9). In assessing positive and negative ideal solutions, if the criteria are benefits, the V^+ value is based on the largest V_{ij} value. Conversely, if the criterion is cost, the V^+value is based on the smallest V_{ij} value. For the V^-value on the benefit criteria, the smallest V_{ij} value is used, while for the cost criteria, the V^- value is based on the largest V_{ij} value. The next step is to determine the distance between the value of each supplier and the positive and negative ideal solution matrix. The distance calculation formula can be found in Equations (10) and (11). The final stage is determining the preference value for each supplier. At this stage, the preference value of each supplier (S_i) is calculated based on Equation (12). The best supplier in sustainable selection is determined based on the largest preference value.

$$Rij = aij/\sqrt{\textstyle\sum_{k=1}^{m} aij^2} \quad i = 1,2,\dots,m \quad j = 1,2,\dots,n \tag{6}$$

$$V_{ij} = w_j \; x \; r_{ij} \forall_i, j, w_j \text{ is the weight of the criteria } j \tag{7}$$

$$V^+ = (max_i Vij | j \in J), (min_i Vij | j \in J) \tag{8}$$

$$V^- = (min_i Vij | j \in J), (max_i Vij | j \in J) \tag{9}$$

$$D_i^+ = \sqrt{\textstyle\sum_{j=1}^{n} (Vij - V^+)^2} \; i = 1,2,3,\dots,m \tag{10}$$

$$D_i^- = \sqrt{\textstyle\sum_{j=1}^{n} (Vij - V^-)^2} \; i = 1,2,3,\dots,m \tag{11}$$

$$S_i = D_i^- / \, (D_i^- + D_i^+) \quad i = 1,2,3,\dots,m \tag{12}$$

Table 3. Rating scale

Scale	Assessment Description
1	Very bad
2	Bad
3	Fair
4	Good
5	Very good

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The final step in the continuous supplier selection and allocation process is establishing the allocation using the Goal Programming technique. Once supplier preference is established through the AHP-Topsis method, order allocation is determined based on the Goal Programming procedure. According to Yadavalli, et al. [40], Goal Programming is an effective technique for handling optimization models with many conflicting objectives. The indices, parameters, and decision variables of the Goal Programming model can be seen in Table 4. Furthermore, the formulation of the Goal Programming model for order allocation in this study is adapted from the studies of Cheraghalipour and Farsad [26] and Mohammed, et al. [37].

Table 4. Indices, parameters, and decision variables of the goal programming model

Notations	Descriptions
	Indeks
j	Index supplier (j = 1, 2, …, J)
t	Index period (t = 1, 2, …, T)
i	Goal index or objective (i = 1, 2, …, I)
	Parameter
G	The target to be achieved by the goal
S_j	Supplier j preference score with AHP-Topsis method
P_j	Purchase price at supplier j
Fo_{jt}	Fixed order cost at supplier j in period t
H_t	Storage cost in period t
Tc_{jt}	Transportation cost at supplier j in period t
D_t	Demand in period t
Cap_j	Supplier j capacity
EF_{jt}	Carbon emission factor (g CO/miles) supplier j, 10.2 (g CO/miles)
VMT_j	Number of vehicle miles traveled per year (miles/month) by supplier j
F_E	Factor to convert grams to pounds (lb CO/g). 0.002205 (lb CO/g)
Inv_t	Total inventory in period t
M_{jt}	Minimum order at supplier j in period t
${d_i}^+$ ${d_i}^-$	Positive deviation for goal-i Negative deviation for goal-i
	Decision Variables
V_{jt}	Order allocation to supplier j in period t
Q_{jt}	Order lot to supplier j in period t
X_{jt}	A binary variable for supplier j in period t 1, if the supplier is selected 0, if not

In order to allocate, this research utilizes three goals: maximization of total sustainable purchasing value, minimization of total procurement cost, and minimization of carbon emission. Therefore, the target of each goal is generated from the linear programming optimization of each goal. The target formula of each goal is presented in Equations (13)-(15).

Objective function:

$$G1 = \sum_j \sum_t S_j \times Q_{jt} \tag{13}$$

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$$\mathrm{G2} = \sum_j \sum_t Tc_j \times X_{jt} + P_j \times Q_{jt} + \frac{V_{jt}}{Q_{jt}} \times Fo_{jt} + \frac{Q_{jt}}{2} \times H_t \qquad (14)$$

$$\mathrm{G3} = \sum_j \sum_t Fe \times EF_{jt} \times VMT_j \times Q_{jt} \qquad (15)$$

Constraints:

$$Q_{jt} \le Cap_j \times X_{jt} \forall j \in \mathrm{J}, \forall t \in \mathrm{T} \qquad (16$$

$$V_{jt} \ge M_{jt} \times X_{jt} \ \forall j \in \mathrm{J}, \forall t \in \mathrm{T} \qquad (17)$$

$$Inv_t + Q_{jt} \ge D_t \forall j \in \mathrm{J}, \forall t \in \mathrm{T} \qquad (18)$$

$$\sum_j \sum_t V_{jt} = \mathrm{D}_t \ \forall j \in \mathrm{J}, \forall t \in \mathrm{T} \qquad (19)$$

$$V_{jt}, Q_{jt} \ge 0 \qquad \forall j \in \mathrm{J}, \forall t \in \mathrm{T} \qquad (20)$$

The first objective function is to maximize the total sustainable purchasing score of the suppliers' total economic, social, and environmental criteria scores shown in Equation (13). It should be noted that the supplier score is determined by the AHP-Topsis method of sustainable supplier selection ranking. Equation (14) is the objective function to minimize the total cost of raw material procurement, which is affected by fixed cost, price, order cost, storage cost, order lot, and order allocation. Equation (15) aims to minimize carbon emissions due to shipping raw materials from suppliers. This is influenced by the distance traveled in one year and the carbon emission factor. The three goals are optimized with a linear programming procedure to determine the target goal of each goal. Equation (16) ensures that each goal lot order to suppliers in period t is less than equal to each supplier's capacity. Equation (17) shows that the order allocation must equal the minimum order at each supplier. Equation (18) balances the demand from inventory and lot orders. Equation (19) states that the amount of order allocation must equal the demand. Equation (20) shows that the order allocation and lot order must be greater than equal to zero.

Based on the target goal formula optimized by linear programming, the details of the Goal Programming formula are described as follows:

Objective function.

$$Z_{min} = \sum_i d_i^{+} + d_i^{-} \qquad (21)$$

Constraints:

$$\sum_j \sum_t S_j \times Q_{jt} + d_1^{-} - d_1^{+} = G_1 \qquad (22)$$

$$\sum_j \sum_t Tc_j \times X_{jt} + P_j \times Q_{jt} + \frac{V_{jt}}{Q_{jt}} \times Fo_{jt} + \frac{Q_{jt}}{2} \times H_t + d_2^{-} - d_2^{+} = G_2 \qquad (23)$$

$$\sum_j \sum_t Fe \times EF_{jt} \times VMT_j \times Q_{jt} + d_3^{-} - d_3^{+} = G_3 \qquad (24)$$

$$Q_{jt} \le Cap_j \times X_{jt} \qquad (25)$$

$$V_{jt} \ge M_{jt} \times X_{jt} \qquad (26)$$

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$$Inv_t + Q_{jt} \geq D_t \tag{27}$$

$$\sum_j \sum_t V_{jt} = \mathrm{D_t} \tag{28}$$

$$d_i^{+}, d_i^{-} \geq 0 \tag{29}$$

$$V_{jt}, Q_{jt} \geq 0 \tag{30}$$

Equation (21) is the objective function of the order allocation sustainable goal programming problem to minimize the deviation from the target goal. Equation (22) is the goal 1 formula to maximize the total value of sustainable purchases. Equation (23) shows the goal 2 formula that minimizes the total cost of procuring raw materials from suppliers. Equation (24) shows the goal 3 formula that minimizes carbon emissions. Equation (25) lot orders at suppliers in period t are less than equal to each supplier's capacity. Equation (26) shows that the order allocation must equal the minimum order at each supplier. Equation (27) constraint function to show the balance of demand. Equation (28) shows the function that the total order allocation must be equal to the demand. The positive and negative deviation goal cannot be less than 0 as shown in Equation (29). Order allocation and order lots must be greater than zero as shown in Equation (30).

2.2 Data and Case Studies

This research data is based on case study data from the plastic packaging manufacturing industry in Sidoarjo, East Java, Indonesia. The raw material suppliers to be selected are plastic seed suppliers used in producing various plastics. In this study, the decision maker consists of three experts: Quality Control, Procurement and Production managers. The experts conducted a focus group discussion to determine the criteria and sub-criteria and the goal of order allocation. The criteria and sub-criteria for the problem of sustainable supplier selection and order allocation are shown in Table 5.

Table 5. Criteria and sub criteria sustainable supplier selection and order allocation

Criteria	Sub Criteria	Type
Economy	Product price (A1)	Cost
	Financial capability (A2)	Benefit
	Service (A3)	Benefit
	On time delivery (A4)	Benefit
	Quality (A5)	Benefit
	Technology (A6)	Benefit
	Cooperative relationship (A7)	Benefit
	Flexibility (A8)	Benefit
Social	Employee training (B1)	Benefit
	Reputation (B2)	Benefit
	Employee rights and interests (B3)	Benefit
	Customer issues (B4)	Benefit
	Occupational health and safety (B5)	Benefit
Environment	Pollution control (C1)	Benefit
	Environmental management system (C2)	Benefit
	Resource consumption (C3)	Benefit
	Waste management (C4)	Benefit

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The company selects and determines the order allocation based on 5 alternative suppliers in this case study. The distance data for each supplier is shown in Table 6. Meanwhile, the cost data for each supplier is presented in Table 7. In this study, order allocation is estimated for 3 periods with demand in period 1 to period 3 being 40000, 45000, and 50000. Optimization of each goal target with linear programming and order allocation in goal programming is carried out with the help of LINGO software..

Meanwhile, the optimization results to determine each goal using linear programming procedures are also presented. The objectives Maximization of total sustainable purchasing value (Goal 1), Minimization of total procurement cost (Goal 2), and Minimization of carbon emission (Goal 1) resulted in target goals of 10046.41, 3000000000, and 2873172.709, respectively.

Table 6. Distance data for each supplier

Supplier Code	Distance
S A	6.835 miles
S B	15.534 miles
S C	536.865 miles
S C	452.979 miles
S E	9.321 miles

Table 7. Cost data of each supplier

Supplier Code	Price (Rp/kg)	Minimum order (kg)	Order Capacity (kg)	Order Cost	Inventory Cost (Rp/kg)	Transportation Cost
S A	Rp 19,800	5,000	18,000	Rp 150,000	Rp 300	Rp 1,840,000
S B	Rp 19,900	2,000	10,000	Rp 150,000	Rp 325	Rp 1,780,000
S C	Rp 20,076	6,000	16,000	Rp 150,000	Rp 310	Rp 8,765,000
S D	Rp 19,996	5,000	15,000	Rp 150,000	Rp 290	Rp 7,679,000
S E	Rp 19,940	3,000	18,000	Rp 150,000	Rp 275	Rp 1,600,000

3. Results and Discussion

3.1 Supplier Selection and Order Allocation Results

The results of weighting the criteria and sub-criteria of sustainable supplier selection and order allocation are shown in Table 8. The results show that of the three sustainability criteria, the economic criteria generated the highest weight with a score of 0.591. Environmental criteria ranked second with a weight of 0.285. Meanwhile, the social criteria ranked last with a weight of 0.124. This finding shows that in the selection of sustainable suppliers, economic criteria play a crucial role [20]. It may be because economic considerations include elements such as price, production cost, and the supplier's financial stability, which directly affect the sustainability of the company's operations [21]. Meanwhile, environmental criteria ranked second in importance. Environmental sustainability is also crucial in supplier selection [41]. It indicates that companies are also concerned about minimizing negative impacts on the natural environment and increasing awareness from companies [42]. On the other hand, social criteria have a lower importance weight. Although still relevant, the lower importance indicates that social aspects have not been the main focus in supplier selection.

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In the economic dimension of sustainable supplier selection, the quality and price sub-criteria are ranked first and second from the sub-criteria on economic criteria. Quality and price are the two most important factors affecting the organization's performance [43]. Quality is crucial because it ensures the supplier's product or service meets the required standards and specifications. Price is important because it affects the cost of the product or service and the organization's profitability. Therefore, it is crucial to consider both quality and price when selecting a sustainable supplier [44]. In addition, the sub-criteria Environmental management system and Resource consumption are the sub-criteria that occupy the first and second positions on the environmental criteria. Suppliers with a good Environmental Management System indicate that the supplier complies with strict environmental standards [45]. It can contribute to improving the overall sustainability of the supply chain. In addition, Resource Consumption in the second position shows that the importance of efficiency in using natural resources directly impacts environmental issues [46].

Furthermore, in the social criteria, the sub-criteria, supplier reputation, and Occupational health and safety are the most critical in the social criteria. Supplier reputation is a crucial aspect in the selection of sustainable suppliers. A good reputation reflects the supplier's commitment to sustainable business practices [47]. In addition, the Occupational Health and Safety sub-criteria is also very important. Occupational safety and health is an aspect that affects employee productivity, morale, and satisfaction, which in turn can affect the quality and consistency of products or services provided by suppliers [48]. Meanwhile, the score consistency ratio for pairwise comparison of criteria, economic, social, and environmental sub-criteria are 0.056, 0.096. 0.095, and 0.092. These results show consistent pairwise comparison data on each criterion: economic, social, and environmental sub-criteria. It is evident from the consistency ratio value, which is less than 0.1.

Table 8. Weight calculation result

Criteria	Weight	Sub Criteria	Weight	Global weight
Economy	0.591	Product price (A1)	0.226	0.133
		Financial capability (A2)	0.162	0.096
		Service (A3)	0.047	0.028
		On time delivery (A4)	0.099	0.059
		Quality (A5)	0.280	0.165
		Technology (A6)	0.027	0.016
		Cooperative relationship (A7)	0.066	0.039
		Flexibility (A8)	0.094	0.056
Social	0.124	Employee training (B1)	0.126	0.016
		Reputation (B2)	0.334	0.041
		Employee interest rights (B3)	0.207	0.026
		Customer issues (B4)	0.114	0.014
		Occupational health and safety (B5)	0.218	0.027
Environment	0.285	Pollution control (C1)	0.126	0.036
		Environmental management system (C2)	0.507	0.144
		Resource consumption (C3)	0.254	0.072
		Waste management (C4)	0.113	0.032

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Furthermore, the results of the preference assessment with the Topis procedure are presented in Table 9. The results show that the ranking of the best to the worst suppliers in a row is supplier C - supplier E - supplier A - supplier D - supplier B. Furthermore, the order allocation optimization results with the goal programming procedure resulted in the order allocation presented in Table 10.

Table 9. Distance of positive and negative ideal solutions, and preference values

	S A	S B	S C	S D	S E
D+	14.416	21.549	5.873	16.854	12.898
D-	12.932	8.708	22.373	8.994	13.968
S	0.473	0.288	0.792	0.348	0.520

Table 10. Order allocation with the Goal Programming method

Supplier	1st period	2nd period2	3rd period
S A	18000	14499.97	17695.79
S C	16000	12500.03	14304.21
S E	6000	18000	18000

3.2 Research Implication

The theoretical implication of this research is the development of the AHP-Topsis and Goal Programming integration method as a holistic approach to dealing with sustainable supplier selection and order allocation problems. This approach provides a solid theoretical foundation in determining the weights of criteria and sub-criteria for sustainable supplier selection through AHP and ranking the best suppliers based on sustainability criteria and sub-criteria through Topsis. Furthermore, by applying Goal Programming, this research also makes a theoretical contribution to determining the optimal order allocation by considering the priority of goals and supplier ranking. Thus, this research expands the theoretical insights in integrating various methods to improve the decision-making process related to sustainable supplier selection and order allocation.

The research also provides valuable practical implications for sustainable supplier selection. The results of the criteria weighting analysis show that in the context of sustainability, economic factors have the highest priority level, followed by environmental and social factors. It confirms that companies must emphasize economic aspects in selecting sustainable suppliers to balance financial benefits and social and environmental impacts. Furthermore, this study shows that quality and price are the two most significant economic sub-criteria. Therefore, companies can consider supplier selection strategies to improve quality and cost efficiency to achieve optimal economic sustainability.

Furthermore, in the environmental context, the findings suggest that focusing on environmental management systems and efficiency in resource consumption are vital in selecting suppliers that contribute to environmental sustainability. These sub-criteria ranked top in the environmental criteria, emphasizing the importance of selecting suppliers by adopting sustainable practices in environmental management and resource use. On the social side, supplier reputation and occupational health and safety aspects emerge as the most crucial sub-criteria in sustainable supplier selection. It signals the need to emphasize ethics and safety standards in selecting suppliers to ensure the entire supply chain operates in a fair and safe environment for all stakeholders. Considering these findings, companies can optimize their supplier selection process by focusing on crucial aspects that affect the overall sustainability of their operations.

4. Conclusion

This study proposes an approach that integrates AHP-TOPSIS and goal programming to solve the problem of sustainable supplier selection and order allocation. AHP is used to assign weights of criteria and sub-criteria in sustainable supplier selection. Meanwhile, TOPSIS scores and ranks the best suppliers based on sustainable criteria. Furthermore, Goal Programming is applied to optimize the order allocation among the selected suppliers and achieve the predefined allocation goal. The analysis results show that economic criteria have the highest weight in this framework, followed by environmental and social criteria with lower weights. The TOPSIS process successfully provides accurate rankings for suppliers based on sustainable criteria. In addition, the optimization results with goal programming indicated that the optimal order allocation involved three leading suppliers, namely supplier C, supplier E, and supplier A. This approach significantly contributed to improving the sustainability of the company's supply chain.

Suggestions for future research may include several important aspects. Future research needs to consider the use of sensitivity analysis methods to evaluate the impact of variations in criteria weights on the final results in sustainable supplier selection and order allocation. It can help in understanding the extent to which changes in criteria prioritization can affect the final decision. Furthermore, future research can also explore the possibility of integrating other techniques, such as fuzzy logic, to improve the precision and accuracy in determining criteria and sub-criteria and supplier ranking. In addition, considering external factors that may affect supplier sustainability, such as changes in government policies or technological developments, could also be an exciting research area.

Declarations

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