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Optimizing the Smallholder Arabica Coffee Supply Chain in Bondowoso, East Java, Indonesia: A Strategic Analysis Using A'WOT

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ABSTRACT

This study aims to develop a strategic that can improve the effectiveness of the Arabica coffee supply chain for local farmers in Bondowoso Regency, one of the largest coffee-producing regions in Indonesia. The Focus Group Discussion (FGD) conducted in this research utilized 10 expert assessments through the A'WOT analysis tool, which combines SWOT and the Analytic Hierarchy Process (AHP). This activity aims to identify and prioritize the most effective development strategies. The results showed that the strategy of strengthening farmers' capacity and empowerment emerged as a priority strategy with the highest weight of 0.220. This strategy is considered the most impactful in improving coffee productivity and quality, as well as supporting coffee supply chain sustainability in Bondowoso. This research is more complex than previous studies with the approach of analyzing the development of an efficient smallholder arabica coffee supply chain through the A'WOT method. The findings have important implications for stakeholders in formulating policies and actions to improve the efficiency of smallholder Arabica coffee supply chains. This study highlights efficiency for supply chain actors to protect the continuity of Arabica coffee product fulfillment needs.

1. INTRODUCTION

One of Indonesia's biggest coffee-producing regions is Bondowoso Regency in East Java Province. The Ijen-Raung mountains, which have received a Geographical Indication (GI) certification, contribute 60% of East Java's Arabica coffee. Its highest production reached 51,177 tons between 2017 and 2021. However, one of the challenges in coffee agribusiness is the length of the trade chain [1]. It is suggested that coffee production would increase if an efficient agribusiness system were established.

Inequality in the supply chain places farmers in a disadvantaged position [2]. The degree to which changes in commodity prices are passed down supply chains is a determining factor in the implementation of state market policy. Strong relationships within the supply chain have a significant impact and are crucial for coordinating and managing the various actors involved [3]. To ensure supply chain sustainability, procurement and supply chain management procedures must be extended to upstream providers, which calls for the establishment of appropriate governance structures [4]. Enhancing efficiency and competitiveness can be achieved through a supply chain management approach [5]. Inadequate management, inaccurate information, and inefficient supply chains are significant challenges in agricultural supply chains [6].

In Bondowoso Regency, Arabica coffee farmers face difficulties in meeting consumer demand due to the lack of integration in the Arabica coffee supply chain management. To develop an effective strategic model for the Arabica coffee supply chain, the SWOT and AHP (A'WOT) approaches must be employed to identify efficient supply chain management activities in the Arabica coffee agribusiness. Furthermore, efforts should be made to design and create alternatives that optimize processes, time, and costs [7].

Various recent studies have proposed advanced technological and managerial approaches to improve supply chain efficiency. For example, the integration of Lean Six Sigma has been shown to improve the effectiveness of supply chain management, while the application of data mining strengthens decision-making and improves the accuracy of demand forecasting in logistics systems [8, 9]. Marketing and logistics integration strategies were also identified to accelerate distribution and improve operational efficiency [10].

Furthermore, a number of studies show the great potential of utilizing blockchain and IoT technologies to strengthen product traceability and supply chain transparency [11, 12]. Mathematical models for efficient supply chain network design have also been developed to optimize costs and carbon emissions, and SCOR and ANP models were used to systematically assess coffee supply chain strategies [13, 14]. However, while these literatures are highly relevant and up-to-date, there are some significant limitations when applied to developing agricultural contexts, particularly smallholder coffee farms such as those in Bondowoso District, Indonesia.

First, most studies adopt high-tech and top-down approaches, such as blockchain and Lean Six Sigma, which are less suited to the limited infrastructure and capacity of smallholder farmers in developing regions. Second, the models used generally focus on economic efficiency, but lack consideration of local socio-cultural factors such as cultivation traditions and resistance to change. Third, farmer participation and local institutions such as cooperatives are often ignored, so the strategies offered tend to be decontextualized and difficult to implement. Fourth, not many studies have specifically examined the efficiency of coffee supply chains in unique regions such as Bondowoso Regency, which has its own geographical characteristics and market dynamics.

One intriguing method for assisting in the strategic decision-making process is the combination of AHP and SWOT analysis. The knowledge base in strategic planning may be improved and enhanced by using this hybrid approach. A'WOT not only gives strong decision assistance but also a useful framework for learning how to make strategic decisions in a variety of circumstances [15]. Previously, A'WOT analysis has been applied to various agricultural commodities and to agro-industrial supply chains [16-19]. However, as far as the writers are aware, the application of A'WOT in the context of smallholder coffee supply chains is still limited. The application of A'WOT in this study is useful for systematically identifying and prioritizing strategies to improve the efficiency of smallholder coffee supply chains. Through A'WOT, strengths, weaknesses, opportunities, and threats can be analyzed in a structured manner, then prioritized based on their level of importance. This is important considering that smallholder coffee supply chains often face challenges such as limited technology, access to capital, and markets. Thus, A'WOT helps generate adaptive and priority-based strategies to improve farmers' competitiveness, efficiency, and resilience in the face of market dynamics and environmental changes.

Therefore, this study offers a novelty by using the integrative approach of A'WOT (a combination of SWOT and AHP) to identify coffee supply chain efficiency strategies in a participatory and contextual manner. A'WOT allows researchers to not only evaluate internal strengths and weaknesses as well as external opportunities and threats, but also prioritize the most relevant strategies through measurable numerical weights, based on local stakeholders' preferences. This approach is considered more adaptive to the complexity of smallholder farming systems and local dynamics, making it a significant practical and scientific contribution to efforts to improve coffee supply chain efficiency in developing regions.

A fundamental technique for creating strategies in a variety of businesses is the SWOT analysis, which stands for Strengths, Weaknesses, Opportunities, and Threats [20]. By integrating A'WOT with the Analytic Hierarchy Process (AHP), it allows for more analytical results, leading to improvements in decision-making processes and greater public acceptance. Compared to previous research, this study is more complex as it utilizes the A'WOT method to analyze an efficient development model for the smallholder Arabica coffee supply chain. However, previous studies did not focus on the efficiency of supply chain development. This research aims to fill that gap by formulating a strategic improving the efficiency of smallholder Arabica coffee supply chain management in Bondowoso Regency, which also constitutes the novelty of this study.

2. MATERIALS AND METHODS

The research site was selected using purposive sampling because Bondowoso Regency is the largest Arabica coffee production center in East Java Province. This regency is also designated as a national coffee cultivation hub, as stated in the Minister of Agriculture Decree No. 830 of 2016 and Decree No. 472 of 2018 on national agricultural zones. Data collection was conducted in April-August 2024, followed by data analysis in September-November 2024 using a quantitative descriptive approach. Report preparation and article writing were conducted in December 2024, and continued with the scientific publication process in 2025.

The expert sampling based on non-probability sampling, involved considerations such as the relevance of the experts' education, their experience, and their track record of expertise. The experts involved in evaluating an efficient coffee supply chain development strategy model comprised ten individuals, including two farmers, two representatives from processing units (UPH), one large-scale trader, one exporter, two experts from coffee agencies, and two academics/researchers in coffee. These experts possess substantial knowledge and experience in both academic and practical aspects of the coffee industry. The qualification of experts is either academics with masters/doctorate degree education and have research experience on supply chains or policy makers or practitioners, such as heads of farmer’s groups, processors, traders, exporters in the Arabica coffee industry with at least 10 years’ experience.

To evaluate and create effective strategies for developing the smallholder Arabica coffee supply chain, the SWOT-AHP method, also known as A'WOT, was employed. A'WOT analysis is a robust quantitative approach used to systematically evaluate the identified SWOT elements [21]. By assessing the supply chain's advantages, disadvantages, opportunities, and risks, this research helps create a model that can increase Arabica coffee producers' production. Based on the replies of the informants, indicators were chosen from these components. Each indication was then given a rating and a weight by the informants. An indicator's role in relation to other indicators is indicated by its weight. Each informant's weight was averaged to determine the weight value. On a Likert scale, the rating displays the informants' opinions on each indicator (1 being not important, 2 being less important, 3 being important, and 4 being extremely important). The average of all informants' ratings was also used to calculate the rating value. The weight and rating were then multiplied to determine the final score. The Arabica coffee supply chain efficiency plan is determined by this score. SO (Strength-Opportunity), WO (Weakness-Opportunity), ST (Strength-Threat), and WT (Weakness-Threat) are the methods that are given priority. The SO strategy is selected if the difference between the scores of strengths and weaknesses is positive while the difference between opportunities and threats is positive. If there is a positive difference between opportunities and threats and a negative difference between strength and weakness ratings, the WO approach is chosen. If there is a positive difference between the strength and weakness scores and a negative difference between the opportunities and threats, the ST strategy is chosen. If there is a negative difference between the strengths and weaknesses ratings, as well as between the opportunities and threats, the WT approach is chosen.

The Analytic Hierarchy Process (AHP) is a valuable decision-making tool. As AHP targets small to medium-sized groups rather than broader social surveys, it can only be used by specific experts [22]. The AHP structure includes components such as consistency, weighting, and hierarchical organization. A pairwise comparison scale with a value range of 1-9 based on a hierarchical structure, as indicated in Table 1, may be used by experts to determine the degree of relevance. Comparing items in pairs to determine which is more favored, which has more quantitative characteristics, or if the two are similar or identical is known as pairwise comparison. Scientific investigations pertaining to operational reduction (C1), product quality improvement (C2), distribution speed (C3), and stakeholder participation (C4) employ the pairwise comparison approach [23]. Relative weights between criteria and options are generated by the pairwise comparison matrix. A criterion's significance for the selected alternative will be evaluated by comparing it to other criteria.

Table 1. Pairwise comparison scale [24]

Intensity of Interest	Definition
1	The two components are equally significant.
3	One component is somewhat more significant than the other.
5	There is one component that is more significant than the other.
7	It is obvious that one component is more crucial than the others.
9	One component is far more significant than the others.
2, 4, 6, 8	Values in the middle
Opposite	J has the opposite value from i if for activity yields a single number proportionate to activity j.

The AHP approach recommends suitable metrics for evaluating pairwise matrix consistency. The following is the formula for the Consistency Index (CI).

$$\mathrm{CI} = \frac{\lambda \max * n}{n-1} \quad (1)$$

The Analytic Hierarchy Process (AHP) is a useful method for making policy decisions. It allows for identifying pressing policy issues and prioritizing tasks within complex situations.

The A'WOT method combines both approaches effectively. Pairwise comparisons are carried out as part of the SWOT-AHP analysis procedure. The results from the SWOT analysis can quantitatively indicate preferences for setting future strategies using strategic factors from the SWOT structure, helping policymakers and top managers to minimize weaknesses and threats while leveraging strengths and opportunities [25, 26]. However, further debate and improvements are necessary to address existing weaknesses and threats. To tackle these issues, this research also conducted brief interviews with ten experts.

3. RESULTS

Based on Table 2, the identification of internal factors shows that the supportive smallholder government received the highest score of 0.58. Through various support programs, the Bondowoso local government assists the growth of Arabica coffee in the region. The government does this to support coffee farmers and strengthen the agribusiness sector. This support includes access to advanced technology and improved market access for farmers.

However, dependence on weather received the highest score of 0.39. Arabica coffee farmers in Bondowoso face significant challenges due to their reliance on weather conditions. Arabica coffee plants are highly sensitive to climate changes. Unpredictable weather patterns have a direct impact on crop output and coffee bean quality.

Based on Table 3, on the external factors, the highest-scoring opportunity, with a score of 0.41, is the growth in specialty coffee demand. The increasing demand for specialty coffee in Bondowoso Regency is a growing phenomenon, driven by rising consumer awareness of coffee quality and uniqueness. Meanwhile, the fluctuation of coffee prices in the global market poses the most significant threat among external factors.

Table 2. Internal factor evaluation (IFE) matrix for Arabica coffee supply chain efficiency

Internal Factors				
No	Strengths	Weight	Rating	Score
1	Recognized coffee quality	0.151	3	0.45
2	Presence of experienced farmers	0.135	3	0.41
3	Strong farmer community	0.140	3	0.42
4	Supportive local government	0.144	4	0.58
No	Weaknesses	Weight	Rating	Score
1	Limited production technology	0.085	3	0.26
2	Dependence on weather	0.131	3	0.39
3	Limited market access	0.109	3	0.33
4	Limited capital and investment	0.104	3	0.31

Table 3. External factor evaluation (EFE) matrix for Arabica coffee supply chain efficiency

Internal Factors				
No	Opportunities	Weight	Rating	Score
1	Growth in specialty coffee demand	0.136	3	0.41
2	Support from government and international programs	0.125	3	0.38
3	Increased awareness of sustainability	0.131	2	0.26
4	Development of coffee tourism	0.122	3	0.37
No	Threats	Weight	Rating	Score
1	Fluctuations in global coffee prices	0.125	3	0.38
2	Competition with other coffee-producing regions	0.121	3	0.36
3	Climate change	0.124	3	0.37
4	Changes in export-import regulations or quality standards affecting access to international markets	0.115	3	0.34

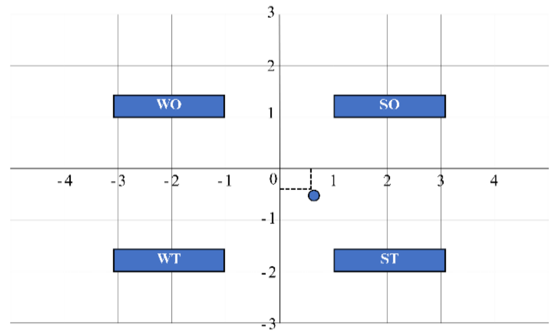

Figure 1. IFAS and EFAS matrices

To determine the most important strategy and how they related to each other based on SWOT weighting, internal and external strategies were combined. The SWOT analysis calculation could be used to convert the qualitative SWOT data above into quantitative data. The IFAS and EFAS matrix values were 1.86 for strengths, 1.29 for weaknesses, 1.41 for opportunities, and 1.46 for threats, respectively. Each weight score is summed up. The summation results are used to determine the priority strategies to be implemented. Each internal and external factor's weight ratings add up to Strength (S): 1.86; Weakness (W): 1.29; Opportunity (O): 1.42; and Threat (T): 1.45. Thus, Y=O-T=1.42-1.45=-0.03 and X=S-W=1.86-1.29=0.57 (Figure 1).

According to Figure 1's mapping, Bondowoso Regency, East Java Province's Arabica coffee supply chain efficiency plan falls into quadrant II, which is a competitive approach. Bondowoso Regency is strong enough to defeat threats in this situation. Based on this, select the ST approach when creating an efficient supply chain plan for Arabica coffee.

According to Figure 1's identification and IFAS and EFAS matrix results, the efficiency strategy for the Arabica coffee supply chain in Bondowoso Regency can be seen by considering the ST quadrant, which involves creating strategies that leverage strengths to address threats.

To improve the efficiency of the Bondowoso coffee supply chain, the following strategies can be implemented by leveraging strengths and addressing the threats faced:

1) Strengthening Quality and Standards
2) Development and Enhancement of Infrastructure
3) Capacity Building and Empowerment of Farmers
4) Diversification and Adaptation
5) Climate Change Adaptation Strategies
6) Risk Management and Regulatory Changes
7) Supply Chain Optimization

The two tiers of the AHP model used in this study are as follows:

Level 1 has four criteria that are taken into consideration (reduction of operational (C1), improvement of product quality (C2), distribution speed (C3), collaboration among stakeholders (C4)).

Level 2 is an alternative strategy consisting of 7 alternatives (strengthening quality and standards (A1), development and enhancement of infrastructure (A2), capacity building and empowerment of farmers (A3), diversification and adaptation (A4), climate change adaptation strategies (A5), risk management and regulatory changes (A6), and supply chain optimization (A7).

The following is a description of the hierarchical model of the components and options (Figure 2):

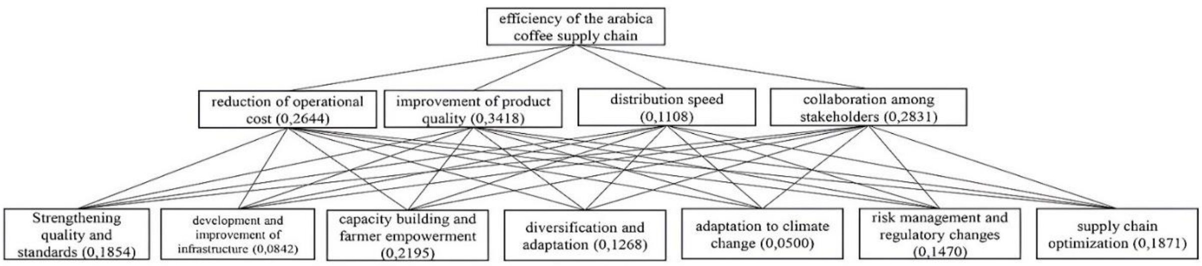

Figure 2. A model for improving the supply chain's efficiency for Arabica coffee

The findings of a survey administered to 10 stakeholders, experts, specialists, and those directly involved in the supply chain for Arabica coffee were used to compile the criterion comparison data. The structure was constructed using a pairwise comparison matrix. In the pairwise comparison matrix, the weight of each criterion is sought by normalizing the geometric mean of the respondents' opinions. The calculation results can be seen in Table 4.

The outcomes of pairwise comparisons between the criteria provided by 10 experts (informants) are displayed in Table 4. The value of 0.667 indicates that the reduction of the operational factor is 0.667 times more significant than the improvement of the product quality factor; in other cases, the improvement of the product quality factor is 1.5 times more significant than the reduction of the operational factor, according to the results of geometric calculations. The distribution speed factor is 0.429 times more significant than the operational factor decrease, or the operational factor reduction is 2.375 times more significant than the distribution speed factor. Stakeholder cooperation is one element that is more significant than operational reduction, whereas operational reduction is 1.111 times more significant than stakeholder collaboration. Distribution speed is 2.75 times less significant than improving the product quality factor. On the other hand, the enhancement in product quality factor is 0.375 times less significant than the distribution speed factor. Collaboration among stakeholders is 1.2 times less significant than improving the product quality factor. On the other hand, stakeholder participation is 0.833 times more significant than the enhancement of the product quality element. Stakeholder participation is 0.333 times less significant than the distribution speed factor. On the other hand, stakeholder participation is 2.8 times more crucial than distribution speed.

The next step is to use the Expert Choice tool to establish the weights after calculating the average comparison of the primary criterion variables. The first-level AHP analysis findings yielded priority weights for every criterion. Table 5 below displays the priority findings.

Table 4. Pairwise comparison of each criterion

Criteria	C1	C2	C3	C4
C1	1	0.667	2.375	1.111
C2	1.5	1	2.75	1.2
C3	0.429	0.375	1	0.333
C4	1	0.833	2.8	1

Table 5. Weights derived from the criterion

Criteria	Priority	Rank
Reduction of operational (C1)	0.2644	3
Improvement of product quality (C2)	0.3418	1
Distribution speed (C3)	0.1108	4
Collaboration among stakeholders (C4)	0.2831	2

Table 6. Pairwise comparison of each strategy alternative

Alternatif	A1	A2	A3	A4	A5	A6	A7
A1	1	2.2	1	1.667	3	1.125	1.2
A2	0.5	1	0.5	0.4	2.883	0.4	0.333
A3	1	2.111	1	2.333	3.2	2.167	1.286
A4	0.6	2.6	0.429	1	2.375	0.667	0.857
A5	0.333	0.333	0.333	0.333	1	0.375	0.25
A6	0.889	2.6	0.5	1.5	2.714	1	0.571
A7	0.833	3	0.778	1.167	4	1.714	1

Table 7. The resulting weights for alternative strategies

Alternatif Strategi	Priority	Rank
Strengthening quality and standards (A1)	0.1854	3
Development and enhancement of infrastructure (A2)	0.0842	6
Capacity building and empowerment of farmers (A3)	0.2195	1
Diversification and adaptation (A4)	0.1268	5
Climate change adaptation strategies (A5)	0.0500	5
Risk management and regulatory changes (A6)	0.1470	4
Supply chain optimization (A7)	0.1871	2

Table 5 indicates that the primary criterion, with a weight of 0.3418, is the enhancement of product quality. Next in line are stakeholder cooperation (weight 0.2831), operational reduction (weight 0.2644), and distribution speed (weight 0.1108), which is the lowest requirement. Therefore, the emphasis is more directed at the improvement of product quality rather than focusing on the reduction of operational, distribution speed, and collaboration among stakeholders.

Next, examine the statistics comparing various supply chain efficiency tactics for Arabica coffee. The geometric mean formula, as shown in Table 6, is used to get the pairwise comparison matrix results.

Priority weights were determined for each option based on the outcomes of AHP analysis at the alternative strategy level. Table 7 below displays the priority findings.

Based on Table 7, the model for developing Arabica coffee supply chain efficiency strategies in Bondowoso Regency is strengthening the capacity and empowerment of farmers with the highest weight of 0.2195. In the early stages of the coffee supply chain, farmers play a crucial role. By empowering and improving the capacity of farmers, the efficiency of the coffee supply chain can be enhanced because the coffee they produce will be more productive and of higher quality. The supply chain heavily relies on a consistent and high-quality supply of raw materials. Empowered farmers can adopt more productive, innovative, and sustainable agricultural practices.

Table 8. Consistency test results

Criteria	λmaks		
Criteria			
C1	4.050	λmaks rata-rata	4.0405
C2	4.045	CI (Consistency Index)	0.0135
C3	4.031	RI (Random Index)	0.90
C4	4.036	CR (Consistency Ratio)	0.015
Alternatif			
A1	7.236	λmaks rata-rata	7.14
A2	7.102	CI (Consistency Index)	0.0233
A3	7.087	RI (Random Index)	1.32
A4	7.165	CR (Consistency Ratio)	0.0177
A5	7.015		
A6	7.180		
A7	7.195		

To find out if the data is consistent, consistency ratio testing is done. If the value is less than 0.1 (CR≤0.1=consistent), the pairwise comparison matrix is referred to as consistent. The consistency ratio value is calculated using the CI/RI formula. The assessment data is consistent or acceptable based on Table 8's criteria consistency ratio value of 0.015. Furthermore, each alternative strategy's consistency ratio value is known to be 0.0177. As a result, the data from the pairwise comparison is reliable or consistent.

4. DISCUSSION

Coffee, as a commodity, faces price variability over time [27]. One of the biggest issues facing Bondowoso coffee producers is the volatility of world coffee prices. The viability of coffee cultivation operations and farmers' earnings may be directly impacted by this price volatility.

Based on the results of the research, strategies to improve the efficiency of the Arabica coffee supply chain can be described as follows:

1) Strengthening Quality and Standards: Improving production processes can enhance product quality, potentially increasing sales performance by 15% [28]. The specialty coffee sector in Nicaragua has improved a number of sustainable coffee certification programs in response to the livelihood crisis that millions of coffee growers and rural communities are facing. The value chain structure where certification programs are implemented is highly diverse and significantly impacts livelihood outcomes. Nevertheless, each certification necessitates more work and expenses for the organization and the farmer [29]. However, the implementation of this strategy is not free from various obstacles. Certification requires additional costs for training, post-harvest infrastructure and annual audits, which are difficult for smallholders to afford due to limited access to funding. In addition, there is a technical capacity gap, with some farmers lacking the skills to meet high-quality production standards. Another obstacle comes in the form of resistance to new policies, especially if farmers do not immediately feel the economic benefits. On the other hand, not all markets provide proper price incentives for certified products, which demotivates farmers. Lack of coordination among stakeholders can also slow down the implementation of this strategy. Therefore, comprehensive support from financial institutions, integrated training, and market assurance are crucial factors in driving the success of the coffee quality improvement strategy.
2) Development and Enhancement of Infrastructure: Investing in processing, storage, and distribution infrastructure to improve efficiency and reduce post-harvest losses. Research found that one of the causes of the underdevelopment in the coffee value chain is the high logistics costs associated with reaching markets [30]. The availability and quality of infrastructure supporting the flow of goods from farmers to end-users are crucial [31].
3) Capacity Building and Empowerment of Farmers: Providing the farmers with training on effective agricultural techniques, orchard management, and post-harvest practices. Training programs should be

tailored to existing experience and include new techniques that can enhance coffee yield and quality.

4) Diversification and Adaptation: Coffee producers should enhance the production of high-quality coffee and diversify post-harvest processes to produce coffee with more distinctive characteristics [32]. Exploring new markets can help mitigate the impact of global price fluctuations.
5) Climate Change Adaptation Strategies: Coffee production and growth are both directly and indirectly impacted by climate change [33, 34]. The production of coffee, including both yield and quality, is significantly affected by climate change. Potential environmental solutions include shifting cultivation elevations, developing resilient new cultivars, altering agrochemical inputs, and implementing agroforestry [35, 36]. Additionally, improving water use efficiency and incorporating organic soil amendments are crucial for moisture retention, with organic fertilizers considered a strategic response to climate change [37]. Rainfall and slope also affected soil organic matter in coffee plantations [38].
6) Risk Management and Regulatory Changes: Ensuring compliance with quality standards and international regulations by implementing systems for monitoring and analyzing changes in export-import regulations.
7) Supply Chain Optimization: Optimizing the logistics processes from the farms to the global market by reducing transit time, transportation costs, and risk of damage. Coffee value chain partnerships have the potential to reverse the current decline in coffee production, enhance farmer productivity, and address issues related to low-quality and inconsistent coffee supply.

By empowering and improving the capacity of farmers, the efficiency of the coffee supply chain can be enhanced because the coffee they produce will be more productive and of higher quality. The supply chain heavily relies on a consistent and high-quality supply of raw materials. Empowered farmers can adopt more productive, innovative, and sustainable agricultural practices.

Through training and technical support, farmers can enhance their knowledge of more effective cultivation techniques, technology utilization, and improved land management. Training and capacity development, as well as ongoing retraining of farmers, are crucial for the adoption of advanced agricultural technologies [39]. Such training can significantly support the enhancement of coffee productivity [40]. Technology preferences shape adoption and land use decisions in production systems. This capacity improvement will directly impact better coffee quality and more optimal yields, thereby enhancing the efficiency of the entire supply chain by reducing reliance on additional inputs to improve quality at subsequent stages. Empowering farmers is also closely related to environmental and social sustainability. By educating farmers about environmentally friendly agricultural practices, the efficiency of the supply chain can be improved in the long term through the adoption of more sustainable practices. This approach not only reduces operational costs but also ensures the sustainability of the coffee supply. Coffee growers benefit from enhanced market access and more value addition as a result of these sustainable techniques, which also help to preserve the environment [41].

Empowering farmers also fosters closer collaboration among farmers and other stakeholders in the supply chain, such as cooperatives, processors, and distributors [42, 43]. Cooperatives can play a pivotal role in empowering smallholder farmers, particularly in enhancing their agricultural productivity and economic opportunities. With improved connectivity, the distribution and management of coffee supplies can be carried out more swiftly and efficiently, reducing communication and coordination barriers. Only through the integration of all involved parties can social, economic, and environmental benefits for all stakeholders be assured [44].

Empowerment helps farmers become more independent in managing finances, accessing markets, and negotiating prices [45]. The stability of the whole supply chain is preserved by more successful farmers since they have greater negotiating power and can generate more steady revenue. In the Analytical Hierarchy Process (AHP) study, the strategy of capacity building and farmer empowerment is seen as a top priority since farmers are essential to the success of the whole coffee supply chain. By adopting sustainable farming techniques, lowering costs, and fostering more collaboration, enabling them will result in increases in quality, production, and overall efficiency. Specifically for the coffee industry in Bondowoso, this strategy lays a strong foundation for long-term sustainability and success.

However, the implementation of this strategy also faces a number of potential barriers that could reduce the practical value of this approach. One of the main barriers is the funding gap, where many smallholders do not have access to sufficient financial resources to attend training, purchase tools, or implement new technologies. In addition, farmers' lack of trust in external institutions and resistance to changing traditional farming methods can hinder the effectiveness of empowerment programs. Limited experts and training facilities in rural areas are also a challenge. From a policy perspective, top-down program implementation without active involvement of farmers may lead to resistance to new policies. Therefore, the feasibility analysis of this strategy needs to include institutional readiness, access to funding, and participatory program design. Without adequate policy support and active multi-stakeholder involvement, this empowerment strategy risks not achieving the expected results despite its great theoretical potential.

5. CONCLUSIONS

The A'WOT method is used in this study to create an efficient Arabica coffee supply chain. This approach combines AHP and SWOT analysis. Seven strategies to improve supply chain efficiency were found and assessed by the investigation. With a priority weight of 0.220, the AHP results show that the strategy of Strengthening Capacity and Empowering Farmers is the most important one to adopt. Enhancing coffee quality and production, as well as creating long-term sustainability for farmers and other supply chain members, this strategy is deemed the most efficient. Therefore, farmers should be given training, access to technology, and improved management skills in order to increase the efficiency of the Arabica coffee supply chain in the research region.

This study has identified strategies that can be implemented to improve the efficiency of smallholder Arabica coffee supply chains. On the other hand, there are some limitations in this study that need to be noted. The research was limited to a case study location in one of the districts with the highest Arabica coffee production in East Java Province, Indonesia. Therefore, the results may not fully reflect the conditions of other regions that may have different agribusiness characteristics. The author hopes that future research can expand the scope of research locations not only to the districts with the highest production, but also to areas with medium and low production levels. Future research is also recommended to conduct a multi-region comparison, in order to obtain a more comprehensive picture of variations in coffee supply chain strategies between regions. In addition, an interdisciplinary approach combining the perspectives of agribusiness, regional economics and rural sociology could enrich the understanding of sustainability and efficiency at the farm level. Future research can also further analyze the sustainability efforts that have been made, especially regarding farmers' access to technology, managerial skills, and the effectiveness of existing training programs.

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