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CONNECTING THE DOTS: WHAT DRIVES THE LINKAGES BETWEEN GREEN MSMEs AND LARGE INDUSTRIES IN THE FOOD-BEVERAGE SECTOR IN EAST JAVA?

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ABSTRACT

Despite national and regional efforts to advance the green economy agenda, linkages between micro and small enterprises (MSMEs) and large industries in Indonesia remain limited. East Java, a key contributor to the national economy with a substantial base of MSMEs, reports the lowest linkage rate in the food and beverage sector, falling below the national average. This gap reflects structural, institutional, and policy challenges that hinder partnerships between MSMEs and large industries. This study aims to identify key barriers, prioritize them based on urgency and impact, and formulate optimal policy strategies to strengthen linkages between green MSMEs and large industries in East Java's food and beverage sector. A mixed-method approach was employed, combining practitioner and expert interviews with the Analytic Hierarchy Process (AHP) and Grey-TOPSIS to identify and prioritize 24 sub-barriers grouped into eight main categories. The analysis is grounded in primary data collected through focus group discussions and structured AHP questionnaires. Based on stakeholder evaluations, five policy alternatives were analyzed. Capital support and product upgrading were identified as the most effective measures to strengthen industrial linkages. The study recommends a direct approach, namely, local governments mapping green MSMEs with potential or existing ties to large industries, thereby enabling targeted interventions. For the indirect approach at the national level, fiscal and monetary instruments are proposed, including tax incentives for industries that support green MSMEs and preferential credit schemes offering low-interest financing. Additionally, collaboration through the hexahelix model, involving government, industry, academia, financial institutions, communities, and media, is essential to enhance industrial linkages and support green MSME development in East Java.

Keywords: *Green MSMEs, Industrial Linkages, Policy Evaluation, Food and Beverage Sector*

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ABSTRAK

Meskipun upaya nasional dan daerah untuk mendorong agenda ekonomi hijau telah dilakukan, keterkaitan antara usaha mikro, kecil, dan menengah (UMKM) dengan industri besar di Indonesia masih terbatas. Jawa Timur, sebagai salah satu kontributor utama perekonomian nasional dengan basis UMKM yang besar, tetapi memiliki tingkat keterkaitan terendah di sektor makanan dan minuman dan berada di bawah rata-rata nasional. Kesenjangan ini mencerminkan adanya tantangan struktural, kelembagaan,

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dan kebijakan yang menghambat kemitraan antara UMKM dan industri besar. Penelitian ini bertujuan untuk mengidentifikasi hambatan utama, memprioritaskan hambatan tersebut berdasarkan tingkat urgensi dan dampaknya, serta merumuskan strategi kebijakan optimal untuk memperkuat keterkaitan antara UMKM hijau dan industri besar di sektor makanan dan minuman di Provinsi Jawa Timur. Penelitian ini menggunakan pendekatan metode campuran dengan menggabungkan wawancara dengan praktisi dan pakar menggunakan Analytic Hierarchy Process (AHP) dan Grey-TOPSIS, untuk mengidentifikasi dan memprioritaskan 24 sub-hambatan yang dikelompokkan ke dalam delapan kategori utama. Analisis didasarkan pada data primer yang dikumpulkan melalui focus group discussion (FGD) dan kuesioner AHP. Berdasarkan evaluasi terdapat lima alternatif kebijakan yang dianalisis. Dukungan permodalan dan peningkatan kualitas produk diidentifikasi sebagai langkah paling efektif untuk memperkuat keterkaitan industri. Studi ini merekomendasikan pendekatan langsung dengan pemerintah daerah melakukan pemetaan UMKM hijau yang memiliki potensi atau keterkaitan yang sudah ada dengan industri besar, sehingga memungkinkan intervensi yang tepat sasaran. Untuk pendekatan tidak langsung di tingkat nasional dapat menggunakan instrumen fiskal dan moneter seperti insentif pajak bagi industri yang mendukung UMKM hijau serta skema kredit dengan pembiayaan berbunga rendah. Selain itu, kolaborasi melalui model heksaheliks, yang melibatkan pemerintah, industri, akademisi, lembaga keuangan, komunitas, dan media sangat penting untuk meningkatkan keterkaitan industri dan mendukung pengembangan UMKM hijau di Jawa Timur.

Kata Kunci: *UMKM Hijau, Keterkaitan Industri, Evaluasi Kebijakan, Sektor Makanan dan Minuman*
JEL: L26; Q01; O25

Introduction

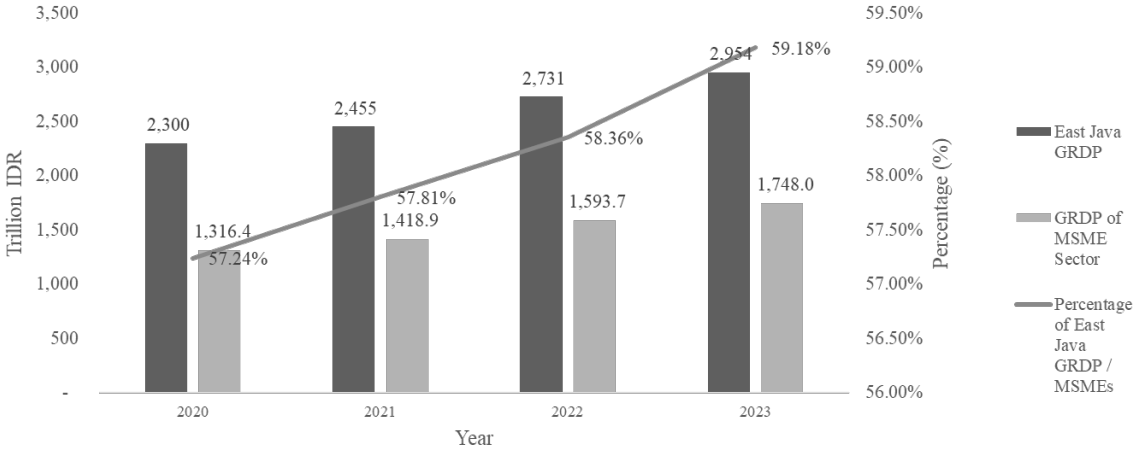
Micro, Small, and Medium Enterprises (MSMEs) are the backbone of the Indonesian economy, playing a key role in the number of business units, their contribution to the Gross Domestic Product (GDP), and their capacity to absorb labor (Aprilia et al., 2025; Marwanto et al., 2023). The Ministry of Cooperatives and SMEs (Ministry of Cooperatives and SMEs, 2024) reports that MSMEs account for 99.9 percent of the total national business units, totalling 64,194,057 units. This includes micro enterprises at 99.62 percent (63,955,369 units), small enterprises at 0.30 percent (193,959 units), medium enterprises at 0.06 percent (44,728 units), and large enterprises at 0.01 percent (5,550 units).

The contribution of MSMEs to the national GDP reaches a substantial 61.07 percent. This includes contributions from micro-enterprises at 37.51 percent, small enterprises at 15.81 percent, and medium enterprises at 8.31 percent (Ministry of Cooperatives and SMEs, 2024). Furthermore, MSMEs collectively employ approximately 119.6 million workers, equivalent to 96.9 percent of the total national workforce. However, the productivity level of MSME labor remains comparatively low. The average productivity is approximately IDR 80.13 million per person per year, while the average added value per business unit is IDR 146 million per year (Fiscal Policy Agency, 2024).

East Java is one of the provinces that make a major contribution to the Indonesian economy. The province ranks second after Greater Jakarta in terms of its share of Gross Regional Domestic Product (GRDP) (Statistics Indonesia, 2025). According to the report from the Department of Cooperatives and SMEs of East Java province (2024), cooperatives and SMEs contributed 59.18 percent to East Java's total GRDP in 2023. This reflects an increase of 0.83 percent compared to 2022, as illustrated in Figure 1.

According to data from the Ministry of Cooperatives and SMEs (2024), East Java ranks as the province with the third largest number of MSMEs in Indonesia, following West Java

and Central Java. The number of MSMEs in East Java reached 1,541,566 business units, with micro-enterprises accounting for 99.74 percent (1,537,536 units), small enterprises for 0.23 percent (3,460 units), and medium enterprises for 0.04 percent (570 units). Furthermore, MSMEs in East Java employ approximately 20.80 million workers, equivalent to 96.3 percent of the total labor force in the province.



Source: Statistics Indonesia (2025)

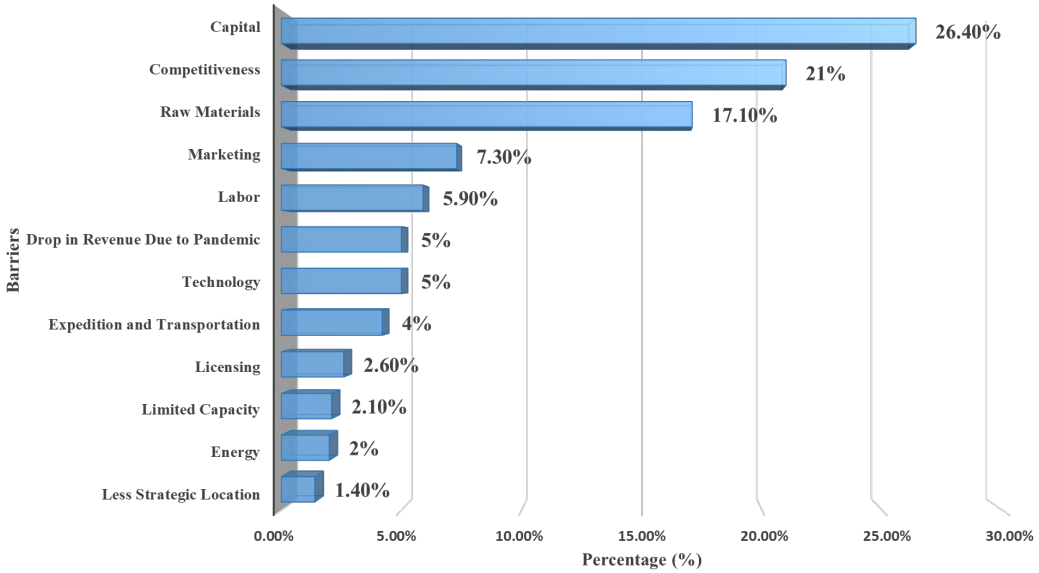
Figure 1: The Contribution of the MSME Sector to the GRDP of East Java

Despite the substantial contribution of MSMEs to the regional economy, the sector continues to confront numerous challenges. Based on data from the Department of Cooperatives and SMEs of East Java province (2024), 57.54 percent of MSME operators reported experiencing barriers in conducting their businesses, while 42.46 percent did not encounter any such obstacles. Among those who reported barriers, the primary issues identified are the enormous contribution of MSMEs to the regional economy, the sector still faces numerous problems. Based on data from the Department of Cooperatives and SMEs of East Java province (2024), 57.54 percent of MSME actors admitted to facing barriers in running their businesses, while 42.46 percent did not experience any barriers. Among those who reported barriers, the main problems included limited capital (26.4 percent), low competitiveness (21 percent), limited availability of raw materials (17.1 percent), marketing challenges (7.3 percent), labor issues (5.9 percent), technological limitations (5.0 percent), declining revenue due to the pandemic (5.0 percent), logistics and transportation constraints (4.2 percent), licensing (2.6 percent), limited production capacity (2.1 percent), energy supply issues (2 percent), and less strategic business locations (1.4 percent), as presented in Figure 2.

Inadequate institutional and managerial conditions further exacerbate these problems. Most MSMEs lack a structured financial accounting system, with only 6 percent having formal financial statements (Department of Cooperatives and SMEs of East Java province, 2024). Additionally, the majority of MSMEs (66 percent) continue to rely on direct marketing methods, which limit their market reach. On the financing side, although the proportion of MSME credit to total credit in East Java has shown an increasing trend each year, it remains below 50 percent, reflecting limited access to formal financing for this sector (Department of Cooperatives and SMEs of East Java province, 2024).

In recent years, both the central and local governments have placed greater emphasis on the green economy agenda by adopting green economy principles. In line with Indonesia's commitment outlined in *Visi Indonesia Emas 2045*, the implementation of green economy practices across all sectors of development has become a government priority. The promotion of sustainability transformation is pursued not only through macro-level policies but also through sectoral approaches, including the development of green Micro, Small, and Medium Enterprises (MSMEs). At the regional level, East Java Province has demonstrated a strong commitment to this transition. According to the materials presented at the East Java

Regional Development Planning Agency Technical Coordination Meeting (*Rapat Koordinasi Teknis Bappeda Provinsi Jawa Timur*), the long-term regional development plan (*Rencana Pembangunan Jangka Menengah Daerah*/RPJPD) explicitly prioritizes the transformation to a green economy. Sustainable development in East Java is guided by the spirit of *gotong royong* (mutual cooperation), aiming to achieve harmony across ecological, social, economic, and cultural dimensions. This mission is further elaborated in the Draft Economic Development Policy of East Java for 2025, which emphasizes the formulation of sustainable economic policies through the adoption and promotion of green economic growth.



Source: Ministry of Cooperatives and SMEs (2024)

Figure 2: Barriers Faced by MSMEs

Green MSMEs represent a key instrument for advancing the green economy agenda. According to Bank Indonesia (2024), green MSMEs are business entities that incorporate sustainable business principles by developing environmentally friendly production processes (green processes) and creating ecological products (green outputs). A survey conducted by Universitas Gadjah Mada involving 1,073 MSME participants demonstrated that green practices have a positive impact on business performance (Ministry of Cooperatives and SMEs, 2024). The survey results indicated that 86.2 percent of respondents reported an improvement in their business image, 83.7 percent observed an increase in competitiveness, and 83.3 percent perceived greater long-term business sustainability as a result of adopting green practices.

However, the development of green MSMEs still faces structural challenges on both the supply and demand sides. On the supply side, the transition to a green economy often requires substantial initial investment, which may affect the competitiveness of small businesses (Pangarso et al., 2022; Prakash et al., 2021). The availability of green raw materials and appropriate production technologies also remains limited. Furthermore, the capacity of MSME operators to understand and implement sustainability principles is still relatively low and requires substantial improvement (Panigrahi & Rao, 2018). On the demand side, challenges include weak consumer awareness and limited adoption of sustainability-oriented mindsets, the perception that environmentally friendly products are more expensive, and the limited availability of sustainable product options in the market (Gao et al., 2023a; Mittal & Raman, 2022).

Therefore, fostering linkages between MSMEs and large enterprises represents a pivotal strategy to support the green transition. These linkages can facilitate the accelerated adoption of green business models by providing MSMEs with access to green technology, technical support, innovative financing mechanisms, and expanded market opportunities (Loo

et al., 2023; Tatik & Setiawan, 2025). Strengthening these collaborations not only enhances the competitiveness of MSMEs but also contributes to the development of inclusive and resilient industrial supply chains that adhere to global sustainability standards.

For large industry players, establishing linkages with green MSMEs offers substantial strategic benefits. Beyond improving efficiency and productivity through stable supply, these linkages mitigate supply chain risks and support long-term sustainability initiatives (Kristanto & Kurniawati, 2025). Furthermore, large companies accrue social advantages, including an enhanced reputation and contributions to local economic development (Latifah et al., 2020). Such collaborations serve to strengthen regional economic resilience by generating added value and promoting a more equitable distribution of benefits.

Concurrently, for MSMEs, participation in these linkages provides access to technical assistance, managerial capacity building, and expanded marketing and distribution networks (Kustiningsih et al., 2022; Maina et al., 2024). These collaborations augment MSMEs' capacity to meet industry standards, adapt to market dynamics, and drive innovation in the development of green products and processes. With support from large industry players, green MSMEs are better positioned to upgrade their operations and integrate into a more competitive and sustainable economic system.

Moreover, linkages between MSMEs and large industries contribute significantly to the achievement of the Sustainable Development Goals (SDGs) (Verma & Nema, 2019). These linkages promote inclusive economic growth and the creation of decent employment opportunities, consistent with SDG 8. By encouraging responsible production and consumption practices, they also support the realization of SDG 12. Additionally, cooperation between large enterprises and MSMEs reflects the principles of SDG 17, which underscores the importance of cross-sectoral linkages in advancing inclusive, sustainable, and participatory development objectives.

The government's commitment to promoting linkages between Micro, Small, and Medium Enterprises (MSMEs) and large industries has been demonstrated through various hierarchical and integrated regulations. On January 18, 2021, the President of the Republic of Indonesia explicitly emphasized the importance of MSME linkages with large industries as a strategic endeavor to integrate MSMEs into the global value chain and create opportunities for business upgrading. This directive was further reinforced through Law Number 6 of 2023, Article 90, which stipulates the ratification of Government Regulation in Lieu of Law Number 2 of 2022 on Job Creation. The regulation mandates that both central and regional governments facilitate, support, and promote partnership activities between large industries and cooperatives, micro-enterprises, and small enterprises. The primary objective is to enhance the competence and competitiveness of MSMEs, thereby enabling them to access broader markets.

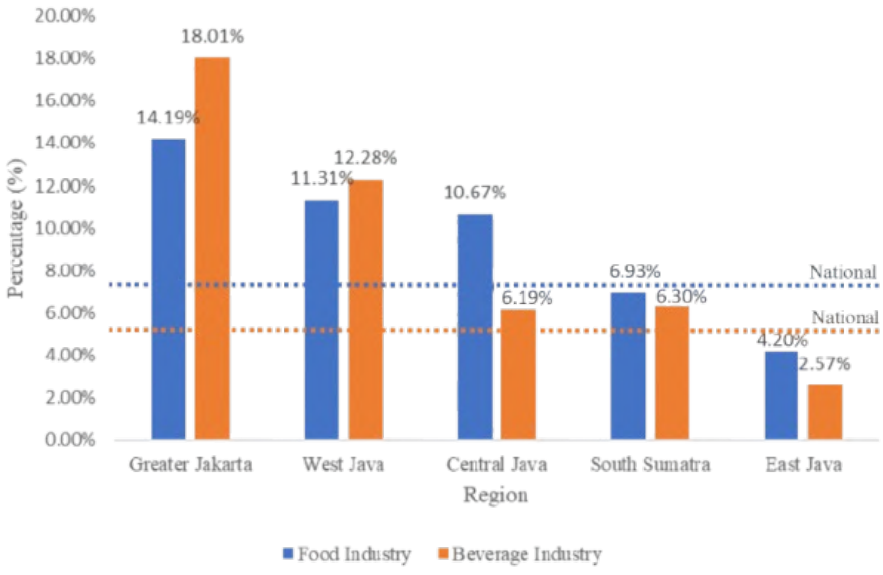
Supporting policies are also evident within the framework of government regulations. Article 118, paragraph 1 of Government Regulation No. 7 of 2021 concerning the Ease, Protection, and Empowerment of Cooperatives and Micro, Small, and Medium Enterprises (MSMEs) explicitly mandates that large enterprises establish linkages with MSMEs, while medium-sized enterprises are obligated to collaborate with micro and small businesses. At the technical level, the Regulation of the Minister of Investment and Head of the Investment Coordinating Board (BKPM) Number 1 of 2022 serves as an implementation guideline for partnership arrangements within the investment sector. This regulation specifies the procedures for establishing linkages between large enterprises and MSMEs at the regional level, including the requirements for reporting, monitoring, and evaluation that must be fulfilled by both investors and local governments. In addition, Presidential Decree Number 11 of 2021 on the Investment Acceleration Task Force (*Badan Koordinasi Penanaman Modal*) further reinforces this policy framework. Article 4, letter d of the decree assigns the task force the responsibility of expediting cooperation between investors and MSMEs. This initiative

constitutes a strategic measure aimed at fostering inclusive investment while simultaneously empowering local businesses.

The comprehensive and cross-sectoral regulatory framework highlights the crucial role of linkages between micro, small, and medium-sized enterprises (MSMEs) and large industries. The existing regulations that mandate and promote these linkages provide a strategic basis for reinforcing cross-scale business integration, facilitating the transition of MSMEs toward environmentally sustainable operations, and advancing the broader objective of resilient, sustainable, and inclusive national economic development.

This study focuses specifically on the food and beverage sector, given its contribution to both national and regional economic structures. In many regions, including East Java, the food and beverage sector remains one of the most prominent business domains due to its accessibility, relatively low entry barriers, and stable market demand. Nevertheless, despite its considerable potential, data from the Fiscal Policy Agency (2024) indicate that the level of MSME engagement in formal linkages arrangements remains limited, particularly within East Java Province.

According to Fiscal Policy Agency, (2024), only 4.20 percent of MSMEs in East Java have established formal linkages, with the beverage sector accounting for just 2.57 percent. These figures are considerably lower compared to several other provinces. In West Java, the percentages reach 11.31 percent for the food sector and 12.28 percent for the beverage sector. Central Java records 10.67 percent and 6.19 percent, respectively, while DKI Jakarta reports 14.19 percent and 18.01 percent. In South Sumatra, the corresponding figures are 6.39 percent for food and 9.52 percent for beverages. Even when compared to the national averages of 7.85 percent for the food sector and 5.23 percent for the beverage sector, East Java remains below the national benchmark (see Figure 3).



Source: Bank Indonesia (2024)

Figure 3: The Contribution of the MSMEs Sector to GRDP of East Java

This indicates the low level of linkages in the food and beverage MSME sector in East Java compared to neighboring provinces. Therefore, research on this sector is essential to identify existing barriers and to develop appropriate solutions for strengthening linkages. Enhancing these linkages may serve as a strategic lever to facilitate the transformation of MSMEs toward a more inclusive and sustainable green economy.

This research is motivated by the limited number of studies on green MSMEs in Indonesia, particularly those examining linkages with large industries in the food and beverage

sector. Most existing studies have focused on MSMEs in general without examining in depth the environmentally sustainable practices that some small businesses have begun to adopt (Latifah et al., 2020; Loo et al., 2023; Primandaru et al., 2023). Promoting a green economy requires identifying the barriers faced by micro, small, and medium-sized enterprises (MSMEs) and developing solutions that support the adoption of sustainable business practices. A region-specific approach to MSME development is necessary, as MSMEs exhibit diverse characteristics and encounter distinct challenges across different regions.

This study also addresses the methodological limitations present in previous research, which has often relied on descriptive quantitative approaches without developing systematic prioritization of problems or formulation of solutions (Salim et al., 2024; Sobar, 2025; Ulfah et al., 2024). To overcome these limitations, this research employs two multi-criteria decision-making methods: the Analytic Hierarchy Process (AHP) and Grey-TOPSIS. The AHP method is applied to identify and prioritize barriers to linkages between green MSMEs and large enterprises, as it allows complex problems to be structured into a hierarchical framework that facilitates scalable analysis. Grey-TOPSIS is then used to rank alternative solutions based on their proximity to ideal conditions while incorporating uncertainty in the evaluation process through grey logic. This study combines the Analytic Hierarchy Process (AHP) and Grey-TOPSIS to provide a multi-criteria decision-making framework that not only ranks the importance of identified barriers but also evaluates the relative effectiveness of multiple policy alternatives. The objectives of this study are: (1) to identify barriers affecting the establishment of linkages between green MSMEs and large industries in the food and beverage sector in East Java; (2) to prioritize these barriers based on their urgency and impact; and (3) to formulate optimal solutions for strengthening sustainable linkages between MSMEs and large industries.

This research provides both theoretical and practical contributions by addressing methodological and contextual gaps in the existing literature. From a theoretical perspective, it contributes more than just a new approach by demonstrating how the integration of the Analytic Hierarchy Process (AHP) and Grey-TOPSIS offers a structured and scalable decision-making framework. Unlike prior studies that rely heavily on descriptive analysis (Gudeta & Tulu, 2022; Gupta & Nanda, 2015), this framework allows for systematic prioritization of complex barriers and comparative evaluation of policy alternatives. It also introduces a focused analytical perspective by shifting attention from general MSME challenges to specific issues affecting green MSMEs in building linkages with large industries in the food and beverage sector.

From a practical perspective, this is the first study to apply the combined AHP and Grey-TOPSIS methods in East Java to design targeted policy strategies that support sustainable industrial linkages. In contrast to research that adopts a broad national perspective (Sari & Kusumawati, 2022; Utama et al., 2024), this study emphasizes local specificity and incorporates insights from green MSME actors, government officials, and industry stakeholders. As a result, the findings are both actionable and grounded in local realities, offering relevant guidance for regional policymakers pursuing inclusive and sustainable economic development.

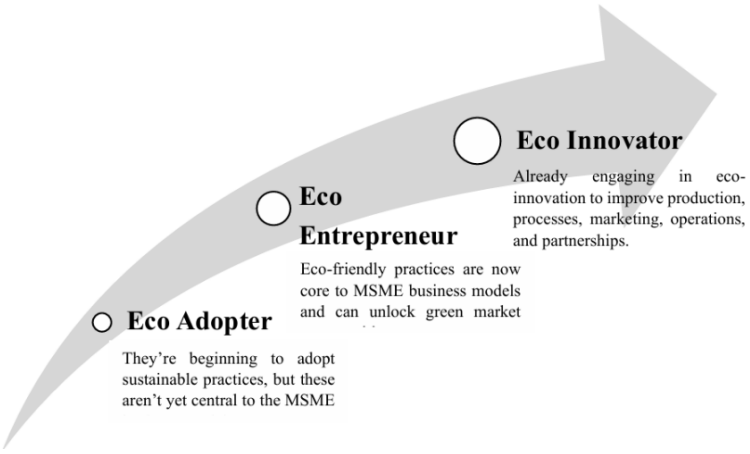
Literature Review

Concept of Green MSMEs

Bank Indonesia (2024) defines green MSMEs as enterprises that incorporate green processes and green outputs into their business models, aligning with circular economy principles to achieve economic, social, and environmental goals. This definition differs slightly from that of the OECD, which defines green MSMEs as those contributing to the protection of the climate, environment, and biodiversity through their products, services, and business practices (Koirala, 2019).

Bank Indonesia's Green MSME business model is predicated on the integration of green practices throughout the value chain, drawing upon the OECD concept (Koirala, 2019).

These practices are categorized into three developmental stages: (i) Eco-adopter, (ii) Eco-entrepreneur, and (iii) Eco-innovator, as delineated in Figure 4. The classification of each MSME is contingent upon green indicators across three primary dimensions: (i) production, (ii) human resources, and (iii) finance. These indicators are further bifurcated into mandatory and complementary categories.



Source: Bank Indonesia (2024)

Figure 4: Roadmap of Green MSMEs Business Model Development Stages

Within the production aspect of green MSMEs, specific mandatory indicators are applicable at each stage of development. At the initial Eco-adopter stage, MSMEs are required to satisfy one mandatory indicator pertaining to waste management. Progression to the subsequent Eco-entrepreneur stage necessitates fulfillment of six additional mandatory indicators. To attain the final Eco-innovator stage, MSMEs must meet two further mandatory indicators, which encompass the utilization of renewable energy sources and the possession of Intellectual Property Rights for their organic products.

Regarding the production aspect, one complementary indicator, waste management, is applicable across all stages. The detailed criteria for the nine indicators of the production aspect are presented in Table 1.

Table 1: Indicators and Criteria for the Production Aspect of Green MSMEs

No.	Indicator	Eco-Adapter	Eco-Entrepreneur	Eco-Innovator	Description
1	Agricultural Inputs: a. Land b. Seeds c. Fertilizer d. Integrated Pest Management (IPM)	In organic conversion phase (at minimum, land and fertilizer aspects).	Has implemented Good Agricultural Practices (GAP) according to established standards.	Organic cultivation has been implemented and certified both nationally (SNI 6729:2016) and internationally.	Mandatory for Eco-Entrepreneur and Eco-Innovator.
2	Post-harvest Handling	Has not conducted post-harvest handling.	Has conducted a minimum of 2 post-harvest handling practices.	Conducts more than two post-harvest handling practices.	Mandatory for Eco-Entrepreneur and Eco-Innovator.
3	Energy Source	Uses fossil fuels with efforts to explore renewable energy alternatives.	Combines fossil fuels and renewable energy sources.	Primarily uses renewable energy sources (more than 50 percent).	Mandatory at the Eco-Innovator stage.

No.	Indicator	Eco-Adapter	Eco-Entrepreneur	Eco-Innovator	Description
4	Production of by-products, derivatives, and/ or value-added products	Has plans to produce by-products, derivatives, and/ or value-added products.	Produces at least one by-product, derivative, and/ or value-added product.	Produces more than one by-product, derivative, and/or value-added product.	Mandatory at the Eco-Entrepreneur and Eco-Innovator stages.
5	Waste Management	At least 20 percent of production waste is managed.	20 percent to 50 percent of production waste is managed.	More than 50 percent of production waste is managed, with some reused in the production process.	Mandatory at all stages.
6	Digitalization of Production Process	No use of digital technology in the production process.	Uses at least one digital tool in the production process.	Uses more than one digital tool in the production process.	Mandatory at the Eco-Entrepreneur and Eco-Innovator stages.
7	Green Standard Operating Procedures (SOPs)	No formal green SOP document, but green practices are applied.	Has and implements a green SOP document.	Has and implements a green SOP document with monitoring or quality control mechanisms.	Mandatory at the Eco-Entrepreneur and Eco-Innovator stages.
8	Intellectual Property Rights (IPR) Ownership	Does not hold any IPR.	Holds at least one IPR.	Holds at least one IPR.	Mandatory at the Eco-Innovator stage.
9	Innovation to Reduce Environmental Impact	Adopts existing eco-friendly innovations.	Modifies innovations developed by others.	Develops original innovations.	Complementary at all stages.

Source: Bank Indonesia (2024)

In the human resources aspect, Green MSMEs are required to meet two mandatory indicators at all stages. These include motivation to implement environmentally friendly business practices and gender representation. In addition, three complementary indicators apply across all stages: training on environmentally friendly business practices, empowerment of individuals with physical limitations, and the origin of labor. A detailed explanation of these five indicators and their corresponding criteria for each stage of Green MSMEs, focusing on the human resources aspect, is presented in Table 2.

Table 2: Indicators and Criteria for the Human Resource Aspects of Green MSMEs

No.	Indicator	Eco-Adapter	Eco-Entrepreneur	Eco-Innovator	Description
1	Motivation for Implementing Environmentally Friendly MSMEs	Motivation stems from external encouragement (not self-initiated)	Motivation is driven by market demand and/or the opportunity to obtain better pricing	Motivation is driven by market demand, the opportunity to obtain better pricing, and awareness of environmental sustainability	Mandatory at all stages
2	Training on Environmentally Friendly MSMEs	Participates when training is externally facilitated	Participates independently	Acts as a speaker or instructor	Complementary at all stages
3	Origin of Labor	All workers come from within the family	Some workers come from within the family	The majority of workers (more than 50 percent) come from outside the family	Complementary at all stages

No.	Indicator	Eco-Adapter	Eco-Entrepreneur	Eco-Innovator	Description
4	Empowerment of Individuals with Physical Limitations	Provides equal opportunities for individuals with physical limitations in recruitment as casual workers	Provides equal opportunities for individuals with physical limitations in recruitment as permanent workers	Provides equal opportunities for individuals with physical limitations in recruitment for administrative or management roles	Complementary at all stages
5	Gender	Provides equal opportunities for women in recruitment	Employs women as workers or laborers	Employs women in roles beyond labor, such as administrative or managerial positions	Mandatory at all stages

Source: Bank Indonesia (2024)

In the financial aspect, Green MSMEs are required to meet several mandatory indicators that demonstrate a commitment to sustainable financial practices. At the initial stage, the Eco-Adopter must meet two mandatory indicators. The first is environmental cost allocation, which refers to the specific costs that a business allocates to manage the environmental impact of its production process. Second, business actors are required to record financial transactions in accordance with Micro, Small, and Medium Enterprise (MSME) standards. This includes preparing reports such as balance sheets, income statements, and cash flow statements, which serve to demonstrate the level of health and financial transparency of MSMEs. The five indicators and criteria related to financial aspects for each stage of Green MSMEs in the food and beverage sector can be further reviewed in Table 3.

Table 3: Indicators and Criteria for the Financial Aspects of Green MSMEs

No.	Indicator	Eco-Adapter	Eco-Entrepreneur	Eco-Innovator	Description
1	Financing Received	Has received funding from CSR programs and/ or government budget allocations	Has received financing from banking and non-banking financial institutions	Has received financing from banking and non-banking financial institutions as well as from investors	Complementary at all stages
2	Environmental Cost Allocation	Has allocated funds for managing internal production waste	Has allocated funds for managing production waste in the surrounding environment (possibly as part of CSR)	Has allocated funds for managing production waste in the surrounding environment (possibly as part of CSR)	Mandatory at all stages
3	Sustainability Report	Not yet available	Has developed components covering economic, social, and environmental performance	Has completed a full sustainability report	Mandatory at the Eco-Innovator stage
4	Financial Reporting	Records at least basic financial transactions such as cash inflows and outflows	Prepares basic financial statements such as a balance sheet and income statement, though not yet fully aligned with MSME standards	Prepares financial statements in full compliance with MSME standards.	Mandatory at all stages.
5	Digital Transactions/ Payment Methods	Utilizes digital payments for less than 20 percent of transactions.	Utilizes digital payments for 20 to 50 percent of transactions.	Utilizes digital payments for more than 50 percent of transactions.	Complementary at all stages.

Source: Bank Indonesia (2024)

Research Methodology

Data

This study draws on original primary data collected through field-based focus group discussions (FGDs) and structured AHP questionnaires. The objective is to empirically identify the most pressing barriers and evaluate effective policy strategies for strengthening linkages between large industries and green MSMEs in East Java's food and beverage sector. The analysis emphasizes firsthand insights from key stakeholders, particularly green MSMEs, large firms, and public institutions, providing grounded perspectives that are often absent in secondary datasets. A total of eight stakeholders participated in the FGDs, representing: (i) three green MSMEs (Mrs. Y, Mr. A, and Mr. S), (ii) two large industries (PT BR and PT S), (iii) two local government officials from the Department of Cooperatives and MSMEs of East Java Province and the Department of Industry and Trade of East Java Province, and (iv) one representative from Bank Jatim with expertise in MSME financing. Among them, six participants (Mrs. Y, Mr. A, Mr. S, PT BR, the Cooperative Department, and Bank Jatim) also completed the FGD and AHP questionnaire, while the remaining two (PT S and the Industry Department) contributed qualitative input through FGDs only.

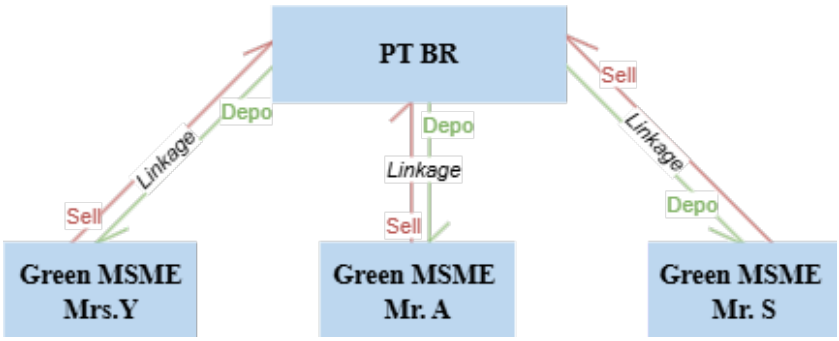


Figure 5: Linkage Map Between PT BR and Selected Green MSMEs in East Java

The selection of PT BR as a representative large-scale firm is based on its position as one of Indonesia's most prominent and internationally recognized food and beverage franchises. The company has implemented a range of environmentally responsible practices, particularly those aligned with the principles of reduce, reuse, and recycle (3R), making it a relevant case for analyzing green linkage formation.

The three MSMEs were selected based on their classification as eco-adopters, particularly due to their compliance with minimum green standards such as waste separation and basic environmental responsibility (see Section II.A). Field observations and supporting documentation confirmed these baseline practices, which qualify them as representative early-stage green MSMEs. Green MSME Mrs. Y is a sole proprietorship based in Sidoarjo specializing in the distribution of fresh vegetables. She maintains active linkages with multiple large-scale food and beverage industries, including PT BR, and currently employs four workers, two in logistics and two in sorting operations. Mr. A operates as a vegetable distributor in Malang, sourcing directly from farmers in Tumpang, Tlogomas, and Karang Ploso. His business is supported by one employee for sorting, while distribution relies on third-party logistics. Mr. S, on the other hand, is a smallholder vegetable farmer based in Karang Ploso, cultivating lettuce, pakcoy, broccoli, and cauliflower. He supplies directly to PT BR as well as to modern retail outlets such as Hypermart. Mr. S runs a self-managed operation with the help of two agricultural workers.

In addition to qualitative input, participants completed a structured Saaty-scale questionnaire using a 1–9 rating scale to assess the relative importance of both linkage major barriers and policy alternatives. Individual judgments were aggregated using the geometric

mean method, following established AHP and TOPSIS procedures (Hwang & Yoon, 1981; Saaty, 1990). The eight key major barriers adopted in this study reflect the most frequently mentioned obstacles to MSME development in East Java, as identified in the 2022 publication of the Ministry of Cooperatives and SMEs, feedback from local stakeholders, and prior studies. These include capital access, competitiveness, raw materials, marketing, labor, technology, infrastructure and logistics, and legality.

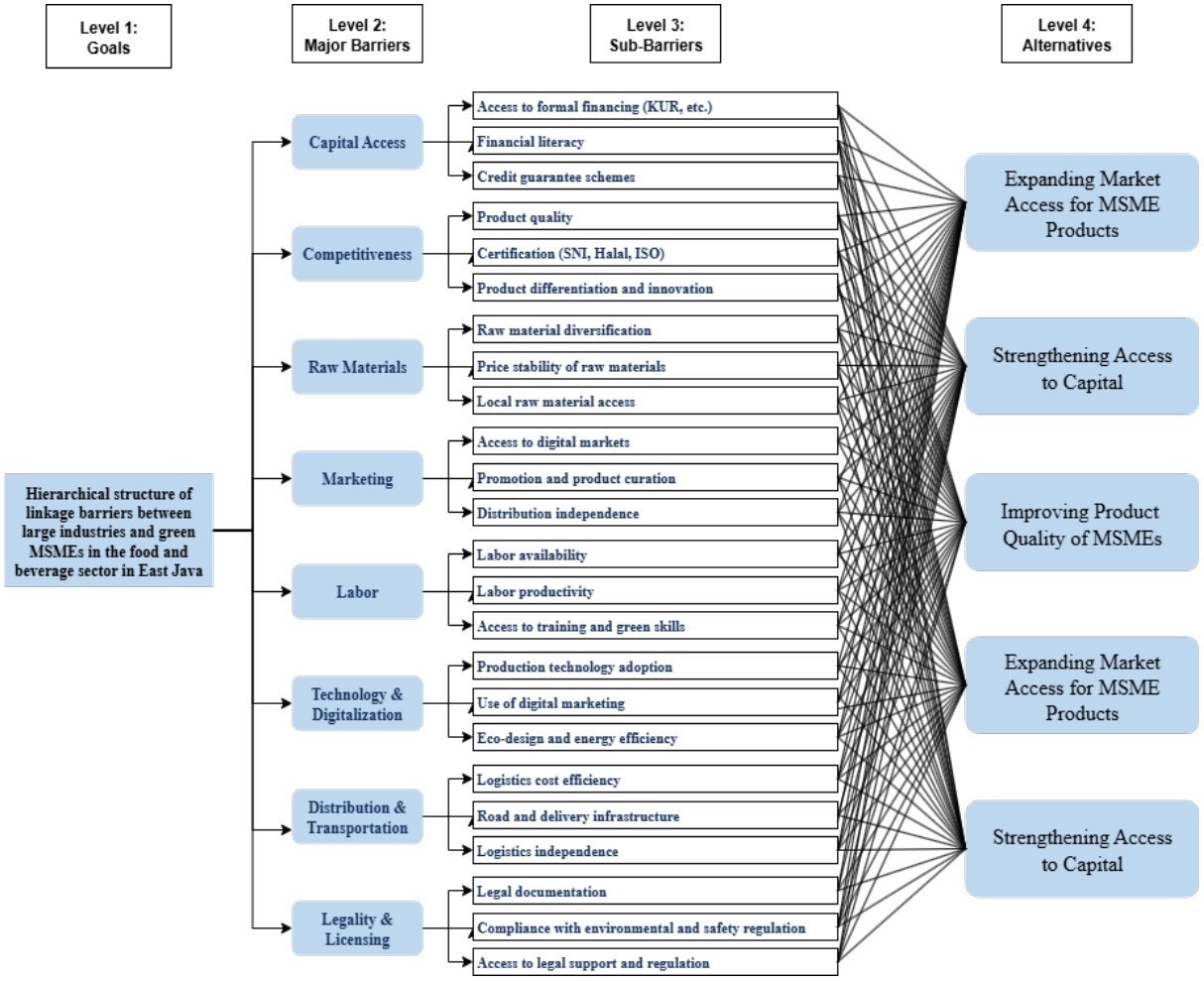


Figure 6: Hierarchical Structure of Linkage Barriers Between Large Industries and Green MSMEs in the Food and Beverage Sector in East Java

The 24 sub-barriers were developed through a triangulation of literature review, field observations, and stakeholder input from FGDs. Each sub-barrier captures a specific operational or institutional obstacle relevant to the linkage process, for instance, “financial literacy” under capital access or “certification” under competitiveness. While there is no single national standard for such sub-barriers, the ones included here represent recurring themes that emerged across sources and are highly contextual to the East Java green MSME landscape.

The five policy alternatives (A1–A5) evaluated in this study correspond to the five core development domains prioritized by the East Java Provincial Cooperative Agency: (i) institutional strengthening, (ii) human resource development, (iii) product improvement, (iv) market access expansion, and (v) financing support. The goal was to determine which of these policy focus areas, if addressed first, would most effectively strengthen MSME–industry linkages within a green economic framework.

Table 4: Summary of Barriers and Sub-Barriers Affecting Green MSME–Industry Linkages

Code	Major Barriers	Code	Sub-Barriers	Reference
CA	Capital Access	CA1	Access to formal financing (KUR, etc.)	Mittal & Raman (2022)
		CA2	Financial literacy	Kumar et al. (2025)
		CA3	Credit guarantee schemes	Adhikary et al. (2021)
CP	Competitiveness	CP1	Product quality	Hanggraeni & Sinamo (2021)
		CP2	Certification (SNI, Halal, ISO)	Ardiantono et al. (2024)
		CP3	Product differentiation and innovation	Latifah et al. (2020)
RM	Raw Materials	RM1	Raw material diversification	Yunus et al. (2025)
		RM2	Price stability of raw materials	Ariani et al. (2023)
		RM3	Local raw material access	Kristanto & Kurniawati (2025)
MK	Marketing	MK1	Access to digital markets	Gao et al. (2023)
		MK2	Promotion and product curation	Amoa-Gyarteng et al. (2024)
		MK3	Distribution independence	Purnomo et al. (2022)
LB	Labor	LB1	Labor availability	Wibiseno & Usman (2021)
		LB2	Labor productivity	Kumarasamy et al. (2024)
		LB3	Access to training and green skills	Pangarso et al. (2022)
TD	Technology & Digitalization	TD1	Production technology adoption	Loo et al. (2023)
		TD2	Use of digital marketing	Tatik & Setiawan (2025)
		TD3	Eco-design and energy efficiency	Prashar (2019)
DT	Distribution & Transport	DT1	Logistics cost efficiency	Wong et al. (2015)
		DT2	Road and delivery infrastructure	Sindhwani et al. (2023)
		DT3	Logistics independence	Marjan et al., (2022)
LG	Legality & Licensing	LG1	Legal documentation	Mishra & Kushwaha, (2023)
		LG2	Compliance with environmental and safety regulation	Sendawula et al. (2024)
		LG3	Access to legal support and regulation	Padilla-Angulo et al. (2023)

Methodology

This study employs a three-level multi-criteria decision-making (MCDM) framework to analyze the barriers and evaluate policy alternatives for enhancing industrial linkages between green MSMEs and large firms. As shown in Figure 7, the methodology integrates the Analytic Hierarchy Process (AHP) and Grey-TOPSIS (G-TOPSIS) in a sequential structure consisting of three main stages: (i) problem structuring and data collection, (ii) derivation of sub-barrier weights using AHP, and (iii) evaluation of policy alternatives using G-TOPSIS.

Initially, qualitative insights were gathered through focus group discussions (FGDs) involving green MSME actors, industry representatives, government officials, and financial institutions. These FGDs served to identify eight primary barriers and 24 sub-barriers pertinent to MSME–industry linkages within East Java's food and beverage sector. The identified barriers and sub-barriers were subsequently validated through a comprehensive literature review and field documentation. Based on regional MSME empowerment priorities, five policy alternatives (A1–A5) were formulated. The second and third stages of the methodology involved quantitative analysis employing the Analytic Hierarchy Process (AHP) and Generalized Technique for Order Preference by Similarity to Ideal Solution (G-TOPSIS). AHP was utilized to derive global weights for all sub-barriers via structured pairwise comparisons, with consistency ensured through the Consistency Ratio (CR). These derived weights were then integrated into the G-TOPSIS framework to evaluate and rank the five policy options based on stakeholder assessments across all 24 sub-barriers.

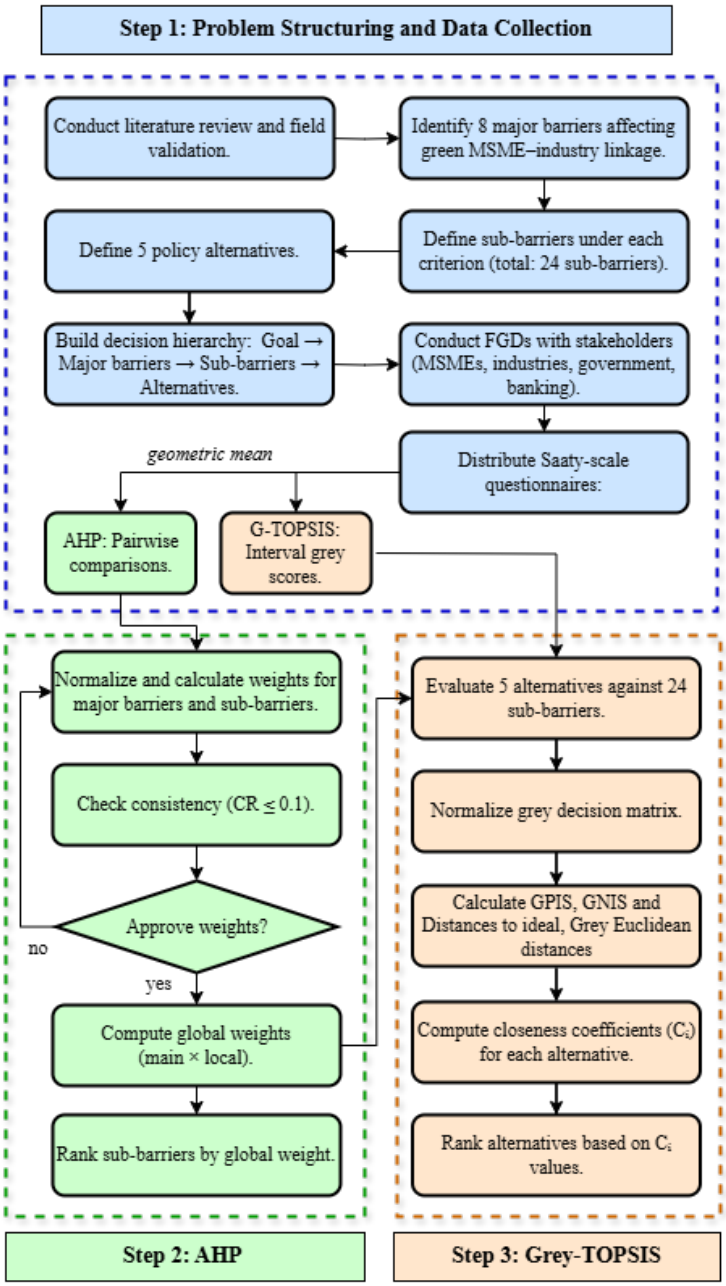


Figure 7: Research Framework

The Analytic Hierarchy Process (AHP), developed by Saaty (1990), was employed to quantify the relative importance of factors influencing linkage formation. A three-level hierarchy was constructed: the overarching goal at the apex, eight major barriers at the second level, and 24 sub-barriers at the third level. Pairwise comparisons were conducted using Saaty's 1–9 scale, with inputs solicited from seven respondents, including green MSME owners, representatives from large firms, and officials from public and financial institutions. Their judgments were aggregated using the geometric mean, consistent with standard AHP procedures for group decision-making.

Table 5: Saaty Pairwise Comparison Scale

Definition	Intensity of Importance
Equally important	1
Moderately more important	3
Strongly more important	5

Definition	Intensity of Importance
Very strongly more important	7
Extremely more important	9
Intermediate values	2, 4, 6, 8

Note: This scale was utilized by participants in the AHP pairwise comparison to express the relative importance of one barrier over another. The 1–9 scale adheres to Saaty (1990), where higher values denote a stronger preference.

To enhance the credibility of AHP responses, informants were purposively selected from stakeholders directly involved in the linkage process, comprising three green MSME owners, two large firms, two government agencies, and one financial institution. These respondents were deemed qualified due to their representation of the actual actors making strategic and operational decisions in linkage formation. To mitigate the perception of their judgments as mere personal opinions, the pairwise comparisons were cross-referenced with findings from FGDs and supporting literature. The AHP consistency test was also applied, and all matrices satisfied the threshold (CR ≤ 0.1), thereby indicating the coherence and reliability of the judgments. In instances where inconsistencies emerged during FGDs, participants were invited to review their responses to improve clarity. Furthermore, the aggregation of individual judgments was conducted using the geometric mean, which minimizes the influence of individual bias and is recognized as a standard procedure in group AHP analysis (Forman & Peniwati, 1998). Similar methodological approaches have been applied in (Batool et al., 2023) for energy policy evaluation and for MSME technology adoption (Loo et al., 2023), confirming that expert-based AHP with consistency checks constitutes a robust and widely accepted method for prioritizing barriers and policy alternatives.

The details of institutions and individuals who participated in the FGDs and AHP survey are summarized in Table 6.

Table 6: List of FGD Participants in East Java

No	Organization	Location	Notes
1	Green MSME A	Sidoarjo	FGD and questionnaire
2	Green MSME B	Malang	FGD and questionnaire
3	Green MSME C	Karangploso, Malang	FGD and questionnaire
4	PT BR	Malang	FGD and questionnaire
5	PT S	Surabaya	FGD
6	Department of Cooperatives and Small and Medium Enterprises of East Java	Surabaya	FGD and questionnaire
7	Department of Industry and Trade of East Java	Surabaya	FGD
8	Bank Jatim (MSME Finance)	Surabaya	FGD and questionnaire

Note: Respondents are anonymized for confidentiality purposes. All participants are directly involved in MSME–industry linkage activities within the food and beverage sector, with some participating in both the FGD and AHP questionnaire.

The AHP process involved the following calculation steps:

Stage 1: Participants compared each barrier (and subsequently each sub-barrier) against the others in its group. These pairwise comparisons resulted in a reciprocal matrix:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}, where\ a_{ij} = \frac{1}{a_{ji}}, a_{ii} = 1 \quad (1)$$

Stage 2: Each element in the matrix was normalized by dividing it by the sum of its column:

$$n_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (2)$$

Stage 3: The local weight of each element was obtained by taking the average of each row in the normalized matrix:

$$w_i = \frac{1}{n}\sum_{j=1}^{n} n_{ij} \quad (3)$$

Stage 4: To ensure the consistency of the pairwise judgments, the principal eigenvalue $\lambda_{\max}$ was approximated from the weighted sum vector, the consistency index (CI) and consistency ratio (CR) were then calculated:

$$CI = \frac{\lambda_{\max} - n}{n-1}, CR = \frac{CI}{RI} \quad (4)$$

Where RI is the Random Index based on the matrix size. The matrix was considered consistent if $CR \leq 1$.

Stage 5: To reflect the overall influence of each sub-barrier, global weights were calculated by multiplying the local weight of a sub-barrier by the local weight of its parent barrier:

$$Global\ Weight_i = Main\ Criterion\ Weight_j \times Local\ Weight_i \quad (5)$$

The resulting global weights represent the composite influence of each sub-barrier in determining the strength of MSME–industry linkages. These values served as weighted inputs in the subsequent G-TOPSIS analysis.

The second stage of analysis employed the Grey-TOPSIS (G-TOPSIS) method to evaluate five policy alternatives (A1–A5) in addressing the most critical sub-barriers to green MSME–industry linkages. G-TOPSIS combines grey system theory with TOPSIS to support decision-making under uncertainty, allowing the use of interval data to capture subjective judgments, particularly from MSME practitioners and stakeholders (Batool et al., 2023). Each alternative was assessed against the 24 sub-barriers using interval scores (L, U) derived from FGDs, forming a Grey Decision Matrix. These scores were normalized, then weighted using AHP-derived global weights to reflect both perceived effectiveness and relative importance. A five-level linguistic scale was used to guide participant evaluations during FGDs (see Table 6).

Table 7: Linguistic Scale for Scoring Policy Effectiveness

Definition	L	U
Not helpful at all	1	2
Slightly helpful	3	4
Moderately helpful	5	6
Very helpful	7	8
Highly significant and transformative	9	9

Note: The table presents the five-level linguistic scale used by participants during FGDs to evaluate the effectiveness of each policy alternative. L and U denote the lower and upper bounds of the interval scores applied in the Grey-TOPSIS analysis.

To ensure comparability across barriers, the scores were normalized using a benefit-type transformation. The analytical process was conducted as follows:

Stage 1: Each alternative was evaluated against each sub-barriers C_j, resulting in a grey interval score $[L_{ij}, U_{ij}]$. These formed the grey decision matrix $X = [x_{ij}]$ with $x_{ij} = [L_{ij}, U_{ij}]$.

Stage 2: Since all sub-barriers are benefit-oriented, normalization was performed as:

$$L_{ij}^{*} = \frac{L_{ij}}{\max(U_{ij})}\ 'U_{ij}^{*} = \frac{U_{ij}}{\max(U_{ij})} \quad (6)$$

where $\max(U_{ij})$ is the highest upper bound observed across alternatives for sub-barriers j.

Stage 3: The normalized grey values were weighted by the global AHP-derived weight w_j producing the weighted normalized matrix:

$$v_{ij} = [w_j \times L_{ij}^{*}, w_j \times U_{ij}^{*}] \tag{7}$$

This step ensures that more influential sub-barriers exert greater impact on the final rankings.

Stage 4: The Grey Positive Ideal Solution (GPIS) and Grey Negative Ideal Solution (GNIS) represent the best and worst possible performance values across alternatives. For each sub-barriers, they are defined as:

$$A_j^{+} = [\max(v_{ij}^{L}), \max(v_{ij}^{U})], A_j^{-} = [\min(v_{ij}^{L}), \min(v_{ij}^{U})] \tag{8}$$

Stage 5: The grey Euclidean distances of each alternative from both GPIS and GNIS were computed:

$$D_i^{+} = \sqrt{\sum_{j=1}^{n} (v_{ij}^{L} - A_j^{+L})^2 + (v_{ij}^{U} - A_j^{+U})^2}\,; \quad D_i^{-} = \sqrt{\sum_{j=1}^{n} (v_{ij}^{L} - A_j^{-L})^2 + (v_{ij}^{U} - A_j^{-U})^2} \tag{9}$$

Stage 6: The final closeness coefficient CC_i of each alternative was calculated as:

$$CC_i = \frac{D_i^{-}}{D_i^{+} + D_i^{-}} \tag{10}$$

A higher CC_i value indicates greater proximity to the ideal solution and thus a more favorable policy option. The alternatives were ranked accordingly based on their respective CC_i values.

Results and Findings

The Analytic Hierarchy Process (AHP) was applied to assess the relative importance of barriers affecting the linkage between large industries and green MSMEs in East Java. The model comprised eight major barriers and 24 associated sub-barriers. Final weights were derived through geometric mean aggregation of pairwise comparisons, with consistency ratios maintained below the acceptable threshold (CR ≤ 0.1). Global weights were obtained by multiplying each sub-barrier's local weight with the corresponding major barrier's weight.

Ranking of Major Barriers

The Analytic Hierarchy Process (AHP) was used to rank eight major barriers affecting the linkage between green MSMEs and large industries in East Java's food and beverage sector. The pairwise comparison matrix was consistent (CR = 0.068).

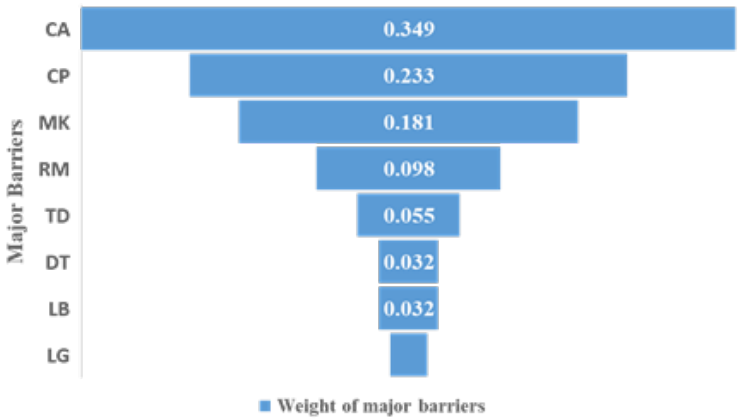


Figure 8: Ranking of Major Barriers

The AHP analysis identified the top barriers hindering linkage formation between green MSMEs and large industries in East Java. As shown in Figure 8, Capital Access (CA) emerged as the most critical barrier (weight = 0.349), highlighting persistent financing constraints. Many

MSMEs operate informally, lack collateral, and find it difficult to access formal credit, despite existing schemes such as People's Business Credit (KUR) or *Program Kredit Sejahtera* (Prokesra). Although these programs aim to support small enterprises, their uptake remains limited due to bureaucratic procedures and outreach gaps. Competitiveness (CP) ranks second (0.233), indicating that MSMEs often struggle to meet product quality standards and certification requirements expected by large buyers. Market Access (MK) follows (0.181), reflecting issues around branding, digital visibility, and inconsistent participation in promotional channels. Other barriers such as Raw Materials (RM), Technology and Digitalization (TD), and Distribution and Transport (DT) hold moderate weights, pointing to structural constraints in input procurement and delivery systems. Labor (LB) and Legality (LG) were considered less urgent, although still relevant as enabling conditions for long-term integration. These results align with previous studies. Financing constraints as the top barrier reflect similar evidence from (Mittal & Raman, 2022) while competitiveness issues correspond to (Hanggraeni & Sinamo, 2021) and who highlight product quality as central to MSME performance. Likewise, marketing challenges resonate with (Gao et al., 2023a), who found that limited digital adoption constrains MSME competitiveness. Technology and digitalization barriers identified in this study are also consistent with findings by (Loo et al., 2023), which confirm low levels of technology upgrading among Southeast Asian MSMEs.

Ranking of Sub-Barriers

Pairwise comparison matrices were developed for each group of sub-barriers under the eight major barriers. Each matrix was constructed using aggregated judgments from experts and practitioners, and normalized to derive local weights. All consistency ratios (CR) were below 0.1, indicating acceptable reliability. The following sections describe the priority sub-barriers for each category based on local and global weights.

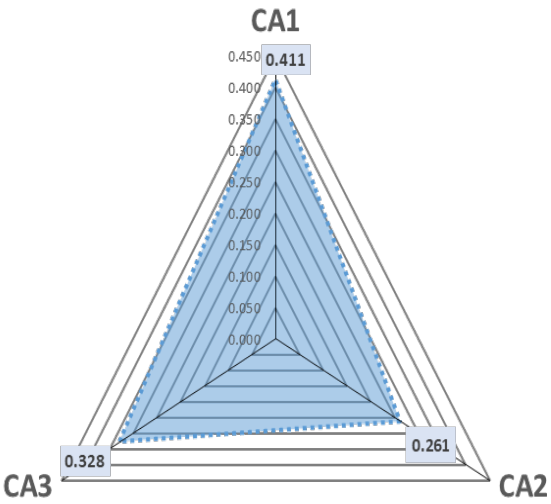


Figure 9: Ranking of Sub-Barriers Under Capital Access Barriers

The prioritization of sub-barriers within the Capital Access (CA) category is structured as follows: CA1 > CA3 > CA2 (refer to Figure 9). The primary sub-barrier, CA1 (Access to formal financing), exhibits a local weight of 0.411 and a global weight of 0.144, thereby establishing it as the most critical sub-barrier overall. A significant proportion of agricultural MSMEs encounter difficulties in securing bank financing, primarily attributable to their informal operational status, insufficient collateral, and irregular seasonal income. A respondent articulated this challenge, stating, "We attempted to apply for KUR but were rejected due to the absence of a guarantee or clear legal status." While financing initiatives such as KUR and Dana Bergulir are available, their adoption rates remain low, particularly in rural areas characterized by a paucity of legal documentation and limited outreach efforts. As of 2024, the MSME credit ratio stood at 31.5 percent, which underscores persistent exclusion from formal

credit mechanisms. Although some local governments implement subsidized programs like Prokesra, their coverage remains constrained. This finding is consistent with Mittal & Raman (2022) who emphasize that financing gaps persist as the most pervasive challenge for MSMEs throughout South Asia, even in the presence of government-backed schemes.

CA3 (Credit guarantee schemes) is positioned as the second-ranked sub-barrier, possessing a local weight of 0.328 and a global weight of 0.114, which places it fourth in the overall ranking. Credit guarantees are designed to mitigate lending risks for financial institutions; however, their utilization among MSMEs remains limited. Many MSMEs involved in vegetable production are unfamiliar with institutions such as Askrindo or the Lembaga Penjamin Kredit Daerah (LPKD). Several local cooperatives have endeavored to bridge this knowledge deficit, but coordination among these entities remains suboptimal. Focus group discussions (FGDs) revealed that while these schemes exist, their procedures are not adequately disseminated at the grassroots level, particularly outside urban centers. As one participant elaborated, "Guarantee institutions are present, but MSMEs lack knowledge regarding how to access them or what preparatory steps are required." Adhikary et al. (2021) similarly observed that credit guarantee schemes in Indonesia are underutilized owing to low awareness and procedural complexities, thereby curtailing their impact on MSME financing.

Finally, CA2 (Financial literacy) occupies the third rank (local weight 0.261; global 0.091). Despite concerted efforts to broaden financing options, numerous MSMEs encounter difficulties in managing acquired funds, frequently commingling personal and business expenditures. A government representative remarked, "Most MSMEs do not delineate their personal spending from operational cash flow, which adversely affects their repayment capacity and long-term viability." While training programs are available, they are often characterized by their one-off nature, generic content, and lack of tailored application to green enterprises. This limits their efficacy in enabling MSMEs to manage loans effectively and sustain long-term engagement with financial institutions. Kumar et al. (2025) confirm that limited financial literacy substantially diminishes MSMEs' capacity to manage credit and maintain performance, especially when business and household finances are not segregated.

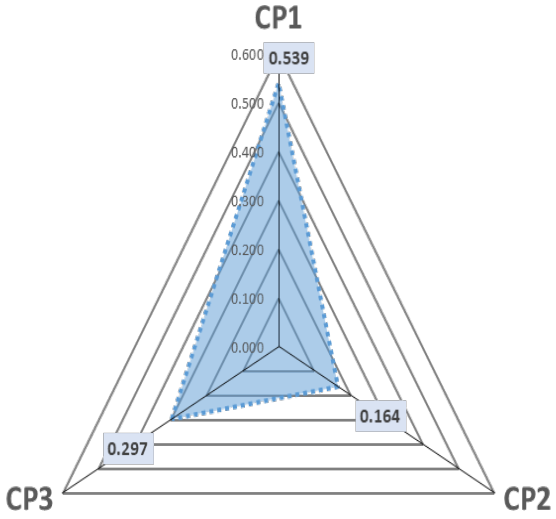


Figure 10: Ranking of Sub-Barriers Under Product Competitiveness Barriers

The priority order of sub-barriers within the Product Competitiveness (CP) category is CP1 > CP3 > CP2 (refer to Fig. 10). The top-ranked sub-barrier is CP1 (Product quality), possessing a local weight of 0.539 and a global weight of 0.126, which establishes it as the second most influential sub-barrier overall. PT BR emphasized that consistent appearance, cleanliness, and proper post-harvest handling constitute minimum standards for fresh vegetable suppliers. A representative stated, "Even if the vegetables are fresh, if they're not sorted properly or arrive with too much damage, we can't accept them." Many MSMEs lack

access to critical infrastructure such as cold storage, grading tools, or appropriate packaging, which results in irregular product shape and compromised freshness. Furthermore, limited adoption of Good Agricultural Practices (GAP) diminishes their capacity to meet requisite quality standards, thereby discouraging long-term engagements with large buyers. This finding corresponds with Hanggraeni & Sinamo (2021) who contend that entrepreneurial and product quality are central to MSME competitiveness in Indonesia, and Kristanto & Kurniawati (2025) who highlight certification and product standards as pivotal factors shaping the performance of food-based MSMEs.

CP3 (Product differentiation and innovation) ranks second, with a local weight of 0.297 and a global weight of 0.069. This barrier underscores the limited capacity of green MSMEs to distinguish themselves in competitive or niche markets. Several experts observed that MSMEs in East Java are frequently typecast into repetitive product categories, such as "batik, lurik, and chips." While some enterprises are experimenting with sustainable packaging or local ingredients, such initiatives are typically small-scale and lack adequate technical guidance. One green MSME participant articulated, "We want to innovate, but if the product changes too much or the process gets more expensive, buyers lose interest or margins disappear." Innovation is recognized as essential but necessitates structured support, including access to R&D, business mentoring, or buyer feedback mechanisms. This aligns with Latifah et al. (2020) who demonstrate that innovation capability significantly enhances MSME competitiveness, and with international evidence emphasizing the role of continuous product differentiation in sustaining small firms' market positions.

CP2 (Certification) is the lowest-ranked sub-barrier, with a local weight of 0.164 and a global weight of 0.038. Certifications such as Halal, SNI, and PIRT are frequently mandated by large buyers; however, MSMEs perceive the acquisition process as costly, bureaucratic, and opaque. Focus group discussions (FGDs) revealed that many enterprises abandon the process prematurely due to protracted delays and insufficient guidance. An official from the Department of Industry and Trade of East Java Province noted, "The programs are there, but MSMEs either don't know about them or give up halfway through because the bureaucracy is too much." Green certification efforts remain largely confined to large firms, as most MSMEs lack the requisite documentation and compliance capabilities. Comparable findings are reported by Ardiantono et al. (2024) who identify bureaucratic complexity and high compliance costs as major obstacles for MSMEs in meeting halal and SNI certification standards.

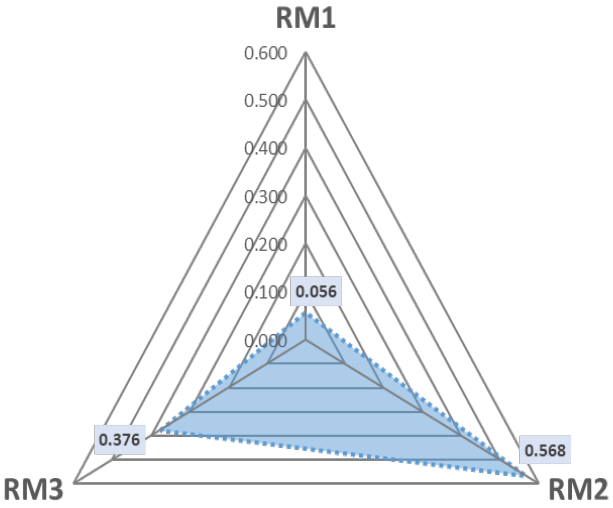


Figure 11: Ranking of Sub-Barriers Under Raw Materials Barriers

The priority ranking of sub-barriers under the Raw Materials (RM) category is RM2 > RM3 > RM1 (see Fig. 11). The highest-ranked sub-barrier is RM2 (Price stability), with a local weight of 0.568 and a global weight of 0.056. Price volatility, particularly for perishable

commodities such as vegetables or fruit-based inputs, was cited as a major concern in Focus Group Discussions (FGDs). One MSME participant explained, *"Price goes up and down, but our bigger problem is whether we can even produce at all without upfront cash."* Without price predictability, MSMEs struggle to commit to supply contracts or plan for stable monthly production. According to testimonies from farmer-suppliers, extreme weather and crop failures directly affect both quality and price, exposing downstream MSMEs to sharp cost fluctuations. After the pandemic, many MSMEs faced prolonged recovery periods, with some reporting income drops of over IDR 10 million. These conditions have raised calls for government intervention to protect MSMEs from raw material shocks, particularly through aggregation mechanisms or price guarantees. This result is consistent with Ariani et al. (2023) who find that raw material price volatility significantly undermines the performance of green MSMEs in Indonesia, and with Yunus et al. (2025) who emphasize that lack of resilience in resource orchestration exposes small firms to prolonged recovery after crises.

RM3 (Local raw material access) ranks second (local weight 0.376; global weight 0.037). Rural MSMEs often depend on a limited number of suppliers, with no local cooperatives or aggregation hubs to buffer supply risks. While urban MSMEs have better access, rural producers face high transport costs and inconsistent quality from informal sources, especially for organic inputs. This finding is in line with Kristanto & Kurniawati (2025) who show that MSMEs in the food sector face difficulties in maintaining supply consistency without cooperative-based sourcing or strengthened local supply chains.

RM1 (Raw material diversification) is the lowest-ranked, with a local weight of 0.056 and a global weight of 0.006. Most MSMEs rely on familiar vendors for convenience and trust. *"We always buy from the same seller because we know their quality"* said one respondent. While this simplifies procurement, it heightens exposure to price hikes and stockouts. Due to limited resources, supplier diversification remains a low priority. Similar concerns have been highlighted by Yunus et al. (2025) who note that MSMEs often struggle to diversify input sources, which limits their ability to innovate and scale production.

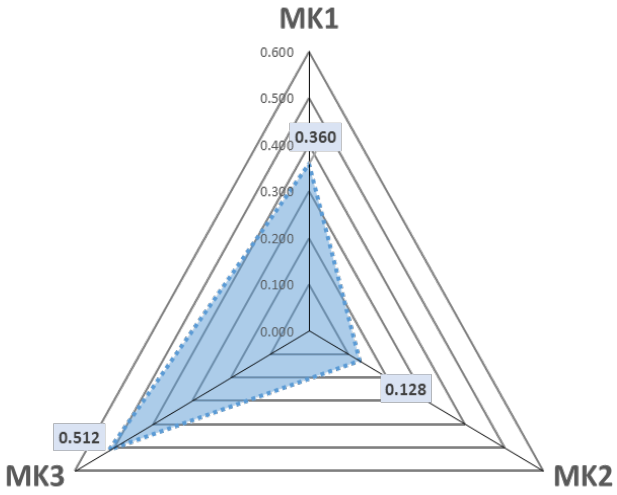


Figure 12: Ranking of Sub-Barriers Under Marketing Barriers

The priority order of sub-barriers under the Marketing (MK) category is MK3 > MK1 > MK2 (see Fig. 12). MK3 (Distribution independence) is the most critical sub-barrier, with a local weight of 0.512 and a global weight of 0.093. Many MSMEs depend on third-party distributors, limiting their control over product handling, delivery timing, and margins. One respondent noted, *"We send products through agents, but we don't know how they are stored or when they're delivered. That makes industries hesitant."* Such uncertainty raises concerns for large buyers, especially those requiring cold chain or food safety compliance. According to Bank Indonesia (2024), 77.7 percent of MSMEs in Indonesia still face marketing barriers due

to limited digital infrastructure and poor coordination between production and delivery. This finding is consistent with Maina et al. (2024) who show that dependence on intermediaries weakens SMEs' ability to negotiate and reduces their competitiveness in local markets.

MK1 (Access to digital markets) ranks second, with a local weight of 0.360 and a global weight of 0.065. While digital tools have expanded market access, most MSMEs continue to rely on informal channels, such as WhatsApp or basic social media posts. According to the Department of Cooperatives and MSMEs of East Java Province, 66 percent of MSMEs still depend on offline sales. Programs like the *Sijawara* platform offer training and e-commerce support, but adoption remains uneven, particularly outside major cities. Comparable evidence is provided by Gao et al. (2023b) who find that limited adoption of e-commerce platforms significantly constrains MSME competitiveness and sustainability performance.

MK2 (Promotion and product curation) is the lowest-ranked, with a local weight of 0.128 and a global weight of 0.023. Vegetable producers rarely participate in trade expos due to product perishability and a lack of suitable formats. Instead of branding, visibility in institutional procurement or aggregator systems is more urgent. One MSME shared, "*We heard about the government buying from small farmers, but no one tells us how to register or if we qualify.*" Curated matchmaking has potential but is still limited and often inaccessible to rural producers. Amoa-Gyarteng et al. (2024) similarly highlight that promotional strategies in SMEs often fail to deliver expected benefits when not tailored to product type and market conditions, underscoring the limited effectiveness of generic promotion.

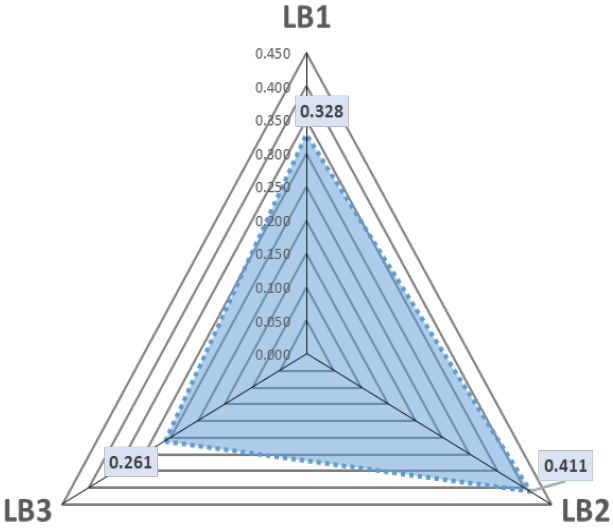


Figure 13: Ranking of Sub-Barriers Under Labor Barriers

The priority order of sub-barriers under the Labor (LB) category is LB2 > LB1 > LB3 (see Fig. 13). The top sub-barrier is LB2 (Labor productivity), with a local weight of 0.411 and a global weight of 0.013. While labor was not identified as a major barrier in the overall AHP ranking, productivity remains a concern for large industry partners. Focus group discussions (FGDs) revealed that green MSMEs in agriculture often operate with small, multitasking teams, where output depends heavily on manual labor and weather conditions. One industry stakeholder noted, "*When orders scale up, many MSMEs can't keep up, not because of quality issues, but because they don't have the capacity to meet volume or time requirements*". This result is consistent with Kumarasamy et al. (2024) who show that limited access to finance and technology hampers labor productivity in developing-country MSMEs, reinforcing the importance of improving efficiency rather than only expanding workforce size.

LB1 (Labor availability) ranks second, with a local weight of 0.328 and a global weight of 0.010. MSMEs generally reported that labor supply is not a critical issue, particularly in urban

and peri-urban zones like Surabaya or Gresik. However, recruitment challenges occasionally arise during planting or harvesting peaks, especially when competing with other sectors or when wages fluctuate. Some practitioners mentioned that even when workers are available, high turnover rates and low job commitment can affect operational consistency. Comparable findings were noted by Wibiseno & Usman (2021) who observed that fluctuations in labor availability across regions are closely linked with wage competition and seasonality in MSME activities.

LB3 (Access to training and green skills) is the lowest-ranked sub-barrier, with a local weight of 0.261 and a global weight of 0.008. Although not seen as urgent, it highlights a long-term gap in workforce preparedness. Most MSME training still centers on basic topics like operations or bookkeeping, with little emphasis on sustainable agriculture or eco-certification. The East Java government has launched initiatives such as the Forum Industri Hijau to support green practices through collaboration with various stakeholders. As green standards become more common in supply chains, the absence of targeted training could hinder future linkage opportunities. This resonates with Pangarso et al. (2022) who stress that the lack of structured green skills training is a major barrier to MSME readiness for green economy transition.

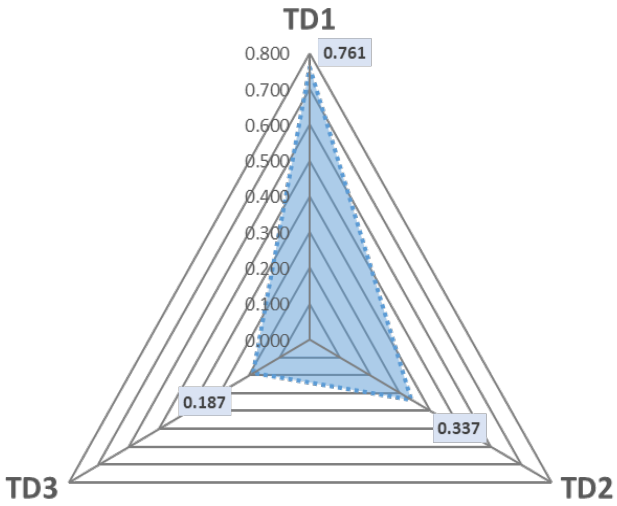


Figure 14: Ranking of Sub-Barriers Under Technology and Digitalization Barriers

The priority order of sub-barriers within the Technology and Digitalization (TD) category is TD1 > TD2 > TD3 (see Fig. 14). TD1 (Production technology adoption) ranks highest, with a local weight of 0.761 and a global weight of 0.042. Many vegetable-producing MSMEs continue to rely on manual tools with minimal post-harvest infrastructure. This limits scalability and product consistency, particularly within formal supply chains. A buyer from PT BR noted, *"Some suppliers deliver vegetables without sorting or cooling. That affects shelf life and makes it hard for us to meet quality standards."* Lack of investment in basic agricultural technologies such as cold storage or grading continues to hinder linkage opportunities. This aligns with Loo et al. (2023) who emphasize that MSMEs across Southeast Asia face persistent difficulties in upgrading production technologies due to financial and technical barriers.

TD2 (Use of digital marketing) ranks second (local weight: 0.337; global weight: 0.019). Although MSMEs increasingly utilize social media and online marketplaces, most engagement is basic and lacks integration with inventory or logistics systems. *"We post on WhatsApp, but we don't know how to get more buyers or follow up after orders,"* stated one MSME owner. Despite training initiatives, short program durations and weak follow-up limit digital marketing adoption, especially in rural areas where technical capacity remains low. Comparable evidence is reported by Tatik & Setiawan (2025) who find that while many Indonesian MSMEs adopt social media marketing, its impact remains limited when not accompanied by managerial capacity and integration into wider business strategies.

TD3 (Eco-design and energy efficiency) is the lowest-ranked sub-barrier, with a local weight of 0.187 and a global weight of 0.010. Environmentally oriented MSMEs rarely implement green innovations such as reusable crates, optimized transport, or solar-powered cooling. These practices are perceived as costly and complex. As one stakeholder put it, *"They're open to green practices, but unless there's a subsidy or guidance, it's hard to expect farmers or MSMEs to make these investments on their own."* Uptake remains low despite interest, due to financial and technical barriers. This observation is consistent with Prashar (2019) who shows that SMEs often lack the resources to adopt eco-design and energy-efficient practices despite recognizing their long-term benefits for competitiveness and sustainability.

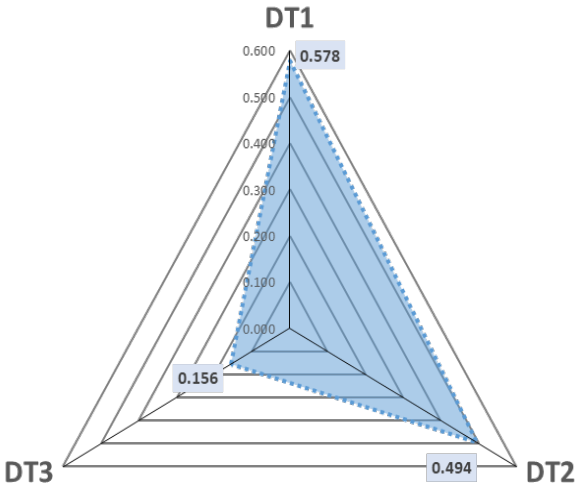


Figure 15: Ranking of Sub-Barriers Under Distribution and Transport Barriers

The ranking of sub-barriers under the Distribution and Transport (DT) category is DT1 > DT2 > DT3 (see Fig. 15). DT1 (Logistics cost efficiency) is ranked highest with a local weight of 0.578 and a global weight of 0.019. While not among the most critical barriers overall, this factor reflects growing concerns over rising transportation costs, especially for MSMEs attempting to scale production or serve buyers outside their immediate locale. MSMEs noted that while intra-city deliveries remain manageable through ride-hailing services or direct courier arrangements, long-distance shipping becomes burdensome without access to bulk logistics rates. As one MSME put it, *"Delivering to Surabaya is still okay, but when we try to ship to Jakarta, the courier cost can match the value of the product itself"*. This is consistent with Wong et al. (2015) who show that cost efficiency in logistics is a decisive factor for SME competitiveness, with high transportation expenses eroding profit margins.

DT2 (Road and delivery infrastructure) ranks second with a local weight of 0.494 and a global weight of 0.016. Although not frequently identified as a primary barrier in focus group discussions (FGDs), infrastructure concerns were articulated by MSMEs situated in peri-urban or rural areas. Substandard road conditions and unreliable pickup services can result in delivery delays, product damage, or diminished buyer confidence. According to feedback from PT S, *"Timeliness is critical for food industry buyers. If the delivery is late or the packaging is compromised because of bad roads, we just don't reorder"*. Similar concerns are highlighted by Sindhwani et al. (2023) who identify road quality and last-mile infrastructure as major determinants of MSME supply chain resilience in developing regions.

DT3 (Logistics independence) is the lowest-ranked sub-barrier with a local weight of 0.156 and a global weight of 0.005. MSMEs generally rely on third-party platforms for distribution and rarely operate their own logistics networks. This was not perceived as a significant issue unless the business attained a certain scale. For most participants, outsourcing delivery remains more cost-effective than maintaining proprietary transport units. However,

dependence on external couriers occasionally results in reduced flexibility and loss of control over the customer experience. This finding echoes Marjan et al. (2022) who argue that heavy reliance on external logistics providers can limit SMEs' flexibility and control, despite offering short-term cost savings.

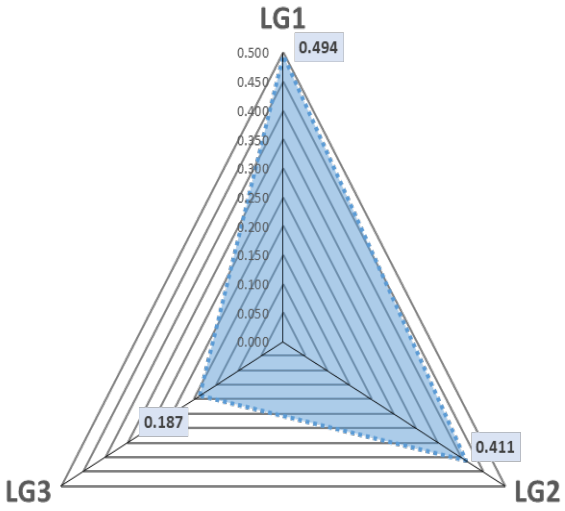


Figure 16: Ranking of Sub-Barriers Under Legality Barriers

LG1 (Business legality) is the top-ranked item in this group, with a local weight of 0.494 and a global weight of 0.010. Although legal documentation is a basic requirement for most formal linkages, many vegetable-producing MSMEs stated that they already possess basic permits such as a Business Identification Number (NIB) or home industry certification (PIRT). However, stakeholders emphasized that legality alone does not guarantee compliance with industrial partnership standards. As one official from the Department of Industry and Trade of East Java Province remarked, *"Many MSMEs have NIB, but it doesn't mean they understand or follow industrial partnership requirements."* This gap between formal legality and operational readiness remains a critical issue for MSMEs seeking long-term contracts. Comparable findings are reported by Mishra & Kushwaha (2023) who show that legal compliance alone does not protect MSMEs from operational and litigation risks, stressing the importance of understanding contractual obligations.

LG2 (Understanding of legal obligations) is second with a local weight of 0.411 and a global weight of 0.008. These barriers refer to MSME knowledge regarding their rights and obligations in formal linkages, including contracts, liability, and labor law. Experts noted that many MSMEs sign supply agreements without fully understanding the terms, which can expose them to risks such as late payments or one-sided termination clauses. The need for legal education or legal aid services was mentioned, though demand for such support remains low unless problems arise. This finding resonates with (Sendawula et al., 2024) who argue that regulatory compliance mechanisms are often poorly understood among SMEs, leading to vulnerabilities in meeting contractual and environmental obligations.

The lowest-ranked sub-barrier is LG3 (Access to legal assistance), with a local weight of 0.187 and a global weight of 0.004. This low score reflects both a limited perceived need and a lack of familiarity with legal services. Many MSMEs reported never consulting legal professionals, viewing such services as expensive, irrelevant, or intimidating. As one MSME noted, *"We don't think about lawyers unless we get into trouble and by then it's already too late"*. While not an urgent barrier, the absence of legal support mechanisms can still affect MSME resilience in the long run. Padilla-Angulo et al. (2023) similarly emphasize that without accessible and affordable support services, small enterprises in developing contexts struggle to navigate legal complexities, which undermines long-term sustainability.

Final Ranking of Sub-Barriers

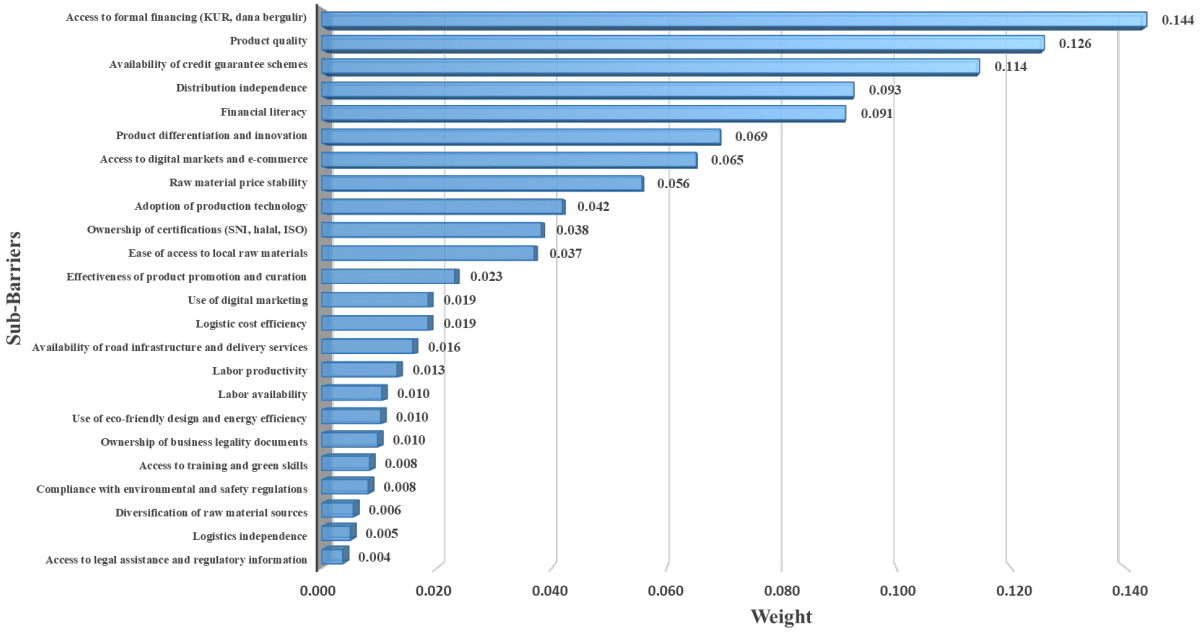


Figure 17: Overall Ranking of Sub-Barriers to MSME-Industry Linkage

The final ranking of the 24 sub-barriers was determined by calculating their global weights, which were obtained by multiplying the local weight of each sub-barrier with the weight of its corresponding major barrier. The complete ranking is as follows: CA1 > CP1 > CA3 > MK3 > CA2 > CP3 > MK1 > RM2 > TD1 > CP2 > RM3 > MK2 > TD2 > DT1 > DT2 > LB2 > LB1 > TD3 > LG1 > LB3 > LG2 > RM1 > DT3 > LG3. Figure 17 presents the graphical distribution of the global weights across all sub-barriers.

It is evident that Access to formal financing (CA1) is the top-ranked sub-barrier, with the highest global weight of 0.144. This confirms that financing remains the most critical obstacle to strengthening industrial linkages. Following closely are Product quality (CP1) (0.126), Availability of credit guarantee schemes (CA3) (0.114), and Distribution independence (MK3) (0.093), which together reflect the combined importance of financial access, assurance mechanisms, and logistical autonomy. This result is consistent with Mittal & Raman (2022) who highlight financing as the most persistent MSME barrier in South Asia, and with Hanggraeni & Sinamo (2021) who emphasize the role of product quality in shaping MSME competitiveness in Indonesia. Similarly, Adhikary et al. (2021) confirm that credit guarantees are often underutilized in Indonesia due to lack of awareness, echoing our finding that CA3 ranks high in importance. The importance of distribution independence is also aligned with (Maina et al. (2024) who stress that reliance on third-party distributors weakens SMEs' bargaining power and market access.

At the lower end of the spectrum, sub-barriers such as Logistics independence (DT3) (0.005), Compliance with environmental and product safety regulations (LG2) (0.008), and Access to legal assistance and regulatory information (LG3) (0.004) hold the least weight, indicating that while these are not irrelevant, they are currently perceived as less urgent or impactful in facilitating linkage formation. Comparable results were observed by Sendawula et al. (2024) who found that compliance with environmental regulation is often under-prioritized by SMEs in Uganda, and by Padilla-Angulo et al. (2023) who noted that legal support mechanisms are rarely accessed by small firms due to high costs and limited perceived need.

The ranking pattern shows a clear emphasis on structural enablers, particularly capital, product readiness, and distribution systems, as dominant concerns for green MSMEs aiming

to integrate with large industries. Conversely, softer or enabling sub-barriers such as legal compliance or green design practices are considered long-term priorities but not immediate constraints.

G-TOPSIS Results and Policy Priority

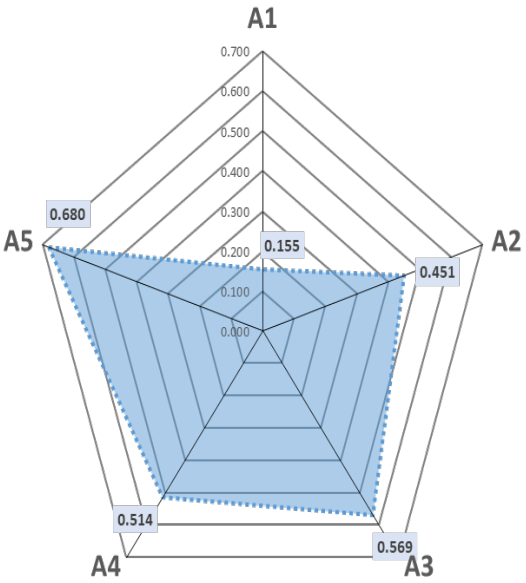


Figure 18: Final Ranking of Policy Alternatives Based on G-TOPSIS Analysis

Figure 18 presents the final ranking of five policy alternatives based on their relative closeness to the ideal solution, which incorporates the global weights of 24 sub-barriers derived from the AHP stage. A higher value reflects a more favorable policy intervention in addressing the most critical barriers to industrial linkage between green MSMEs and large industries in East Java's food and beverage sector. The resulting rank order is as follows: A5 > A3 > A4 > A2 > A1.

A5 (Strengthening Access to Capital) emerges as the top priority, with the highest score of 0.680. This policy directly addresses the most critical sub-barriers, particularly CA1 (access to formal financing) and CA3 (availability of credit guarantees). Focus group discussions (FGDs) emphasized that improved access to capital via simplified procedures for People's Business Credit (KUR), strengthened local guarantee institutions such as LPKD and Askrindo, and blended financing schemes would immediately benefit MSMEs operating under informal or under-collateralized conditions. A5 also indirectly supports financial literacy (CA2), especially if linked with mentoring and digital tools. The provincial *Program Kredit Usaha Rakyat Sejahtera*, under the East Java Cooperative and MSME Agency, has been highlighted as an opportunity to expand beneficiary coverage. However, while Bank Jatim's green credit program has supported larger industries, green MSMEs have yet to access these facilities. Comparable findings are reported by Batool et al. (2023) who demonstrate that policies combining financing schemes and guarantee mechanisms produce the strongest outcomes for MSME sustainability in Pakistan's energy sector.

A3 (Improving Product Quality of MSMEs) ranks second, with a score of 0.569. This alternative is closely aligned with CP1 (product quality), the second-highest sub-barrier overall. It focuses on improving MSME production consistency, packaging, and hygiene standards, all of which were cited by large industry actors as basic supply chain requirements. The policy also contributes moderately to CP3 (product innovation), especially for MSMEs entering niche markets. Nevertheless, its limited coverage of financial or distribution barriers restricted its position in the final ranking. This aligns with Kristanto & Kurniawat (2025) who emphasize that

certification and product quality upgrades enhance competitiveness in food MSMEs, and with Latifah et al. (2020), who show that innovation is essential for long-term resilience.

A4 (Enhancing MSME Production and Technology Capacity) is placed third, reflecting its alignment with TD1 (technology adoption), TD2 (digital marketing), and LB2 (labor productivity). The policy is recognized for addressing MSMEs' limited production efficiency, manual operations, and weak technological integration. However, high equipment costs and implementation barriers were noted in FGDs, along with the need for targeted support in scaling and maintaining new technologies. Similar issues are highlighted by Loo et al. (2023) who underline that MSMEs often struggle to adopt production technologies without subsidies or tailored technical assistance.

A2 (Enhancing Human Resource Capacity of MSME Managers) ranks fourth. This alternative addresses CP3 (product innovation), TD1 (technology adoption), and LB3 (green skills training). Stakeholders valued this option for its potential to improve managerial capacity and sustainability knowledge. Nonetheless, it was seen as limited in reach and effectiveness due to inconsistent program monitoring and disconnection from actual market demands. For example, the *Sijawara* digital learning platform offers online training modules for MSMEs, including digital marketing. However, FGDs revealed that short durations and theory-heavy materials hinder MSMEs' ability to implement these lessons effectively. Moreover, while East Java has launched the *Green Industry Forum* to promote sustainable practices, MSMEs have yet to be actively included in this platform. This reflects observations by Pangarso et al. (2022) who argue that weak training design and lack of monitoring limit the effectiveness of MSME capacity-building programs.

Policy alternative A1 (Improving Institutional Quality of MSMEs) ranks last. While institutional strengthening, encompassing formalization, cooperative support, and governance training, is important, this policy alternative was perceived as too foundational to yield immediate results. Focus group discussions (FGDs) revealed that many MSMEs prioritize practical support (e.g., access to buyers or working capital) over abstract institutional reforms. One respondent stated*, "Formalizing MSMEs is important, but without demand or credit, it's just paperwork."* Consequently, A1 may yield long-term benefits but is currently regarded as less urgent by most stakeholders. This finding is similar to those by Salim et al. (2024), who suggest that institutional reforms are necessary but insufficient unless supported by direct access to markets and financing.

In summary, policies addressing immediate financial and quality-related constraints (A5 and A3) are perceived as the most impactful, whereas foundational or capacity-building interventions (A1 and A2) are necessary but not sufficient on their own. These findings highlight the need for a phased approach, commencing with access-enabling reforms, followed by structural upgrades in skills and governance, to cultivate sustainable linkage ecosystems between green MSMEs and large industries in East Java.

Conclusions

As one of Indonesia's leading provincial economies, East Java possesses significant potential to foster the development of green Micro, Small, and Medium Enterprises (MSMEs) that adopt sustainable practices. However, the prevalence of green MSMEs remains limited in both distribution and scale across the region. The existing linkages between green MSMEs and large industries in the food and beverage sector primarily comprise basic purchasing arrangements and limited product facilitation efforts, such as the provision of depots to maintain product quality. Despite these initial forms of engagement, green MSMEs continue to encounter a wide range of barriers that impede stronger and more sustainable partnerships with large industries. In addition to the commonly cited issues of limited access to capital, low competitiveness, and constrained marketing reach, this study identifies other critical constraints. These include a lack of access to modern production technologies, limited

technical skills among workers, inconsistent production capacity, and difficulties in meeting quality and volume standards required by large firms. These challenges are particularly significant for green MSMEs aiming to integrate into formal supply chains within the food and beverage sector. Strengthening linkages with large industries remains a promising pathway, offering green MSMEs opportunities for market expansion, knowledge transfer, and quality improvement. Efforts to strengthen the linkage between green MSMEs and large industries in East Java can be approached through both direct and indirect strategies. Via a direct approach, the East Java Provincial Government can commence by mapping and identifying green MSMEs that currently have or demonstrate potential for linkage with large industries, especially within the food and beverage sector, given its economic significance. Concurrently, the central government, through the Ministry of Industry and the Ministry of Trade, should assess the operational and developmental input needs of these MSMEs. The synergy between the central and provincial governments is essential to ensure a proper "link and match" between green MSMEs and large industries.

The indirect approach involves identifying green MSMEs with high potential for linkage readiness. The provincial government can then support these MSMEs through targeted facilitation. Simultaneously, the central government may provide fiscal incentives, such as tax breaks, for large food and beverage industries that empower green MSMEs, as well as monetary support through low-interest financing schemes to ease credit access for green MSMEs.

To optimize linkage development, it is crucial to address the specific needs of green Micro, Small, and Medium-sized Enterprises (MSMEs), particularly concerning financial support. Many green MSMEs continue to face barriers to accessing bank loans, which impedes their operational capacity and growth. Therefore, financial institutions should be encouraged to develop dedicated green financing schemes to support environmentally friendly MSME transformation. The imperative to empower green MSMEs through stronger linkages with the food and beverage industry also aligns with East Java's broader commitment to sustainable development. This transformation not only enhances MSME competitiveness but also contributes to regional environmental objectives.

Moreover, Bank Indonesia has engaged in synergistic efforts without explicitly addressing the capital dimension. The institution applies the Pentahelix ecosystem model for MSME development; however, its current focus remains on implementing SIAPIK, which is susceptible to manipulation. Therefore, a shift towards the Hexahelix model is proposed for future implementation. This model incorporates an additional financial dimension, specifically encompassing financing and financial literacy.

Achieving this necessitates multisectoral synergy. The government, at both national and local levels, must play a central role, supported by academic institutions, community organizations (such as cooperatives or MSME associations), financial actors (particularly banks), and the media. Universities and research institutions can contribute through applied research, innovation, and training that strengthen product quality and sustainable practices. These efforts can provide the foundation for policies that expand the number and capacity of green MSMEs while enhancing their linkages with larger industry partners.

In addition to linkage-focused policies, green MSMEs must also enhance their internal capabilities. This includes securing intellectual property rights (trademarks and copyrights), obtaining Good Agricultural Practices (GAP) certification, organic agriculture certification, as well as Halal and HACCP/SNI certification, and improving product quality through packaging design, laboratory testing, and effective branding. Technological support should also emphasize the use of environmentally friendly innovations to improve operational efficiency.

The provincial government can play a facilitative role by supporting access to certification programs (e.g., GAP, organic, Halal, HACCP/SNI), which are critical for improving

MSME product quality. Additional support can include brand development, packaging assistance, laboratory testing, and access to appropriate green technologies. Expanding the market for green MSME products can also be achieved by integrating them into government-sponsored exhibitions or promotional events.

Ultimately, the banking sector can support sustainability goals by facilitating easier access to credit and developing tailored green financing products. Academia can contribute by advancing research and innovation in eco-friendly MSME practices. Community organizations can help strengthen MSME capabilities and promote sustainability awareness, while the media can broaden public understanding and encourage MSMEs to adopt sustainable practices and engage in linkages with large industries to enhance their market reach and green product offerings.

Declaration

Authors' Contributions

DELP: Software, Data Curation, Visualization, Methodology, Formal Analysis, Writing - original draft. **PAP**: Conceptualization, Writing - original draft, Formal Analysis, Investigation. **FFA**: Methodology, Project administration, Software, Supervision, Writing - review & editing, Visualization.

Funding Source

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study prior to completing the survey questionnaire. Participants were informed about the purpose of the research and consented to the use of their anonymized data for publication

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Availability of Data and Materials

The data that support the findings of this study are not publicly available due to privacy and ethical restrictions, as they contain sensitive information regarding the participating MSMEs and large industries. Consequently, the datasets are restricted and not available for public access to ensure the confidentiality of the respondents.

Use of Artificial Intelligence (AI)

The authors declare that AI tools, namely Grammarly, were used strictly for language editing and proofreading purposes to improve the readability of the manuscript. All ideas, data interpretations, results, analyses, and conclusions remain the sole responsibility of the authors

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Appendix

Table A1: Pairwise Comparison Matrix of Major Barriers

Barriers	CA	CP	MK	RM	TD	DT	LB	LG	Main Weight	Ranking
CA	1	3	2	8	5	9	9	9	0.349	1st
CP	0.333	1	3	2	5	9	9	9	0.233	2nd
MK	0.500	0.333	1	2	4	9	8	9	0.181	3rd
RM	0.125	0.500	0.500	1	3	4	4	5	0.098	4th
TD	0.200	0.200	0.250	0.333	1	2	3	3	0.055	5th
DT	0.111	0.111	0.111	0.250	0.500	1	2	2	0.032	6th
LB	0.111	0.111	0.125	0.250	0.333	0.500	1	4	0.032	7th
LG	0.111	0.111	0.111	0.200	0.333	0.500	0.250	1	0.020	8th

Consistency Ratio (CR) = 0.068

Table A2: Pairwise Comparison Matrix of Capital Access Barriers

CA	CA1	CA2	CA3	Local Weight	Ranking
CA1	1.000	2.000	1.000	0.411	1st
CA2	0.500	1.000	1.000	0.261	3rd
CA3	1.000	1.000	1.000	0.328	2nd

Consistency Ratio (CR) = 0.046

Table A3: Pairwise Comparison Matrix of Competitiveness Barriers

CP	CP1	CP2	CP3	Local Weight	Ranking
CP1	1.000	3.000	2.000	0.539	1st
CP2	0.333	1.000	0.500	0.164	3rd
CP3	0.500	2.000	1.000	0.297	2nd

Consistency Ratio (CR) = 0.008

Table A4: Pairwise Comparison Matrix of Marketing Barriers.

MK	MK1	MK2	MK3	Local Weight	Ranking
MK1	1.000	4.000	0.500	0.360	2nd
MK2	0.250	1.000	0.333	0.128	3rd
MK3	2.000	3.000	1.000	0.512	1st

Consistency Ratio (CR) = 0.094

Table A5: Pairwise Comparison Matrix of Raw Materials Barriers

RM	RM1	RM2	RM3	Local Weight	Ranking
RM1	1.000	0.125	0.111	0.056	3rd
RM2	8.000	1.000	2.000	0.568	1st
RM3	9.000	0.500	1.000	0.376	2nd

Consistency Ratio (CR) = 0.064

Table A6: Pairwise Comparison Matrix of Technology & Digitalization Barriers

TD	TD1	TD2	TD3	Local Weight	Ranking
TD1	1.000	3.000	3.000	0.761	1st
TD2	0.333	1.000	2.000	0.337	2nd
TD3	0.333	0.500	1.000	0.187	3rd

Consistency Ratio (CR) = 0.053

Table A7: Pairwise Comparison Matrix of Distribution & Transport Barriers

DT	DT1	DT2	DT3	Local Weight	Ranking
DT1	1.000	1.000	4.000	0.578	1st
DT2	1.000	1.000	3.000	0.494	2nd
DT3	0.250	0.333	1.000	0.156	3rd

Consistency Ratio (CR) = 0.010

Table A8: Pairwise Comparison Matrix of Labor Barriers

LB	LB1	LB2	LB3	Local Weight	Ranking
LB1	1.000	1.000	1.000	0.328	2nd
LB2	1.000	1.000	2.000	0.411	1st
LB3	1.000	0.500	1.000	0.261	3rd

Consistency Ratio (CR) = 0.046

Table A9: Pairwise Comparison Matrix of Legality & Licensing Barriers

LG	LG1	LG2	LG3	Local Weight	Ranking
LG1	1.000	1.000	3.000	0.494	1st
LG2	1.000	1.000	2.000	0.411	2nd
LG3	0.333	0.500	1.000	0.187	3rd

Consistency Ratio (CR) = 0.017

Table A10: Global Weights and Ranking of Sub-Barriers from AHP Results

Sub-barriers	Main Weight	Local Weight	Global Weight	Ranking
CA1	0.349	0.411	0.144	1st
CA2	0.349	0.261	0.091	5th
CA3	0.349	0.328	0.114	3rd
CP1	0.233	0.539	0.126	2nd
CP2	0.233	0.164	0.038	10th
CP3	0.233	0.297	0.069	6th
RM1	0.098	0.056	0.006	22nd
RM2	0.098	0.568	0.056	8th
RM3	0.098	0.376	0.037	11th
MK1	0.181	0.360	0.065	7th

Sub-barriers	Main Weight	Local Weight	Global Weight	Ranking
MK2	0.181	0.128	0.023	12th
MK3	0.181	0.512	0.093	4th
LB1	0.032	0.328	0.010	17th
LB2	0.032	0.411	0.013	16th
LB3	0.032	0.261	0.008	20th
TD1	0.055	0.761	0.042	9th
TD2	0.055	0.337	0.019	13th
TD3	0.055	0.187	0.010	18th
DT1	0.032	0.578	0.019	14th
DT2	0.032	0.494	0.016	15th
DT3	0.032	0.156	0.005	23rd
LG1	0.020	0.494	0.010	19th
LG2	0.020	0.411	0.008	21st
LG3	0.020	0.187	0.004	24th

Table A11: Weighted Normalized Grey Decision Matrix

Sub-Barriers	Global Weight	A1		A2		A3		A4		A5	
		L_wn	U_wn	L_wn	U_wn	L_wn	U_wn	L_wn	U_wn	L_wn	U_wn
CA1	0.144	0.048	0.064	0.080	0.096	0.080	0.096	0.112	0.128	0.144	0.144
CA2	0.091	0.010	0.020	0.071	0.081	0.091	0.091	0.051	0.061	0.051	0.061
CA3	0.114	0.064	0.076	0.064	0.076	0.064	0.076	0.038	0.051	0.114	0.114
CP1	0.126	0.079	0.094	0.079	0.094	0.110	0.126	0.110	0.126	0.079	0.094
CP2	0.038	0.014	0.019	0.024	0.029	0.024	0.029	0.024	0.029	0.033	0.038
CP3	0.069	0.023	0.031	0.039	0.046	0.069	0.069	0.039	0.046	0.054	0.062
MK1	0.065	0.022	0.029	0.022	0.029	0.036	0.043	0.065	0.065	0.036	0.043
MK2	0.023	0.008	0.010	0.003	0.005	0.013	0.015	0.013	0.015	0.023	0.023
MK3	0.093	0.046	0.062	0.077	0.093	0.077	0.093	0.046	0.062	0.077	0.093
RM1	0.006	0.002	0.002	0.003	0.004	0.006	0.006	0.002	0.002	0.002	0.002
RM2	0.056	0.019	0.025	0.019	0.025	0.031	0.037	0.043	0.050	0.056	0.056
RM3	0.037	0.014	0.018	0.005	0.009	0.023	0.028	0.032	0.037	0.014	0.018
TD1	0.042	0.014	0.019	0.042	0.042	0.023	0.028	0.023	0.028	0.023	0.028
TD2	0.019	0.006	0.008	0.006	0.008	0.014	0.016	0.019	0.019	0.010	0.012
TD3	0.010	0.005	0.007	0.005	0.007	0.002	0.003	0.002	0.003	0.009	0.010
DT1	0.019	0.007	0.009	0.016	0.019	0.012	0.014	0.007	0.009	0.002	0.005
DT2	0.016	0.004	0.008	0.012	0.016	0.004	0.008	0.004	0.008	0.004	0.008
DT3	0.005	0.001	0.002	0.004	0.005	0.002	0.003	0.004	0.005	0.001	0.002
LB1	0.010	0.005	0.007	0.009	0.010	0.005	0.007	0.009	0.010	0.005	0.007
LB2	0.013	0.005	0.007	0.011	0.013	0.005	0.007	0.005	0.007	0.002	0.003
LB3	0.008	0.004	0.006	0.007	0.008	0.004	0.006	0.007	0.008	0.004	0.006
LG1	0.010	0.003	0.004	0.003	0.004	0.008	0.009	0.008	0.009	0.010	0.010
LG2	0.008	0.003	0.004	0.003	0.004	0.003	0.004	0.008	0.008	0.006	0.007
LG3	0.004	0.003	0.004	0.002	0.003	0.001	0.002	0.001	0.002	0.001	0.002

Table A12: Grey Positive (A^+) and Negative (A^-) Ideal Solution

Sub-Barriers	A^+		A^-	
	A^+_L	A^+_U	A^-_L	A^-_U
CA1	0.144	0.144	0.048	0.064
CA2	0.091	0.091	0.010	0.020
CA3	0.114	0.114	0.038	0.051
CP1	0.110	0.126	0.079	0.094
CP2	0.033	0.038	0.014	0.019
CP3	0.069	0.069	0.023	0.031
MK1	0.065	0.065	0.022	0.029
MK2	0.023	0.023	0.003	0.005
MK3	0.077	0.093	0.046	0.062
RM1	0.006	0.006	0.002	0.002
RM2	0.056	0.056	0.019	0.025
RM3	0.032	0.037	0.005	0.009
TD1	0.042	0.042	0.014	0.019
TD2	0.019	0.019	0.006	0.008
TD3	0.009	0.010	0.002	0.003
DT1	0.016	0.019	0.002	0.005
DT2	0.012	0.016	0.004	0.008
DT3	0.004	0.005	0.001	0.002
LB1	0.009	0.010	0.005	0.007
LB2	0.011	0.013	0.002	0.003
LB3	0.007	0.008	0.004	0.006
LG1	0.010	0.010	0.003	0.004
LG2	0.008	0.008	0.003	0.004
LG3	0.003	0.004	0.001	0.002

Table A13: Grey Distances of Alternatives from Ideal Solutions

Sub-Barriers	A1		A2		A3		A4		A5	
	D^+	D^-	D^+	D^-	D^+	D^-	D^+	D^-	D^+	D^-
CA1	0.016	0.000	0.006	0.002	0.006	0.002	0.001	0.008	0.000	0.016
CA2	0.012	0.000	0.001	0.007	0.000	0.012	0.003	0.003	0.003	0.003
CA3	0.004	0.001	0.004	0.001	0.004	0.001	0.010	0.000	0.000	0.010
CP1	0.002	0.000	0.002	0.000	0.000	0.002	0.000	0.002	0.002	0.000
CP2	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
CP3	0.004	0.000	0.001	0.000	0.000	0.004	0.001	0.000	0.000	0.002
MK1	0.003	0.000	0.003	0.000	0.001	0.000	0.000	0.003	0.001	0.000
MK2	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001
MK3	0.002	0.000	0.000	0.002	0.000	0.002	0.002	0.000	0.000	0.002
RM1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RM2	0.002	0.000	0.002	0.000	0.001	0.000	0.000	0.001	0.000	0.002
RM3	0.001	0.000	0.002	0.000	0.000	0.001	0.000	0.002	0.001	0.000

Sub-Barriers	A1		A2		A3		A4		A5	
	D^+	D^-	D^+	D^-	D^+	D^-	D^+	D^-	D^+	D^-
TD1	0.001	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.001	0.000
TD2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TD3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DT1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DT2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DT3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LB1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LB2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LB3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LG3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A14: Closeness Coefficient and Ranking of Policy Alternatives

Alternatives	Closeness Coefficient	Ranking
A1	0.155	5th
A2	0.451	4th
A3	0.569	2nd
A4	0.514	3rd
A5	0.680	1st