



Partnerships Between Sugarcane Factories and Farmers: Performance, Waste Management, and Perception Analysis

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ARTICLE INFO

Article History :

Submitted 15 Juni 2025

Revised 16 September 2025

Accepted 27 November 2025

Keywords :

Farmer perception

Managerial policy

Partnership

Sugarcane factory

Sugarcane farmers

How to cite:

Sahara, D., Dewi, T., Handayani, C.O., Zu'amah, H., and Arianti, FD.2025. Partnerships Between Sugarcane Factories and Farmers: Performance, Waste Management, and Perception Analysis. *Agro Ekonomi* 36(2), 193-213. <https://doi.org/10.22146/ae.107962>

ABSTRACT

Sugarcane plays a crucial role in sugar production, but its supply has declined due to land conversion and inefficient systems, which has led to reduced sugar output. Partnerships between farmers and sugar factories are a strategic alternative to increase productivity. This study aims to evaluate sugar factories' performance, sugarcane waste management, the partnership system with farmers, and farmers' perceptions of the impact of partnerships on the production system and the socioeconomics impact on the community. This research was conducted at three sugar factories in Indonesia (Madukismo, Trangkil, and Mojo Sugar Factories) from March to September 2024. The methods used in this study include in-depth interviews, observations, and surveys. The data were analyzed using descriptive and scoring methods. The results showed that sugar factories produce white crystal sugar, distribute it to retail stores, and sell it to wholesalers through an open auction system. Some sugarcane waste is utilized as fuel for factories and processed into alcohol. The partnership between sugarcane farmers and sugar factories provides mutual benefits in which farmers receive guidance in the production process and access to business capital banking. In contrast, sugar factories receive adequate sugarcane supplies in quantity and quality. Farmers positively perceive the sugarcane production system and its socio-economic impact on the community through this partnership. Farmers' perceptions are a supporting factor for the sustainability of partnerships between sugarcane farmers and sugar factories. Policy implications emphasize the importance of factory management in building sustainable partnerships

through fair contracts, technical support, access to capital, and environmentally friendly waste management innovations.

INTRODUCTION

One of the plantation commodities that plays a strategic role in the Indonesian economy is sugarcane. This commodity is particularly important for boosting the country's prosperity and welfare, generating foreign exchange earnings through exports, supplying domestic demand, obtaining added value, and creating jobs for the local population (Meghana & Shastri, 2020). The cultivation area in Indonesia reached approximately 490,010 hectares in 2022. Thousands of sugarcane farmers and workers in sugar factories rely on the sugar business as one of their main sources of income.

National sugar consumption in the country is projected to increase steadily each year, driven by population growth, economic growth, and the growth of the food and beverage industry. This rising demand presents a significant opportunity to boost the production capacity of sugar mills in Indonesia. However, until now, domestic sugar production has yet to meet the sugar needs in Indonesia because the area and productivity of sugar cane have decreased, resulting in the reliance on imported sugar.

Indonesian sugar production fluctuated over the past five years (2019-2023) with an average annual production increase of 1.30%. In 2020, sugar production decreased compared to 2019, from 2.23 million tons to 2.12 million tons. After 2022,

production increased to 2.23 million tons in 2023 (BPS Indonesia, 2024). Sugar consumption in Indonesia in 2021 was 3.12 million tons of white crystal sugar (Afandi, 2024), and in 2023, sugar demand increased to 6.8 million tons (Rudya, 2023). A growing population and the development of the food and beverage industry drive the increase in sugar consumption. Therefore, to meet this demand, the government imports sugar in the form of both refined sugar and molasses. In the same period (2019-2023), sugar imports fluctuated between 4.09 million tons to 5.07 million tons with an average annual increase of 5.10% per year, while molasses imports decreased from 95.17 thousand tons to 57.47 thousand tons with an average decrease of 10.20% per year (BPS Indonesia, 2024).

Similarly, Ethiopia is experiencing an increase in population and economic growth and its sugar production needs to be increased but it is constrained by the decreasing sugar cane production due to inappropriate sugar cane cultivation techniques (Desalegn et al., 2023; Wondimu et al., 2021). The decline in sugar cane production is also a major challenge for sugar factories in Kenya. Given the circumstances, increasing both sugar cane production and overall sugar output is essential to reduce imports and achieve national sugar self-sufficiency (Thuo et al., 2022).

Partnerships can be a strategy to overcome the problems of

Indonesian sugar production due to limited land control and cultivation technology and limited capital at the farmer level (Ainiyah & Subianto, 2022). The collaboration between farmers and sugar factories are a form of mutually beneficial cooperation.

Partnerships for farmers guarantee a market for the sugar cane produced, while for sugar factories, sugar cane from farmers is a supply of raw materials for the sugar industry. Additionally, it is easier for the farmers to obtain the infrastructure and production facilities needed to increase sugar cane production (Fedi et al., 2022; Nuraeni et al., 2024). Sugarcane production by optimizing production input in several facilities in accordance with environmental and crop conditions. This aligns with the opinion of Sajid et al. (2023) that the optimal use of plant inputs and appropriate irrigation system can streamline production costs, increase sugarcane production, and enhance sugarcane quality. Furthermore, Gunarathna et al. (2018) found significantly higher fresh sugarcane yields using an optimized subsurface irrigation system compared to sprinkler irrigation, while Nosenzo et al. (2024) found that bagasse-based biochar is economically feasible to develop to increase sugarcane production. Partnerships also play a role in minimizing production costs for farmers and labor costs for companies (Rokhani et al., 2020), thereby enhancing overall efficiency of resources by both parties. Farmers partner with sugar factories when

they positively perceive the production system and socioeconomics of the farming community. Understanding farmers' perceptions is very important because farmers' views and insights will influence their attitudes toward the consistency of partnerships with sugar factories.

Several studies on sugar factory-farmer partnerships have focused more on the form/pattern of farmer partnerships with a sugar factory in North Sumatera (Datika et al., 2019); in Takalar (Dewi et al., 2021); and in Nganjuk Regency (Ainiyah & Subianto, 2022). Research by Untari & Sati (2020) found that the partnership between farmers and Wringin Anom Situbondo sugar factory is an effective sub-contract partnership; Fedi et al. (2022) conducted a study at the Wonji/ Shoa sugar factory in Ethiopia and found that contract farmer households in the assisted sugarcane farmer scheme were dissatisfied with the performance of the system. They appeared to have lost hope in solving the problems faced by sugarcane farmers, thus requiring improvements to the partnership scheme.

In addition to sugar producers, sugar factories also manage waste, improving resource use and reducing environmental impacts. Therefore, this study highlights the partnership model between farmers and sugar factories in three regions of Central Java. The study not only describes the partnership model between sugar factories and sugarcane farmers but also presents several sugarcane waste management technologies and

analyses sugarcane farmers' perceptions of the partnership from a cultivation system and socio-economics perspective. This study aims to evaluate sugar factories' performance, waste management practices, the partnership system with farmers, and farmers' perceptions of the impact of partnerships on the production system and the socioeconomics of the community. A key contribution of this study lies in exploring farmers' perspectives on sugarcane production systems, with a particular focus on the socioeconomic dimensions of their partnerships with sugar mills. Capturing these perceptions provides key insight that previous research often overlooks. Positive perceptions will encourage farmers to maintain partnerships with sugar mills, but negative perceptions will hinder the partnership's effectiveness. Therefore, farmer perceptions are crucial as a foundational element for developing sustainable partnership strategies with the sugarcane farmers and increasing their loyalty to the sugar mills.

METHODS

The research was conducted at three sugar factories (SF): (1) Madukismo SF, Bantul Regency, Yogyakarta; (2) Trangkil SF, Pati Regency, Central Java; and (3) Mojo SF, Sragen Regency, Central Java, Indonesia from March to September 2024. These three sugar factories were chosen as research locations because they remain operational in Yogyakarta and Central Java Provinces.

They also have partnerships with local farmers, allowing for a clear understanding of their partnership patterns. Furthermore, their strategic locations support the collection of comprehensive data and information. The methods used in this study, including in-depth interviews, observations, and surveys, were chosen for their comprehensive approach and attention to detail.

In-depth interview and observation method

In-depth interviews were conducted with key informants at the sugar factory including the heads of cultivation, production, engineering and waste management as well as farmers involved in the factory's operations, and partner farmers living both within and outside the factory's surrounding area. Key informants were selected based on their roles in crop cultivation, factory production, and waste management. Additionally, farmer respondents were identified using a snowball sampling technique. This selection process was rigorous and systematic (Ainiyah & Subianto, 2022).

The observation method involved visits to the sugar factory, production areas, and sugarcane plantations, with a focus on the sugar production process and environmental management. This approach is similar to the study by Ainiyah & Subianto (2022), which was conducted at Lestari Sugar Factory in Nganjuk Regency, East Java. The survey method was used to assess farmers' characteristics, their involvement in the sugar

factory, and their perceptions of the impact of sugarcane partnerships on production and local socioeconomics. A total of 44 farmers from the area surrounding sugarcane factories participated, with the sample size meeting the standard of 30 respondents or more (Untari & Sari, 2020). The population size was unknown, the Lemeshow formula was applied with a 95% confidence level and a 10% sampling error, as used by Stevenson (2021) and Piepho et al., (2022). The number of respondents in this study met the criteria for the number of respondents in survey research (Cohen et al., 2017). The respondents were considered representative of sugarcane farmers in three locations, as they shared relatively similar production characteristics due to the support provided by the factory. Respondent farmers ranged in age from 20 to 75, with an average age of 52. Most respondents had a high school education, although a small number (9%) had completed college. On average, farmer-sugar factory partnerships last 16 years, with

durations ranging from 3 to 40. These characteristics are expected to enable farmers to understand the partnership process and provide accurate information.

Data analysis

Data analysis in this study was conducted using qualitative descriptive methods and scoring analysis. The qualitative descriptive methods were used to describe the performance of sugarcane factories and their partnership system with farmers. Qualitative descriptive are one of the methods for obtaining a systematic, factual, accurate overview of the facts, characteristics, and relationships between the phenomena studied (Furidha, 2023). This approach enabled an in-depth understanding of the partnership’s performance and effectiveness, particularly in social, economic, and production contexts. The scoring method was applied to measure farmers' perceptions of partnerships, production systems, socioeconomics, and the associated sugarcane factories. Perception analysis used ordinal data processed

Table 1. Attributes of farmers' perceptions of the sugarcane production system and the socioeconomics of community with the presence of sugar factory

| Attributes of farmers' perceptions | |
|------------------------------------|-----------------------------|
| Sugarcane production | Socioeconomics of community |
| Sugarcane seed | Jobs |
| Fertilizer access | Labor absorption |
| Tractor access | Settlement development |
| Fertilizer price | Agricultural land area |
| Tractor rental | Agricultural production |
| Fertilizer input | Water and air quality |
| Labor | Farmers income |
| Pest and disease | Capital access |
| Sugarcane production | Sugarcane payment |

Source : Primary Data, Processed (2024)

through scoring techniques (Sahara et al., 2021) based on nine attributes outlined in Table 1. The average score for each statement and the interval scale was calculated using the following formula according to Sahara et al., (2021):

$$\text{Average score} = \frac{\text{total score}}{\text{number of respondents}}$$

$$\text{Interval scale} = \frac{(\text{highest value} - \text{lowest value})}{\text{number of interval scales}}$$

Farmers' assessments were structured using a five-point scale, reflecting their confidence in each attribute. This scale, ranging from not very good to very good conditions, provides a systematic way to measure the assessment of attributes. Scale one represents the lowest level of confidence attribute, while scale five signifies the highest level of confidence.

Farmers' perceptions are grouped into five classes, namely: very good, good, neutral, not good and not very good (Oktarina & Malini, 2021). The five categories of perception in this study are defined with the following interval scale: 1) perception is not very good (scale 1.00 - 1.80), 2) perception is not good (scale 1.81 - 2.60), 3) neutral perception (2.61 - 3.40), 4) good perception (3.41 - 4.20), and 5) perception is very good (4.21 - 5.00).

Farmers' perceptions of sugarcane production and socioeconomics were mapped using the Perceptual Mapping technique, visualized through a spider web graph with an average value as a two-dimensional graph. This perceptual mapping can

display the highest and lowest positions of farmers' perceptions of each attribute in two dimensions. This technique describes farmers' perceptions of objects on one or more spatial attributes to see the relationship among them clearly (Chanifah et al., 2021).

RESULTS AND DISCUSSION

Performance of sugar factory

Over the past five years, the Trangkil SF has consistently outperformed the Mojo and Madukismo SF in sugarcane production (Figure 1). The significant expansion of the Trangkil factory's land area dedicated to sugarcane, from 13,460 hectares in 2019 to 21,420 hectares in 2023, has directly contributed to this growth. This expansion is largely due to the factory sourcing sugarcane from Central Java, as well as parts of West Java and East Java.

Conversely, the Madukismo SF experienced a decline in sugarcane land, shrinking from 6,503.62 hectares in 2019 to 5,613.46 hectares in 2023. This reduction resulted in a decline of sugarcane production from 337,929 tons in 2019 to 314,401 tons in 2023. The Madukismo factory mainly receives sugarcane from the Yogyakarta Province and parts of Klaten Regency.

Similarly, the Mojo SF, located in Sragen Regency, Central Java, experienced a reduction in sugarcane land in 2021, dropping to 1,428 hectares with a production of 93,236 tons. However, by 2023, sugarcane production increased to 181,216 tons

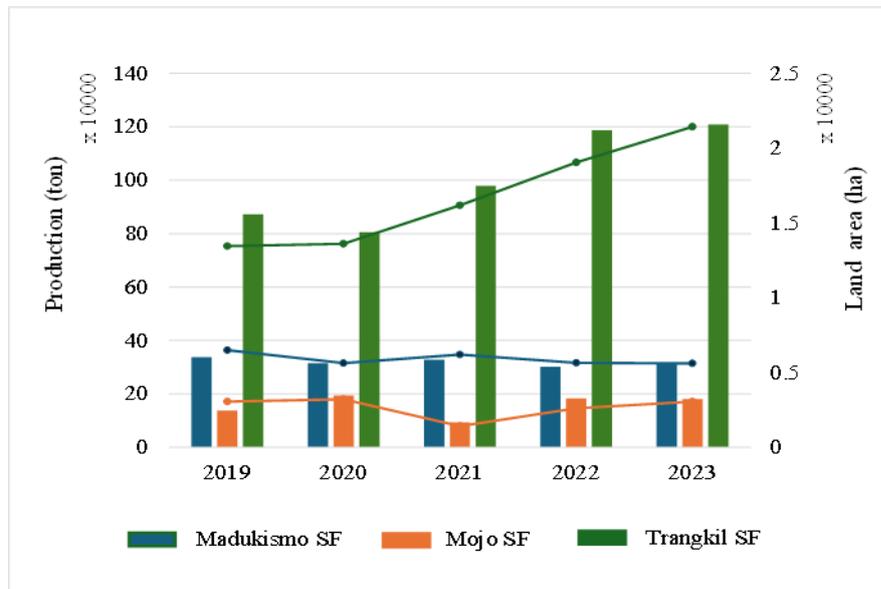


Figure 1. Sugarcane production in 2019-2023
 Source : Primary Data, Processed (2024)

as the land area expanded to 3,058 hectares. The Mojo SF sources its sugarcane primarily from local farmers and nearby areas in Sragen Regency, Central Java.

Sugar factories play a crucial role in preparing raw materials from farmers, but this task comes with several challenges. Declining sugarcane production and outdated machinery result in inefficient performance, hindering the overall process (Khairani et al., 2023). As highlighted by (Kabeyi, 2020) and (Kabeyi & Olanrewaju, 2022), the main challenges faced by sugar factories in Kenya, such as unreliable sugarcane supplies, interrupted milling, poor conversion, and a lack of electricity supply, require urgent collective attention and action. The final product of the sugar factory is sugar for consumption (white crystal sugar/WCS). The number of raw materials, milling capacity, and milling machine operations influence

the performance of the sugar factory in producing WCS. The higher the milling capacity of the sugar factory, the better the performance of the factory.

Changes in sugarcane production in Indonesia, including shifts in planting areas, varieties, and suboptimal land productivity (Riajaya et al., 2022) as well as low technical efficiency and inadequate cultivation management practices (Santosa et al., 2024), contribute to delays in milling, which in turn reduces the sugar yield (Muhtadi et al., 2023). At the industrial level, many sugar mills continue to operate with outdated technology, resulting in low extraction efficiency (Hanani et al., 2023). Unpredictable climate factors also exacerbate production conditions. Thus, the decline in sugarcane production is a result of a combination of agrotechnical, managerial, industrial, and environmental factors, rather than solely from a reduction in planted areas.

Managing and utilizing sugarcane waste

The process of producing sugar from sugar cane generates several types of waste, both solid and liquid. The types of waste produced by sugar factories are: 1) bagasse, which is the sugarcane fiber remaining after the sap (sugar cane juice) is extracted, 2) filter cake, which is the residue the process of refining the sap, 3) liquid waste that still contains sugar and chemicals from the evaporation and crystallization process, and 4) molasses, which is the remainder of the sugar refining process. According to (Makul & Sua-iam, 2016) and (Singh et al., 2021), the process of processing sugar cane into sugar produces main waste that has important economic value, namely bagasse, molasses, and filter cake (filter pulp).

Trangkil SF processes bagasse into boiler fuel to power its production machinery. As Ungureanu et al. (2022) stated, bagasse, or the residue of sugarcane fiber extraction, is used as fuel for steam and electricity generation in a cogeneration system, thereby reducing dependence on fossil fuels. The Sugar Factory (SF) processes solid waste in the form of filter cake into fertilizer for sugarcane plants. Additionally, the SF produces ash from the boiler and filter cake, both of which can be used as compost for sugarcane fields. Madukismo SF processes molasses, the liquid residue from the sugarcane production process, into alcohol, producing vinasse waste. The sugar factory subsequently processes the vinasse

waste into liquid organic fertilizer and distributes it to partner farmers.

a. Bagasse

Bagasse is the fibrous by-product remaining after the extraction of juice during the initial stage of sugar production (Agarwal et al., 2023). Sugar factories produce bagasse ranging from 25% to 40% of the weight of sugarcane. Bagasse fuel is used for production machines, FO oil, and firewood by the sugar factories. Bagasse as fuel in boilers is one way to utilize sugarcane waste to produce some of the energy needed in production (Nunes et al., 2020). Several sugar factories utilize bagasse to produce various products with additional benefits. Research by Chen et al., (2024) shows that bagasse is utilized together with polyvinyl alcohol to become ethanol while Dombinov et al., (2022) used ash from combustion mixed with chicken manure or sewage sludge as fertilizer for soybean plants in a greenhouse. Lu et al. (2024) further processed bagasse into compost using the bioaugmentation method.

b. Filter cake

Filter cake (mud) can be used as compost to enhance soil and plant growth (Silva et al., 2023) and as fuel alongside bagasse in sugar production (Makul & Sua-iam, 2016). Despite its potential, millions of tons are still discarded. Converting filter cake into energy products, such as high-quality pellets with 10-20% moisture, adds value (Pajampa et al., 2024). When combined with biochar, filter cake

improves sugar beet growth and yield and can also be used in concrete for embankment engineering (Wang et al., 2024; Wang et al., 2023).

c. Molasses

Molasses, a byproduct of sugar production, make up around 5% of the waste and contain 50-60% sugar, along with amino acids and minerals. It is a thick, yellow to dark brown liquid with a density around 1.4 to 1.5 g/ml and still holds sucrose, glucose, and fructose (Santos et al., 2019; Moonsamy et al., 2022). The composition of molasses varies depending on soil, climate, sugarcane variety, and refining processes. At the Madukismo SF, 4 kg of molasses is

needed to produce 1 liter of alcohol, while 1 kg can yield 375 grams of ethanol (Sharma et al., 2018). Madukismo produces 250 liters of alcohol daily, while Trangkil SF manufactures pellets, and Mojo SF focuses on molasses. Bumroongsri (2024) developed molasses into a non-calorie sweetener for food and pharmaceuticals, and Mehta and Saboo (2024) used it in bio-asphalt, reducing costs by 20-30%.

d. Vinasse

Vinasse, a waste byproduct of molasses processing into alcohol, is generated at a ratio of about 10 liters per liter of alcohol, resulting in 250,000 liters of waste daily at

Table 2. Potential utilization of sugar factory waste

| Waste type | Benefit | References |
|-------------|------------------------------|--|
| Bagasse | Biogas | Detman et al., (2017); Singh et al., (2024) |
| | Bioethanol | Chen et al., (2024) |
| | Biomass briquet | Raj and Tirkey (2023) |
| | Pellet for fuel | Chen et al., (2021) |
| | Paper raw material | Solís-Fuentes et al., (2019); Zhu et al., (2024) |
| | Activated carbon | Kakom et al., (2023) |
| | Biodegradable food packaging | Thuppahige et al., (2023) |
| | Biochar | Sharma et al., (2024) |
| | Compost | Lu et al., (2024) |
| | Mulch | Yakubu et al., (2021) |
| | Particle board | Salatein et al., (2024) |
| Filter cake | Organic fertilizer | Wang et al., (2024) |
| Molasses | Bioethanol | Hawaz et al., (2024); Moonsamy et al., (2022) |
| | Fermented alcoholic beverage | Samaniego-Sánchez et al., (2020) |
| | Additives in composting | Meng et al., (2020) |
| | Natural food sweetener | Bumroongsri (2024) |
| | Bio-asphalt | Mehta and Saboo (2024) |
| Vinasse | Biofertilizer | Balakrishnan (2024) |
| | Biogas | (Mellyanawaty et al., 2024) |
| | Liquid organic fertilizer | (Carpanez et al., 2022b) |

Source : Primary Data, Processed (2024)

Madukismo SF. This vinasse is repurposed as liquid organic fertilizer (LOF) for sugarcane, serving as a supplement to traditional fertilizers.

Around 0.2–0.68 m³ of vinasse can fertilize 44,260–150,503 hectares annually, highlighting its potential for organo-mineral fertilizer production. (Carpanez et al., 2022a). However, many sugar factories in Indonesia have not fully utilized vinasse and other waste for value-added products, often leading to unsustainable disposal practices that cause pollution and missed economic opportunities (Meghana and Shastri, 2020; Ungureanu et al., 2022). Sugarcane waste management can be utilized to make various products of economic value (Table 2).

Partnership between farmers with sugarcane factory

The partnership between farmers and sugar factories is a cooperative effort to improve sugarcane and sugar productivity. According to (Puspitaningrum & Gayatri, 2019), such partnerships cover the entire process from production to marketing. They address issues such as cultivation challenges, income inequality, regional disparities, and product quality (Datika et al., 2019), benefiting both parties involved (Maryono et al., 2024; Nuraeni et al., 2024; Velten et al., 2021).

In agriculture, partnerships emphasize knowledge transfer and skill development within local communities, which is key in achieving socio-economic goals, such

as job creation (Kaupa & Shindume, 2022). Sugar factories collaborate with various farmer groups-partnered sugarcane farmers (PSF), independent sugarcane farmers (ISF), business cooperatives (BC), and free sugarcane farmers (FSF) to meet production demands, as local sugarcane supplies fulfill only 40-60% of factory needs.

Cooperation between sugar mills and sugarcane farmers is governed by a partnership contract outlining mutual rights and obligations. Farmers must own 0.5-1.0 hectares of sugarcane land and receive support from the factory for production, harvesting, and transportation. However, limited land and internal issues often lead to raw material shortages. Additionally, farmers from outside the region depend on collectors, which can reduce sugar yields due to increased distance and delays in collection.

The sugar factory provides production inputs such as seeds, labor, and machine tools, which are paid for after the sale of sugarcane. The sugar factory cooperates with banking institutions for working capital, providing recommendations based on the history of farmer partnerships. The maximum loan is IDR 20,000/quintal of sugarcane. This facility helps farmers obtain the necessary capital. Sugarcane payments are made with a profit-sharing system (80:20 for Madukismo SF and 70:30 for Trangkil and Mojo SF). Trangkil SF also uses a fixed purchase system with a fixed price per 100 kg of sugarcane, paid through bank transfer if the farmer does not have an outstanding loan.

Farmers perception of sugarcane production system and socioeconomics community

Farmers hold a neutral perception of the sugarcane production system, with an average score of 3.28. Their 30 years of experience have enabled them to manage production effectively. They expressed a very good perception in labor and a good perception in access to and the price of fertilizer. A neutral perception was found in sugarcane seeds, access and rental of tractors, fertilizers, pests and diseases, and sugarcane production (Table 3). Farmers have a very good perception of the availability of labor. Farmers have difficulty getting labor during the planting season because many young workers choose jobs outside the agricultural sector that are more profitable. This difficulty results in delayed planting and hampers production. The growth power of sugarcane seedlings decreases with storage time (Parnidi & Hamida, 2021). Therefore, the process of planting sugarcane seedlings requires sufficient and timely labor.

Fertilizer is a significant input in meeting plant needs and increasing crop production. Plants require appropriate nutrients during growth to increase yields (Alnaass et al., 2021). Sugarcane farmers use NPK fertilizers at 600 kg/ha and ZA at 400 kg/ha, either purchased from shops or facilities from sugar factories. Purchases at shops are made in cash, while those from sugar factories are paid using a profit-sharing system.

Neutral perceptions towards

the sugarcane production system on sugarcane seed attributes indicate that farmers face obstacles in preparing seeds. The sugarcane planted by farmers is either yellow or green sugarcane including varieties such as BS 862, BR 312, and Bulu Lawang. The primary constraints on sugarcane seed preparation are limited availability and access to superior seeds (Ardana et al., 2021), prompting farmers to resort to vegetative propagation through stem cuttings. This practice leads to varietal deterioration due to the high use of seeds from original plants without quality control (Kamat et al., 2023). Therefore, to address this issue, modern propagation technologies, such as tissue culture or the pelleted lateral shoot method, are needed to ensure healthy and uniform seeds (Salokhe, 2021).

Neutral perceptions were also found in tractors' use and rental costs, which are generally available and affordable. Pest and disease control is essential to maintain production because pest attacks can reduce production by up to 20% (Usman, 2020). Farmers' perceptions of sugarcane production tend to be neutral. Farmers' neutral perception indicates that farmers tend to adopt existing technologies such as seed varieties, pest/disease control, and tractors. However, farmers are still willing to accept improvements to increase sugarcane production. Sugarcane production is decreasing due to the reduction of agricultural land and its conversion to non-agricultural land. This condition causes the supply of sugarcane to

Table 3. Farmers' perception of sugarcane production and socioeconomics of the community

| Attributes of farmers' perceptions | | | | | |
|------------------------------------|--------|-----------------------|---------------------------------|--------|-----------------------|
| Sugarcane production | Scores | Perception categories | Socioeconomics of the community | Scores | Perception categories |
| Sugarcane seed | 2.82 | Neutral | Jobs | 3.92 | Good |
| Fertilizer access | 3.63 | Good | Labor absorption | 3.39 | Neutral |
| Tractor access | 2.61 | Neutral | Settlement development | 3.50 | Good |
| Fertilizer price | 3.95 | Good | Agricultural land area | 3.47 | Good |
| Tractor rental | 3.37 | Neutral | Agricultural production | 3.11 | Neutral |
| Fertilizer input | 3.11 | Neutral | Water and air quality | 2.68 | Neutral |
| Labor | 4.24 | Very good | Farmers income | 4.08 | Good |
| Pest and disease | 3.00 | Neutral | Capital access | 4.16 | Good |
| Sugarcane production | 2.84 | Neutral | Sugarcane payment | 4.61 | Very good |

Source : Primary Data, Processed (2024)

sugar factories only to be met at around 60% of production capacity, with the remaining 40% coming from sugarcane from outside the region.

From a socio-economic perspective, farmers have a good perception of nine indicators with an average value of 3.66. One indicator is perceived very well, namely timely sugarcane payment; five attributes are perceived well, and three indicators are perceived as neutral by farmers (Table 3).

Farmers receive payments for sugarcane from the sugar factory on time through a profit-sharing system or cash, depending on prior agreements. The sugar factory supports the creation of local jobs, either as daily laborers, permanent employees, or other supporting businesses. Although employment is positive, labor absorption is perceived as neutral because skilled

labor is needed more, so not everyone can be absorbed in the available jobs.

The development of settlements reduces productive agricultural land, threatens the supply of raw sugarcane to the sugar factory, and undermines the capacity and sustainability of sugar production. Farmers perceive water and air quality as neutral because the sugar factory is quite far from the settlement, so it does not cause significant changes to water and air quality.

Farmers have a positive perception regarding increased income and access to capital through facilities from the sugar factory. This promising trend is further bolstered by the proven success of cooperation between sugarcane farmers and sugarcane mills in West Java, which has increased farmer empowerment through access to capital, provision of production facilities, and marketing of sugarcane,

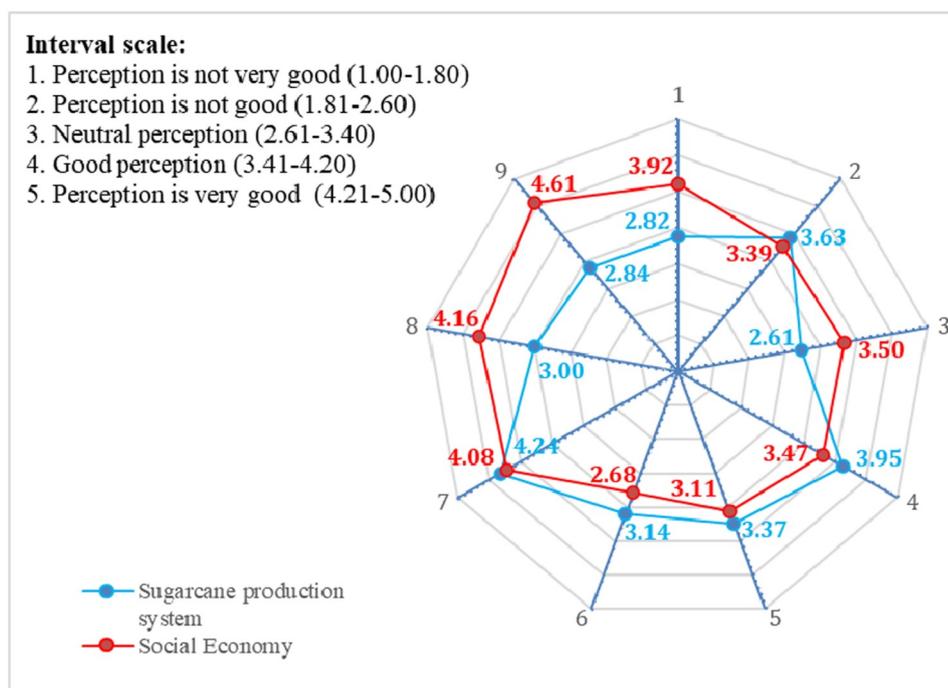


Figure 2. Farmers' perceptual mapping of sugarcane production systems and socioeconomics of sugar factories

Source : Primary Data, Processed (2024)

as well as increasing the income of sugarcane farmers (Rokhani et al., 2020). The sugar industry's potential to significantly increase rural income is a beacon of hope for the future (Sawaengsak and Gheewala, 2017). Farmers' perceptions of the sugarcane production system and the socioeconomics of the community are depicted by perceptual mapping (Figure 2). Most of the attributes in the socio-economic system score higher than those in the sugarcane production system, indicating that farmers perceive partnerships more positively in terms of socioeconomic benefits compared to the production system.

Managerial Implications

This study highlights the critical managerial role of sugar factories in

establishing sustainable partnerships with sugarcane farmers. Factory management should implement fair and transparent partnership policies by creating clear and mutually beneficial contract agreements. Factories also need to provide technical assistance services and production training and facilitate access to farmer financing through cooperation with financial institutions. In addition, optimizing sugarcane waste management through environmentally friendly technological innovations should be a priority, considering the potential of waste as an alternative energy source and industrial raw material. By integrating social, economic, and environmental aspects into managerial policies, sugar factories can improve operational efficiency while strengthening their

contribution to sustainable development in the agricultural and sugar sectors.

Recommendations for sugar factory managerial policies: (1) Sugar factories must strengthen partnerships with farmers through transparent, fair, and mutually beneficial agreements; (2) Factory management is advised to provide technical assistance and facilitate access to farming financing for farmer partners; (3) Farmer institutions must be strengthened to ensure the sustainability of high-quality sugarcane supplies; (4) Sugarcane waste management needs to be optimized through technological innovation and utilizing waste as renewable energy or derivative products; and (5) Factory management needs to integrate social, economic and environmental aspects into partnership strategies to have a positive, sustainable impact.

CONCLUSION AND SUGGESTION

Sugarcane production at the three sugar factories varies and does not meet production capacity requirements, necessitating additional supply from outside the region. Production process efficiency has declined due to reliance on aging machinery. The factories produce and market white crystal sugar to wholesalers and retailers. In addition to the main product, the sugarcane processing generates economically valuable waste in the form of bagasse, molasses, and filter cake, which are used as fuel, alcohol feedstock, and organic fertilizer, respectively. Meanwhile, sugarcane farmers receive support to improve the sugarcane production

system and access to capital through banks to increase sugarcane productivity. Farmers' perceptions of the sugarcane production system and the socio-economic impacts of this partnership also tend to be positive, indicating that this partnership not only increases sugarcane production but also improves the socio-economic conditions of the surrounding community.

This study has limitations, including sugar factory performance, the management and utilization of sugarcane waste, farmer partnerships with sugar factories, and farmer perceptions of the partnership system with sugar factories in the three research locations. The aspects studied focused on technical and socioeconomic dimensions, without including in-depth financial analysis or supply chain efficiency that could strengthen the results of the farmer perception analysis. Therefore, the results of this study are interpreted within the context of the production and partnership systems in effect during the study period.

Therefore, the authors recommend that future research integrate perceptual approaches with quantitative data on the economic and technical performance of farm businesses to provide a more comprehensive and objective analysis of partnerships. Furthermore, sugar factories need to improve efficiency through the modernization of machines and the adoption of more efficient processing technologies. Stakeholders must strengthen partnerships between sugar factories and farmers by implementing

fair and sustainable policies that benefit both parties. Optimizing sugarcane waste management through environmentally friendly innovations is necessary, and further research should focus on the sustainability of production systems and partnerships.

ACKNOWLEDGMENTS

This research activity is supported through RIIM *Kompetisi* funding from the Indonesia Endowment Fund for Education Agency, Ministry of Finance of the Republic of Indonesia and National Research and Innovation Agency of Indonesia according to the contract number: 37/II.7/HK/2023 and 35/III.11/HK/2023. We also thanks to the Research Center for Horticulture, Research Organization for Agriculture and Food, National Research and Innovation Agency and Faculty of Agriculture, Sebelas Maret University of Surakarta, Indonesia for supporting this research activities.

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