



APPLICATION OF ROBUSTA COFFEE PLANT CULTIVATION IN AGROFORESTRY, MAMASA REGENCY

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ABSTRACT

This study examines the implementation of Robusta coffee agroforestry by KTH Kanan Hijau Lestari in Mamasa Regency, Indonesia. The study focuses on coffee cultivation practices, agroforestry patterns, associated plant species, productivity-related constraints, and opportunities for coffee product diversification. A descriptive qualitative approach was employed through field observations, in-depth interviews, structured questionnaires, and document analysis involving 15 coffee farmers. The findings indicate that the farmer group predominantly applies a random-mixture agroforestry pattern, integrating Robusta coffee with various associated plant species, particularly avocado (32%) and cempaka (15%), with planting spacings ranging from 1 × 2.5 m to 2.5 × 2.5 m. Farmers identified several constraints potentially associated with low coffee productivity, including variable fertilizer management, non-selective harvesting, inadequate post-harvest handling, and limited processing facilities. Product diversification remains limited due to insufficient processing knowledge, inadequate equipment, and restricted market access. Opportunities exist to develop value-added products, particularly ground coffee and drip-bag coffee, through technical training, improved processing facilities, and strengthened market access. Strengthening farmers' technical capacity and institutional support is therefore important for improving the sustainability and economic value of the coffee-based agroforestry system.

Keywords

Agroforestry; Robusta_Coffee; Product_Diversification; Community; Empowerment.

INTRODUCTION

KTH Kanan Hijau Lestari is one of the farmer organizations implementing a coffee agroforestry system in Mamasa Regency, Indonesia. The group adopts an integrated land management approach by cultivating Robusta coffee alongside various tree species, including timber trees for shade, fruit trees for product diversification, and ground cover plants to improve soil conservation and ecosystem sustainability.

Indonesia plays a strategic role in the global coffee industry, with more than 1.2 million hectares of coffee plantations and an annual production of approximately 700,000–800,000 tons. Mamasa Regency has a comparative advantage in coffee cultivation, particularly Robusta coffee, with approximately 286 hectares of Robusta plantations and 278 hectares of Arabica plantations. The region's hilly topography and elevation ranging from 400 to 800 meters above sea level provide favorable

environmental conditions for coffee cultivation (Badan Pusat Statistik, 2020). However, the elevation range reported for Mamasa Regency represents the broader topographic conditions of the regency and does not necessarily describe every local agricultural area. The specific coffee agroforestry site investigated in this study is located at a higher elevation, reflecting local topographic variation within Mamasa Regency.

Agroforestry is a sustainable land-use system that integrates perennial crops, such as coffee, with other plant species to improve ecological and economic outcomes. According to Nair (2021), agroforestry is a multifunctional land-use system that can enhance land productivity while contributing to soil conservation, biodiversity, ecosystem resilience, and livelihood diversification. By integrating multiple plant species within the same production system, agroforestry can also help farmers diversify production and reduce risks associated with environmental variability and market fluctuations.

Coffee-based agroforestry systems enable farmers to produce a wide range of products beyond coffee, including fruits, vegetables, and processed products. The Food and Agriculture Organization (FAO, 2018) emphasizes that product diversification can increase household income, improve food security, and strengthen the economic resilience of farming communities. Despite its considerable potential, coffee farmers in Mamasa continue to face several challenges. Coffee productivity in the study area remains a major concern, as indicated by the relatively low production reported by farmers. Additional constraints include climate variability, pest and disease outbreaks, particularly coffee leaf rust (*Hemileia vastatrix*), and fluctuations in market prices. Furthermore, limited research has examined the optimization of Robusta coffee cultivation practices within agroforestry systems under the hilly environmental conditions characteristic of Mamasa. This gap highlights the need for studies that integrate agronomic, ecological, and socio-economic perspectives to improve coffee production and sustainability. This study aims to examine the implementation of Robusta coffee cultivation practices within the agroforestry system managed by KTH Kanan Hijau Lestari, describe cultivation practices and productivity-related constraints, characterize the agroforestry model and associated plant species, and explore opportunities for coffee product diversification. The findings are expected to provide practical information for strengthening coffee agroforestry management, farmer capacity, and value-added processing in Mamasa Regency and other areas with comparable agroecological conditions.

RESEARCH METHODOLOGY

This study was conducted in Kanan Village, Tanduk Kalua District, Mamasa Regency, West Sulawesi Province, Indonesia, from September to December 2024. The study focused on the coffee agroforestry area managed by KTH Kanan Hijau Lestari within the Community Forest (Hutan Kemasyarakatan/HKm) scheme. A descriptive qualitative case-study approach was employed to document Robusta coffee cultivation practices, agroforestry patterns, associated plant species, productivity-related constraints, and opportunities for product diversification.

The study involved 15 coffee farmers affiliated with KTH Kanan Hijau Lestari. Respondents were selected based on their involvement in coffee cultivation within the KTH-managed agroforestry area.

Primary data were collected through field observations, in-depth interviews, structured questionnaires, and document analysis. Field observations were conducted to document agroforestry arrangements, coffee cultivation practices, planting spacing, associated plant species, harvesting methods, post-harvest handling, and farm management activities. In-depth interviews were conducted to obtain information regarding farmers' experiences, cultivation constraints, productivity-related problems, processing practices, and opportunities for product diversification. Structured questionnaires were used to collect information on farm characteristics, coffee species, planting spacing, fertilizer use, harvesting practices, production, productivity, and socio-economic characteristics. Relevant institutional documents were reviewed to complement field observations and interview findings.

Qualitative data were analyzed descriptively to identify patterns in farmers' cultivation practices, perceptions, constraints, and opportunities for product diversification. Quantitative data were summarized using descriptive statistics, including frequencies, percentages, means, and ranges. Planting density was calculated from planting spacing using the theoretical formula: $10,000 \text{ m}^2$ divided by the area occupied by one coffee plant. Because the study was designed as a descriptive case study with 15 respondents, no inferential statistical tests were conducted. Therefore, observed relationships between cultivation practices and productivity are interpreted descriptively and are not presented as causal effects.

RESULTS AND DISCUSSION

Characteristics of the Study Area

The study was conducted in the Social Forestry area managed by KTH Kanan Hijau under the Community Forest (Hutan Kemasyarakatan/HKm) scheme. The study area is located within a protected forest in Kanan Village, Tanduk Kalua District, Mamasa Regency, West Sulawesi Province, Indonesia.

The management permit for the Social Forestry area was officially granted by the Indonesian Ministry of Environment and Forestry through Decree No. SK.7947/MENLHK-PSKL/PKPS/PSL.0/8/2023, issued on 4 August 2023. According to the Business Development Proposal for KTH Kanan Hijau Lestari Coffee Enterprise Group (Coffee-Based Agroforestry KUPS), the approved Social Forestry management area covers approximately 217 ha.

The area has been developed as a coffee-based agroforestry system, integrating Robusta coffee with timber and multipurpose tree species under the Community Forest management scheme. This approach aims to improve forest conservation while enhancing farmers' livelihoods through sustainable coffee production and diversified forest-based products.

Kanan Village can be accessed by road within approximately 13 minutes from the district capital via the main road network. The roads, which are predominantly paved with concrete and asphalt, provide convenient access for both motorcycles and four-wheeled vehicles. However, reaching the Social Forestry Community Forest (Hutan Kemasyarakatan/HKm) area managed by KTH Kanan Hijau Lestari requires traveling an additional 2.5 km from the village. This journey takes approximately 45

minutes along unpaved village roads consisting of rocky and earthen surfaces, which are accessible only by motorcycles (LPPM UNIBOS, 2024).

Table 1. Location and Characteristics of the Social Forestry Area Managed by KTH Kanan Hijau Lestari

No.	Description	Information
1.	Area Size (Ha)	± 217 ha
2.	Location	
	a. Geographic Coordinates	Located between 119°19'51.23" E and 03°05'31.36" S
	b. Forest Status	Protected Forest (HL)
	c. Administrative Area	Province: West Sulawesi Regency: Mamasa District: Tanduk Kalua Village: Kanan
	d. Area Boundaries	North: Tamalantik Village South: Mesakada Village East: Salubalo Village West: Banea Village

Source: Data processing results, 2026

Field observations showed that the elevation of the coffee agroforestry area ranges from 1,057 to 1,117 m above sea level (masl), as measured using the SW Maps application. According to Sirappa et al. (2017), Tanduk Kalua District experiences average air temperatures of 18–23°C and annual rainfall of approximately 2,140 mm. More broadly, Mamasa Regency has a humid tropical climate, with minimum temperatures of around 19°C and an average maximum temperature of 28.1°C. These environmental conditions are considered favorable for coffee cultivation, particularly within agroforestry systems that benefit from cool temperatures and high rainfall.

Based on interviews with members of KTH Kanan Hijau Lestari, most respondents were engaged in farming as their primary occupation. Their educational backgrounds ranged from elementary school to senior high school/vocational school, with the majority having completed primary or secondary education. The size of the farmland managed by individual farmers varied between 0.5 and 3.0 ha, with an average holding of 1–2 ha. Two respondents owned the largest farms, each covering 3 ha. Overall, the coffee agroforestry area managed by the KTH covers approximately 20.5 ha within the approved Community Forest (HKm) management area.

Coffee Cultivation Practices

Nursery Practices

KTH Kanan Hijau Lestari does not apply conventional nursery techniques, such as raising seedlings from seeds in polybags. Instead, coffee propagation relies on the natural regeneration of existing coffee trees that are old or have experienced declining productivity. Naturally emerging seedlings growing beneath or around the mother trees are selected as planting materials for farm establishment. Seedlings with a height of approximately 20–40 cm are carefully uprooted and directly transplanted into farmers' fields without undergoing a nursery phase in polybags.

This practice minimizes nursery costs and utilizes locally adapted planting materials. However, the absence of seed selection and nursery management may result in uneven seedling quality and variable field performance, potentially affecting plant growth, productivity, and long-term plantation sustainability.

Land Preparation and Planting

After suitable coffee seedlings were obtained, they were transplanted directly into fields that had been prepared in advance. Planting holes were manually excavated according to the size of the seedling root system to minimize root damage during transplanting and to promote successful establishment in the field. Land preparation was relatively simple and involved clearing weeds and undesirable vegetation before planting. The direct use of naturally regenerated seedlings without a nursery stage reflects the farmers reliance on locally available planting materials and traditional cultivation practices. While this approach reduces production costs and labor requirements, the absence of standardized land preparation and planting techniques may lead to variability in seedling establishment, growth performance, and plantation productivity.

Table 2. Coffee Planting Spacing Used by the Respondents

No.	Respondent	Planting Spacing (m)	Estimated Plant Population per Hectare
1.	Hamdan	1 x 2,5	4.000
2.	Arifin	2,5 x 2,5	1.600
3.	Joni	2,5 x 2,5	1.600
4.	Martinus	2 x 2	2.500
5.	Alprius	2 x 2	2.500
6.	Demma Gau	2,5 x 2,5	1.600
7.	Asmedi	2 x 2	5.000
8.	Kornelius	2 x 2	5.000
9.	Deppalanna'	2,5 x 2,5	1.600
10.	Agus Palangi	2 x 2	2.500
11.	Ariander	2 x 2	2.500
12.	Meri	2 x 2	2.500
13.	Toding Karaeng	2,5 x 2,5	1.600
14.	Zakaria	2,5 x 2,5	1.600
15.	Marthinus K.	2 x 2	2.500

Source: Data processing results, 2026

The data presented in Table 2 indicate that planting spacing was not standardized among the 15 respondents. The most common spacing was 2.0×2.0 m, practiced by eight respondents (53.3%), followed by 2.5×2.5 m, adopted by six respondents (40.0%), while one respondent (6.7%) used 1.0×2.5 m. Based on the reported spacing, the corresponding theoretical plant population densities are 2,500, 1,600, and 4,000 plants ha^{-1} , respectively. The variation in spacing suggests that farmers adjusted planting arrangements according to individual preferences, site conditions, and farm management practices.

Coffee Crop Management

Field observations revealed considerable variation in coffee crop management practices among members of KTH Kanan Hijau Lestari. The differences were

primarily reflected in fertilizer application and pruning practices, suggesting that cultivation management was not standardized across respondents.

Based on data collected from the 15 respondents, most farmers applied a combination of organic and inorganic fertilizers to maintain coffee growth and productivity. Among the organic fertilizers, compost was the most widely used, with all respondents (100%) reporting its application. Chicken manure was used by seven respondents (47%), while liquid organic fertilizer was applied by only five respondents (33%). The relatively low adoption of liquid organic fertilizer was mainly attributed to its higher cost compared with other organic fertilizer sources.

Regarding inorganic fertilizers, urea, Phonska (NPK compound fertilizer), and ZA (ammonium sulfate) were each used by eight respondents (53%). The combined use of organic and inorganic fertilizers reflects farmers' efforts to improve soil fertility while ensuring adequate nutrient availability for coffee plants. However, the variation in fertilizer types and application practices suggests that nutrient management remains largely dependent on individual farmer experience rather than standardized technical recommendations, which the variation in fertilizer types and application practices indicates that nutrient management was largely based on individual farmer experience rather than standardized recommendations. These differences may be associated with variation in crop management outcomes; however, the present descriptive study did not statistically test the relationship between fertilizer practices and coffee productivity.

Harvesting and Post-Harvest Practices

Harvesting and post-harvest handling represent critical stages in determining the final quality of coffee beans. Figure 1 illustrates the harvesting practices adopted by coffee farmers in the KTH Kanan Hijau Lestari, which generally reflect traditional methods adapted to local environmental and socio-economic conditions.

The observed harvesting practices indicate that farmers primarily rely on manual harvesting techniques. These methods are influenced by the accessibility of the plantation area, labor availability, and farmers' experience. Consequently, harvesting and post-harvest operations play a crucial role in maintaining bean quality and preserving the economic value of coffee. Improving harvesting techniques and post-harvest management is therefore essential to enhance product quality and increase the competitiveness of Robusta coffee produced under the agroforestry system.

Based on interviews with the farmers, coffee harvesting was predominantly carried out using the strip-picking method, in which both unripe (green) and ripe (red) coffee cherries were harvested simultaneously from the same branch. Although this practice reduces harvesting time and labor requirements, it may lower bean quality because cherries of different maturity levels are mixed during processing.

Post-harvest handling also remains largely traditional. After harvesting, coffee cherries are manually depulped using a wooden mortar and pestle before being dried under direct sunlight. While these practices are simple and inexpensive, they provide limited control over processing consistency and bean quality. The absence of selective harvesting and improved post-harvest technologies may reduce the physical and sensory quality of the coffee, thereby limiting its market value and competitiveness. Selective harvesting of ripe cherries is generally considered important for maintaining more uniform raw material quality and supporting consistent post-harvest processing (Kazama et al., 2020).



Figure 1. Coffee Harvesting Practices

Associated Plant Species

Based on field observations, the majority of farmers cultivated Robusta coffee (*Coffea canephora*), while only a few grew Arabica coffee (*Coffea arabica*). Several farmers cultivated both coffee species within the same agroforestry system to diversify production and adapt to varying site conditions. The distribution of coffee species and associated plant species within the agroforestry area managed by KTH Kanan Hijau Lestari is presented in Figure 2.

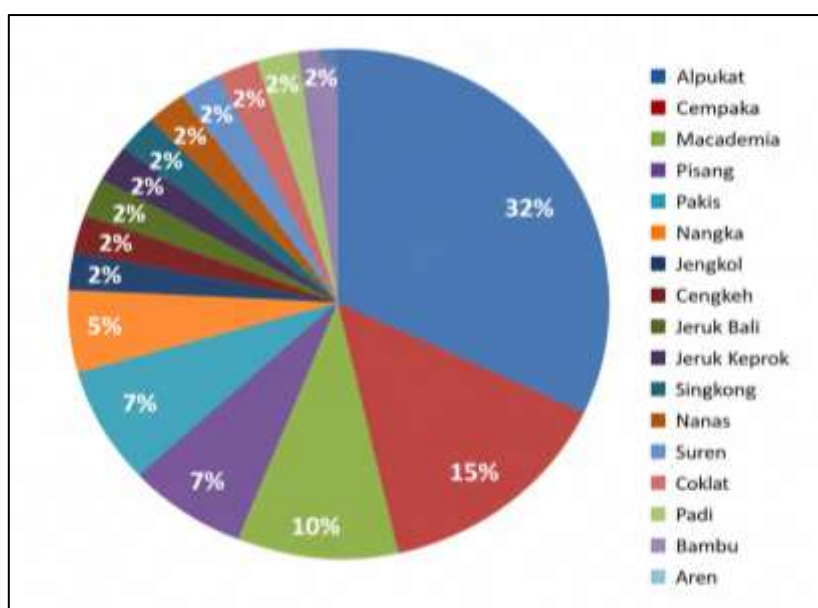


Figure 2. Composition of Associated Plant Species in the Coffee Agroforestry System

In addition to coffee, farmers cultivated a wide range of associated plant species within their agroforestry systems (Figure 2). Avocado (*Persea americana*) was the most dominant associated species, accounting for 32% of the recorded plant composition, followed by cempaka (*Magnolia champaca*), which accounted for 15%. Several farmers also planted timber species, including cempaka (*Magnolia champaca*) and suren (*Toona sinensis*), which provide shade and contribute to the ecological stability of the agroforestry system. Fruit crops such as jackfruit (*Artocarpus heterophyllus*), banana (*Musa paradisiaca*), pomelo (*Citrus maxima*), pineapple

(*Ananas comosus*), and cassava (*Manihot esculenta*) were also commonly cultivated to diversify farm production and household income.

In addition, several high-value economic crops were identified, including cacao (*Theobroma cacao*), macadamia (*Macadamia integrifolia*), and sugar palm (*Arenga pinnata*). The tree fern (*Alsophila spinulosa*) was also observed in several plots, where it occurred naturally without deliberate cultivation. Species such as jengkol (*Pithecellobium jiringa*), clove (*Syzygium aromaticum*), pomelo (*Citrus maxima*), cassava (*Manihot esculenta*), pineapple (*Ananas comosus*), suren (*Toona sinensis*), cacao (*Theobroma cacao*), rice (*Oryza sativa*), bamboo (Bambusoideae), and sugar palm (*Arenga pinnata*) were the least represented, each accounting for approximately 2% of the total associated plant composition.

The diversity of associated plant species demonstrates that the coffee agroforestry system implemented by KTH Kanan Hijau Lestari extends beyond coffee production by integrating timber, fruit, food, and high-value commercial crops. Such diversification can enhance biodiversity, improve ecosystem services, reduce production risks, and provide multiple sources of income, thereby strengthening the ecological and economic sustainability of the agroforestry system.

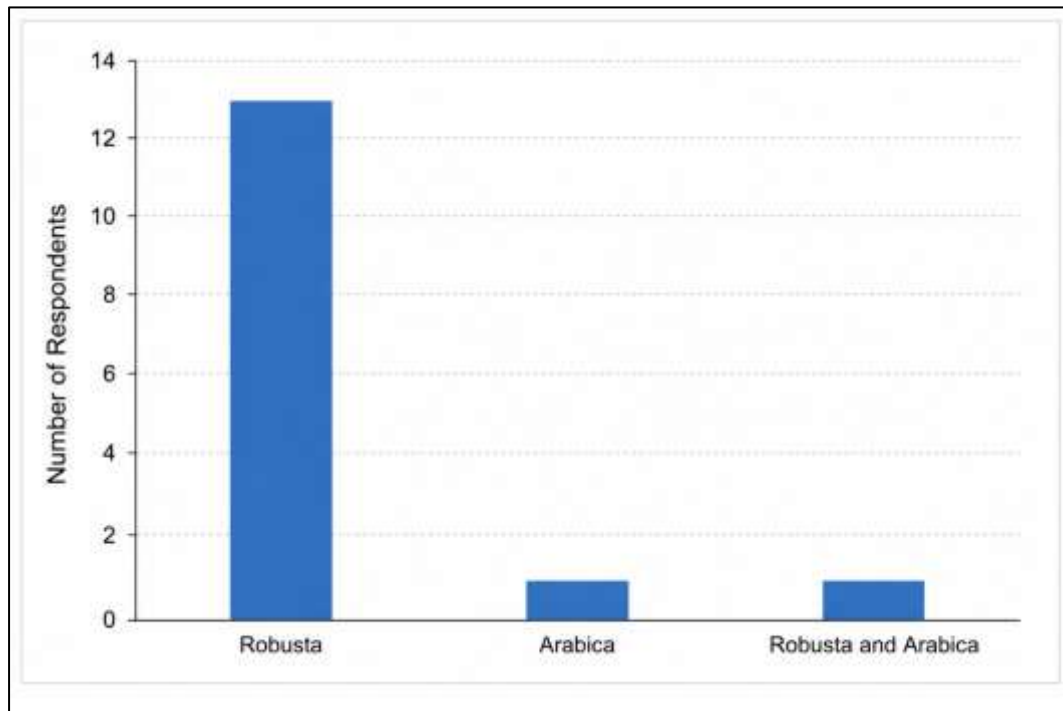


Figure 3. Coffee Species Cultivated by KTH Kanan Hijau Lestari

Figure 3 shows the distribution of coffee species cultivated by members of the KTH Kanan Hijau Lestari. The majority of respondents (86%) cultivated Robusta coffee (*Coffea canephora*), while 7% cultivated Arabica coffee (*Coffea arabica*) exclusively. The remaining 7% cultivated both Robusta and Arabica within the same farming system. These findings indicate that Robusta is the predominant coffee species cultivated by farmers in the study area.

The predominance of Robusta coffee may be related to its adaptation to the environmental and management conditions of the study area. The relatively cool temperatures, high rainfall, and mountainous terrain provide conditions under which Robusta can be cultivated. However, because this study did not compare the

physiological performance or genotype of Robusta and Arabica, the observed predominance should be interpreted as a field observation rather than evidence of superior adaptation.

Field observations further identified two land-use models practiced by the KTH Kanan Hijau Lestari, namely agrosilvicultural and monoculture systems. The agrosilvicultural system integrates coffee with a variety of associated plant species, including timber trees, fruit trees, and other economically valuable crops. This diversified planting pattern enhances ecological functions, such as soil conservation, microclimate regulation, nutrient cycling, and biodiversity conservation, while simultaneously providing multiple sources of income for farmers. In contrast, the monoculture system consists solely of coffee plants and is adopted by only a small proportion of farmers. Although monoculture management may simplify cultivation practices, it generally offers fewer ecological and economic benefits than diversified agroforestry systems, particularly in terms of environmental resilience and long-term farm sustainability.

Table 3. Coffee and Associated Plants Species in the Agroforestry System

Coffee Species	Associated Plant Species
Robusta (<i>Coffea canephora</i>)	Avocado (<i>Persea americana</i>), Macadamia (<i>Macadamia integrifolia</i>), Cempaka (<i>Magnolia champaca</i>), Clove (<i>Syzygium aromaticum</i>), Jeruk Bali (<i>Citrus maxima</i>), Banana (<i>Musa paradisiaca</i>), Cassava (<i>Manihot esculenta</i>), Pineapple (<i>Ananas comosus</i>)
	Avocado (<i>Persea americana</i>), Jengkol (<i>Pithecellobium jiringa</i>), Macadamia (<i>Macadamia integrifolia</i>), Cempaka (<i>Magnolia champaca</i>)
Robusta (<i>Coffea canephora</i>) dan Arabica (<i>Coffea arabica</i>)	Jackfruit (<i>Artocarpus heterophyllus</i>), Cempaka (<i>Magnolia champaca</i>), Suren (<i>Toona sinensis</i>), Banana (<i>Musa paradisiaca</i>)
	Avocado (<i>Persea americana</i>), Jackfruit (<i>Artocarpus heterophyllus</i>), Banana (<i>Musa paradisiaca</i>), Cacao (<i>Theobroma cacao</i>)
Robusta (<i>Coffea canephora</i>)	Avocado (<i>Persea americana</i>), Macadamia (<i>Macadamia integrifolia</i>), Tree fern (<i>Alsophila spinulosa</i>)
	Avocado (<i>Persea americana</i>), Macadamia (<i>Macadamia integrifolia</i>), Cempaka (<i>Magnolia champaca</i>)
	Avocado (<i>Persea americana</i>), Macadamia (<i>Macadamia integrifolia</i>)
	Avocado (<i>Persea americana</i>), Cempaka (<i>Magnolia champaca</i>)
Arabica (<i>Coffea arabica</i>)	Banana (<i>Musa paradisiaca</i>), Rice (<i>Oryza sativa</i>)
	Avocado (<i>Persea americana</i>)
	Bamboo (<i>Bambusoideae</i>), Sugar Palm (<i>Arenga pinnata</i>)
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Source: Data processing results, 2026

Table 3 shows that Based on the classification used in this study, the coffee-based agroforestry system was predominantly classified as an agrosilvicultural system because coffee was integrated with timber and multipurpose tree species. Within this system, two planting arrangements were observed: random mixture and trees along borders. In the random-mixture pattern, coffee and associated species

were distributed irregularly within the same cultivation area, whereas in the trees-along-border pattern, associated trees or crops were planted along field boundaries while coffee occupied the main cultivation area.

A total of 16 associated plant species were recorded within the coffee agroforestry system. These included avocado (*Persea americana*), cempaka (*Magnolia champaca*), rice (*Oryza sativa*), bamboo (*Bambusoideae*), sugar palm (*Arenga pinnata*), macadamia (*Macadamia integrifolia*), banana (*Musa paradisiaca*), tree fern (*Alsophila spinulosa*), jackfruit (*Artocarpus heterophyllus*), jengkol (*Pithecellobium jiringa*), clove (*Syzygium aromaticum*), jeruk bali (*Citrus maxima*), cassava (*Manihot esculenta*), pineapple (*Ananas comosus*), suren (*Toona sinensis*), and cacao (*Theobroma cacao*).



Figure 4. Random Mixture and Trees Along Border

Figure 4 illustrates the coffee agroforestry models based on two planting patterns. In the random mixture pattern, robusta coffee is cultivated together with several shade tree species, including suren (*Toona sinensis*) and avocado (*Persea americana*), as well as other associated crops such as banana (*Musa paradisiaca*) and cassava (*Manihot esculenta*). This pattern represents a diversified agroforestry arrangement in which coffee and associated plant species are distributed irregularly within the same cultivation area. In the trees along border pattern, robusta coffee and banana are planted along the boundaries of rice (*Oryza sativa*) fields. This arrangement allows farmers to combine coffee and other perennial crops with food crops while optimizing the use of available land.

Table 4. Number of Respondents Adopting Different Agroforestry Models

No.	Agroforestry Model	Planting Pattern	Number of Respondents
1.	Agrosilviculture	Random Mixture	13
		Tree Along Border	1
2.	Monoculture	Single Species System	1
Total			15

Source: Data processing results, 2026

Table 4 presents the number of respondents adopting different agroforestry models and planting patterns. The KTH Kanan Hijau Lestari predominantly practiced coffee-based agroforestry using the random mixture pattern, which was adopted by 13 respondents (86.7%). In comparison, the trees-along-border pattern was practiced by only one respondent (6.7%). Meanwhile, the monoculture system, characterized by a row planting pattern, was also adopted by only one respondent (6.7%). These findings indicate that random mixture is the predominant planting pattern within the coffee agroforestry system managed by the KTH Kanan Hijau Lestari, reflecting farmers' preference for integrating coffee with various associated plant species within the same cultivation area. These percentages are descriptive and reflect the distribution of the 15 respondents rather than population-level estimates for coffee farmers in Mamasa Regency.

Coffee Product Diversification

Coffee product diversification is an important strategy for increasing value added and market competitiveness. Field observations revealed that all respondents still relied primarily on the sale of fresh coffee cherries (wet parchment/coffee in cherry form) as their main source of coffee-related income. Several constraints hindered efforts to diversify coffee products, including limited knowledge of coffee processing, lack of processing equipment, high production costs, limited market access for packaged products, and insufficient marketing and institutional support from the farmer group.

These findings highlight the need for a holistic intervention approach that combines farmer capacity building, processing infrastructure, product development, and market support. Strengthening these components could enable farmers to move beyond raw coffee sales toward value-added products, such as roasted and ground coffee and drip-bag coffee, thereby creating additional income opportunities and improving the economic sustainability of the coffee agroforestry system. The constraints and potential opportunities for coffee product diversification are presented in Table 5.

Most farmers still sell their coffee in wet parchment form, primarily due to limited processing knowledge, inadequate equipment, and restricted market access. Neilson et al. (2018) reported that product diversification, including ground coffee and packaged coffee products, can substantially increase profit margins, potentially by up to 300%. Similar constraints, particularly limited access to processing facilities and technical training, have also been reported among smallholder coffee farmers in Ethiopia (Tadesse et al., 2020). Therefore, collaborative interventions involving government agencies, non-governmental organizations (NGOs), and other relevant stakeholders are needed to provide coffee processing equipment, strengthen packaging skills, and facilitate access to digital marketing platforms.

The global specialty coffee market continues to expand, driven by growing consumer demand for value-added products such as single-origin coffee and environmentally friendly packaging (ICO, 2020). The Kanan area has considerable ecological potential, particularly its elevation of more than 1,000 m above sea level, which may support the production of high-quality coffee. Diversification into ground coffee and 250-g packaged products, supported by appropriate branding such as “Mamasa Agroforestry Coffee”, could create opportunities to access urban consumers and e-commerce markets. Previous research in Brazil also reported that farmers who

processed coffee into ground products obtained approximately 2.5 times higher income than those who sold coffee in unprocessed form (Martinez et al., 2021).

Table 5. Constraints and Potential Opportunities for Coffee Product Diversification in KTH Kanan Hijau Lestari

No.	Respondent	Current Product	Reasons for Not Diversifying	Proposed Diversification Potential
1.	Hamdan	Wet parchment coffee	Limited processing knowledge	Ground coffee processing training
2.	Arifin	Wet parchment coffee	No processing equipment	Ground coffee processing training
3.	Joni	Wet parchment coffee	Focus on direct sales	Ground coffee processing training
4.	Martinus	Wet parchment coffee	No market for packaged coffee	Ground coffee processing training
5.	Alprius	Wet parchment coffee	High processing costs	Ground coffee processing training
6.	Demma Gau	Wet parchment coffee	Lack of time for processing	Ground coffee processing training
7.	Asmedi	Wet parchment coffee	No marketing partners	Ground coffee processing training
8.	Kornelius	Wet parchment coffee	Limited support from the farmer group	Ground coffee processing training
9.	Deppalanna'	Wet parchment coffee	No market demand	Ground coffee processing training
10.	Agus Palangi	Wet parchment coffee	No storage facilities	Ground coffee processing training
11.	Ariander	Wet parchment coffee	Lack of packaging skills	Ground coffee processing training
12.	Meri	Wet parchment coffee	Limited access to technology	Ground coffee processing training
13.	Toding	Wet parchment coffee	Lack of financial support	Ground coffee processing training
14.	Zakaria	Wet parchment coffee	Lack of self-confidence	Ground coffee processing training
15.	Martinus	Wet parchment coffee	No development plan	Ground coffee processing training

Source: Data processing results, 2026



Figure 5. Coffee Product Diversification Training at KTH Kanan Hijau Lestari

In addition to the training provided by LPPM Unibos, the KTH Kanan Hijau Lestari is also expected to receive productive processing equipment, including a huller, pulper, and coffee roasting machine, through the Forest Programme IV, implemented by the Karama Watershed Management Agency (BPDAS Karama). This equipment support is expected to address the processing requirements for ground coffee and drip-bag coffee, enabling the farmer group to increase its production capacity and expand the market reach of its value-added coffee products.

The combination of technical training and productive equipment support provides KTH Kanan Hijau Lestari with significant opportunities to develop its coffee enterprise. By applying product diversification strategies and optimizing the available processing equipment, the farmer group can improve the quality, value, and competitiveness of its coffee products while expanding access to higher-value markets. Furthermore, strengthening local processing capacity can reduce farmers' dependence on raw coffee sales and contribute to the long-term economic sustainability of the coffee-based agroforestry system in the study area.

CONCLUSION

Based on the findings of this study on the management of the Community Forest (HKm) by KTH Kanan Hijau Lestari in Kanan Village, Mamasa Regency, West Sulawesi, the coffee-based agroforestry system is developed within a ± 217 ha protected forest area under environmental conditions characterized by an elevation of 1,057–1,117 m above sea level, temperatures of 18–23°C, and annual rainfall of approximately 2,140 mm. Although the study site is located at 1,057–1,117 m above sea level, which is above the commonly cited altitude range for Robusta coffee cultivation, the presence of established Robusta coffee production indicates that cultivation is locally feasible under the agroecological and management conditions observed in the study area. However, this study did not evaluate genotype, physiological adaptation, or the relationship between elevation and coffee productivity; therefore, the mechanisms underlying Robusta performance at this elevation require further investigation.

The agroforestry system is predominantly characterized by the random mixture pattern (86%), incorporating associated plant species such as avocado (32%), cempaka, and macadamia. This diversified system has the potential to support

biodiversity conservation, ecological resilience, and income diversification. In contrast, the limited adoption of Arabica monoculture (7%) may be more vulnerable to climate variability and pest pressures. Coffee product diversification remains limited, as farmers primarily sell coffee in wet parchment form due to constraints in processing knowledge, equipment, and market access. Nevertheless, opportunities for developing ground coffee, drip-bag coffee, and premium packaged products are emerging through training provided by LPPM UNIBOS and productive equipment support from BPDAS Karama.

From a socio-economic perspective, most farmers manage relatively small landholdings of 1–2 ha and have basic to secondary levels of formal education. Although small-scale landholdings may constrain economies of scale, participation in farmer organizations provides opportunities to strengthen technical capacity through collective training and knowledge exchange. Overall, integrating agroforestry practices, technical capacity building, value-added processing, and institutional strengthening is essential for improving the ecological resilience, economic viability, and long-term sustainability of coffee-based agroforestry managed by KTH Kanan Hijau Lestari.

REFERENCES

- Agrawal, A., & Chhatre, A. (2006). *Explaining success on the commons: Community forest governance in the Indian Himalaya*. *World Development*, 34(1), 149–166. <https://doi.org/10.1016/j.worlddev.2005.07.013>
- Badan Pusat Statistik. (2020). Kabupaten Mamasa dalam Angka 2020. Mamasa: Badan Pusat Statistik Kabupaten Mamasa.
- Davis, A. P., Gole, T. W., Baena, S., & Moat, J. (2012). *The impact of climate change on indigenous Arabica coffee (Coffea arabica): Predicting future trends and identifying priorities*. *PLOS ONE*, 7(11), e47981. <https://doi.org/10.1371/journal.pone.0047981>
- Fisher, R. J., Maginnis, S., Jackson, W. J., Barrow, E., & Jeanrenaud, S. (2018). *Linking conservation and poverty reduction: Landscapes, people and power*. Routledge.
- Food and Agriculture Organization (FAO). (2018). *Agroforestry for Sustainable Land Use*. FAO Report.
- Gautz, L. D., Bittenbender, H. C., & Mauri, S. (2002). *Effect of mechanized pruning on coffee regrowth and fruit maturity timing*. ASAE Meeting Presentation, Paper No. 021110. American Society of Agricultural Engineers (ASAE).
- Hakim, L. 2021. *Agroforestri Kopi: Mendorong Taman Hayati dan Wisata Kopi*. Malang: Media Nusa Creative Anggota IKAPI (162/JTI/2015).
- International Coffee Organization (ICO). (2020). *Coffee harvesting practices: Guidelines for selective picking to ensure uniform bean maturity*. International Coffee Organization.
- Kazama, E. H., Silva, R. P. da, Tavares, T. de O., Correa, L. N., Estevam, F. N. de L., Nicolau, F. E. de A., & Maldonado Júnior, W. (2020). *Methodology for selective coffee harvesting in management zones of yield and maturation*. *Precision Agriculture*, 21(6), 1–23. <https://doi.org/10.1007/s11119-020-09751-1>.
- Kusuma, D., et al. (2020). *Liquid organic fertilizer enhances micronutrient availability and coffee growth in agroforestry systems*. *Journal of Soil Science and Plant Nutrition*, 20(3), 1450–1462.

- LPPM Universitas Bosowa (LPPM UNIBOS). (2024). *Pengembangan Usaha Kopi KTH Kanan Hijau Lestari (KUPS Agroforestry Berbasis Kopi)*. Makassar: Universitas Bosowa.
- LPPM Universitas Bosowa (LPPM UNIBOS). (2024). *Rencana Bisnis Budidaya Tanaman Kopi KTH Kanan Hijau Lestari (KUPS Agroforestry Berbasis Kopi)*. Makassar: Universitas Bosowa.
- Martinez, L., Oliveira, R., & Silva, A. (2021). *Value addition in smallholder coffee farming: A case study of income enhancement through coffee powder processing in Brazil*. *Journal of Agribusiness in Developing and Emerging Economies*, 11(4), 567-582. <https://doi.org/10.1108/JADEE-05-2021-0123>
- Martini, E., Riyandoko, & Roshetko, J. M. (2017). *Pedoman membangun kebun agroforestri kopi. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program*.
- Maryudi, A., Devkota, R. R., Schusser, C., Yufanyi, C., Salla, M., Aurenhammer, H., ... & Krott, M. (2021). *Back to basics: Considerations in evaluating the outcomes of community forestry*. *Forest Policy and Economics*, 84, 1-8. <https://doi.org/10.1016/j.forpol.2017.07.005>
- Mugwe, J., & Otieno, E. O. (2021). *Pendekatan Pengelolaan Kesuburan Tanah Terpadu untuk Adaptasi, Mitigasi, dan Peningkatan Produktivitas Tanaman dalam Perubahan Iklim*. Dalam *Handbook of Climate Change Management* (hlm. 10–11). Springer. DOI: 10.1007/978-3-030-22759-3_325-1.
- Nair, P.K.R. (2021). *An Introduction to Agroforestry: Four Decades of Scientific Developments*. Cham, Switzerland: Springer. <https://doi.org/10.1007/978-3-030-75358-0>
- Neilson, J., Wright, J., & Aklmawati, L. (2018). *Value chain upgrading and smallholder coffee farmers: Strategies for enhancing profitability through product diversification*. *Journal of Agricultural Economics*, 69(3), 567-589. <https://doi.org/10.1111/1477-9552.12245>
- Purwanto, D. R., Wijonarko, B. R., & Purwanto. (2020). Karakter Agronomis dan Fisiologis Tanaman Kopi Robusta (*Coffea canephora*) pada Dataran Tinggi di Kecamatan Pejawaran Kab. Banjarnegara. *Composite: Jurnal Ilmu Pertanian*, 2(1), 11-16.
- Sirappa, M. P., Arifin, Z., & Asrul, L. (2017). *Analisis iklim mikro untuk pengembangan komoditas kopi Arabika di Kabupaten Mamasa*. *Jurnal Agroforestri Indonesia*, 2(1), 12-20.
- Somarriba, E., Harvey, C. A., Samper, M., Anthony, F., González, J., Staver, C., & Rice, R. A. (2004). *Biodiversity conservation in neotropical coffee plantations*. *Agroforestry Systems*, 61(1-3), 175-193. <https://doi.org/10.1023/B:AGFO.0000028998.67721.2f>
- Supratman, O., Nurrochmat, D. R., & Darusman, D. (2020). *Strategi pengelolaan agroforestri kopi berbasis masyarakat di Sulawesi Selatan*. *Jurnal Manajemen Hutan Tropika*, 26(1), 45-55. <https://doi.org/10.7226/jtfm.26.1.45>
- Supriadi, H., Ferry, Y., & Ibrahim, M. S. D. (2018). *Teknologi Budi Daya Tanaman Kopi (Edisi Revisi)*. IAARD Press. ISBN 978-602-344-129-7.
- Tadesse, T., Tesfaye, B., & Abera, G. (2020). Coffee production constraints and opportunities at major growing districts of southern Ethiopia. *Cogent Food & Agriculture*, 6(1), 1741982. <https://doi.org/10.1080/23311932.2020.1741982>
- Vaast, P., Harmand, JM., Rapidel, B., Jagoret, P., Deheuvels, O. (2016). Coffee and Cocoa Production in Agroforestry—A Climate-Smart Agriculture Model. In: Torquebiau, E. (eds) *Climate Change and Agriculture Worldwide*. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-7462-8_16
- World Agroforestry (ICRAF). (2017). *Agroforestry for climate resilience and livelihood diversification: Integrating multipurpose trees into farming systems*. ICRAF Working Paper No. 234. World Agroforestry Centre.

World Agroforestry Centre (ICRAF). (2019). *Agroforestry for soil conservation and climate resilience in high-rainfall regions: A technical manual for smallholder farmers*. World Agroforestry. <https://www.worldagroforestry.org/publication/agroforestry-soil-conservation-high-rainfall>