Vol. 12(2): 532-548, May 2024
DOI: https://doi.org/10.23960/jsl.v12i2.877

Jurnal Sylva Lestari

P-ISSN: 2339-0913
E-ISSN: 2549-5747

Journal homepage: https://sylvalestari.fp.unila.ac.id

Full Length Research Article

Land Productivity and Land Equivalent Ratio of Agroforestry System in Marena Customary Forest, Enrekang Regency, South Sulawesi Province, Indonesia

Samsul Samrin[1,*], Syamsuddin Millang[1,**], Ridwan[1], M Daud[2]

[1] Department of Forestry, Faculty of Forestry, University of Hasanuddin, Makassar, Indonesia
[2] Department of Forestry, Faculty of Agriculture, University of Muhammadiyah Makassar, Makassar, Indonesia
[*] Corresponding Author. E-mail address: samsulkehutanan@gmail.com
[**] Corresponding Author. E-mail address: smillang60@yahoo.com

ARTICLE HISTORY:
Received: 30 December 2023
Peer review completed: 17 April 2024
Received in revised form: 19 May 2024
Accepted: 31 May 2024

KEYWORDS:
Agroforestry
Customary forest
Land equivalent ratio
Land productivity

ABSTRACT

Applying agroforestry system in the customary forest area plays a significant role in increasing the productivity of the community's land because it will increase the economic value and welfare of the customary community. This study aims to analyze the agroforestry system's land productivity and land equivalent ratio in the Marena Customary Forest (MCF) area, Enrekang Regency. This research used a survey method involving observation, questionnaires, and interviews with sample respondents who owned land and applied agroforestry systems in the MCF. Data obtained from interviews and field observations were then analyzed descriptively. The study revealed that applying agroforestry systems in the community-managed MCF can increase land productivity, showing the value of land productivity of IDR 20,512,208/ha/year. The agroforestry system's land equivalent ratio (LER) amounted to 2.34. This shows that applying the agroforestry system is considered capable of increasing land productivity and the income and welfare of the indigenous people of Marena.

1. Introduction

Sustainable utilization of forest resources and improvement of community welfare can be done through agroforestry systems. Agroforestry is a land use that manages a variety of mixed crops, with the main crop type being (Escobar-Lopez et al. 2022). Communities around forests generally use forests to support their social, economic, ecological, and cultural aspects of life (Nurmansah et al. 2021). Forest management with agroforestry systems is guaranteed to support the utilization of forest ecosystem products and services while still considering production aspects, sustainability, and biodiversity conservation (Hartoyo et al. 2019; Mosquera-Losada et al. 2020). Agroforestry plays a significant role and can potentially strengthen smallholders' resilience to climate change (Duffy et al. 2020; Krishnamurthy et al. 2019; Temani et al. 2021). Apart from the economic and social benefits of agroforestry systems for farmers, these systems are also known to play an essential role in conserving tree species (Negawo and Beyene 2017).

Agroforestry is a system of intensive land management by combining forestry crops and crops to obtain maximum results from these forest management activities without overriding aspects of land conservation and practical cultivation of local communities (Eyasu et al. 2020; Latue et al. 2018; Singh et al. 2021). It can be said that agroforestry can be an alternative to solve the problem of decreasing the quality and quantity of natural resources, supporting ecosystem services and environmental benefits, including community empowerment in achieving increased welfare and more efficient use of resources (Pantera et al. 2021). Agroforestry systems are multifunctional in increasing agronomic productivity (Lehmann et al. 2020). Agroforestry is also one practice that contributes to increased agricultural productivity due to its ability to provide multiple ecosystem services (Awazi and Tchamba 2019; Santiago-Freijanes et al. 2021). Ecological, economic, and social benefits are the main benefits of agroforestry (Rimbawati et al. 2018; Romanova et al. 2021).

Optimal land productivity by applying agroforestry systems is expected to increase community yields continuously (Sulistiyowati et al. 2023). It also depends on the variety of species nominated and the management system (Puspasari et al. 2017). Production can increase when optimizing the productivity of land managed by the community, namely by implementing an agroforestry system, where crops or seasonal crops are planted under the stand so that the income of the community implementing the agroforestry system can be sustainable (Afentina et al. 2019; Kunio and Lahjie 2015; Martin et al. 2022; Van Noordwijk 2021). The application of agroforestry is a system with up-and-coming prospects for farmers to achieve their goals (Idris 2019; Ruba and Talucder 2023). Furthermore, agroforestry is a land-use technique that is already practiced by most farmers in Indonesia (Syahri et al. 2019). The results will be much more optimal with the right combination in the agroforestry system, so a suitable plant composition is essential to increase household income (Abebe 2013; Syahidah et al. 2020; Ulina et al. 2020). The combination of agricultural and forestry crops in one land management unit must pay attention to the environmental, social, economic, and cultural conditions of the people who manage it (Widayanti et al. 2020).

Farmers can obtain more maximum income by implementing agroforestry systems than if they only plant wood plants. This is because farmers will obtain sustainable income when applying agroforestry systems compared to those who only apply monoculture cropping systems (Aminah et al. 2013). The increase in total production per unit of land area by implementing an agroforestry system will be directly proportional to the rise in community income. Agroforestry is a more complex production system than monoculture (Cecílio et al. 2019). A review of community income with the management of the agroforestry system applied is very important to know the level of influence of its management on the level of community income (Zainuddin and Sribianti 2018). Agroforestry is a crucial indicator of the socio-economic aspects of rural communities for sustainable development. The application of agroforestry systems is generally perfect from the environmental and socio-economic aspects of the community. However, there is still a lack of awareness and knowledge of local communities from rural areas about it (Musa et al. 2019).

The Marena Customary Forest (MCF) is located within the territory of the Marena customary law community and has long been managed by the community for generations. The Marena Customary Law Community, which lives around the customary forest, generally works as farmers and utilizes non-timber forest products taken from the customary forest for their daily needs. The customary forest they manage with an agroforestry system is a source of livelihood for the community. In addition to managing the customary forest, the community manages their land outside the MCF area. Some people who own and manage land within the customary forest also own land outside the customary forest. The indigenous community manages land within the customary forest area with an agroforestry system, while the community generally manages land outside the customary forest location.

Land managed by indigenous peoples by implementing an agroforestry system is a customary forest area. Agroforestry management in the MCF area is carried out by integrating cultural, social, economic, and environmental aspects. Indigenous people are active and pay attention to local knowledge so that agroforestry practices can effectively maintain the sustainability of natural resources and improve community welfare. The total land area managed by respondents in this study is 50 ha. Each respondent has a different land area.

The Marena indigenous community in Enrekang Regency manages their customary forest by applying an agroforestry system consisted various commodities such as gmelina (*Gmelina arborea*), suren (*Toona sureni*), avocado (*Persea americana*), coffee (*Coffea arabica*), jackfruit (*Artocarpus heterophyllus*), cloves (*Syzygium aromaticum*), cocoa (*Theobroma cacao*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), bananas (*Musa paradisiaca*), cayenne pepper (*Capsicum frutescens* L.) and Toraja chili (*Capsicum annum* L. *varian sinensis*). Coffee is a commodity widely managed by the community with an agroforestry system in the customary forest. The average volume of coffee production obtained by respondents was 384.7 kg/ha/year (0.3847 tons/ha/year). In the agroforestry system, several plants can be harvested simultaneously, such as coffee harvesting and harvesting of ground cover plants can be done simultaneously. The timber-producing species managed in the MCF are gmelina arborea and suren. Marena indigenous people generally plant and utilize these two types of wood because they have a relatively high selling price and many benefits for the community. The price for gmelina is IDR 2,500,000/m^3, and suren is IDR 3,700,000/m^3. The system for cutting down trees in customary forest areas with an agroforestry system is carried out carefully and considers sustainability. After logging, the indigenous community replants or natural regeneration to replace the trees cut down.

On the other hand, many people are more likely to manage their land outside the customary forest area with a monoculture cropping system than maximizing customary forest management with an agroforestry system. For this reason, it is necessary to evaluate the advantages or disadvantages of agroforestry systems with monoculture cropping patterns by calculating the land equivalent value (LER). The land equivalent ratio is an indicator used to determine the yield advantage (Deb and Dutta 2021). This value will show the level of productivity and efficiency of land planted in monoculture with agroforestry systems. This study analyzes the productivity and LER of agroforestry systems applied by the Marena indigenous community.

2. Materials and Methods

2.1. Location and Time

This research was conducted from March 2023 until April 2023. This research was conducted in the Marena Customary Forest (MCF), Pekalobean Village, Anggeraja District, Enrekang Regency, which the community manages with an agroforestry system (**Fig. 1**).

2.2. Data Collection

This research uses a survey method, which involves taking a sample of a population and using a questionnaire for data collection. The sample of this study was determined using a purposive sampling method. The consideration is that the sample fulfills the criteria needed in the study, namely that the respondent applies the agroforestry planting pattern used in the study. Thirty respondents were purposively selected from the community population who manage and utilize the MCF of 90 people. The criteria for determining this respondent are the Marena indigenous people who manage land in the MCF area with an agroforestry system.

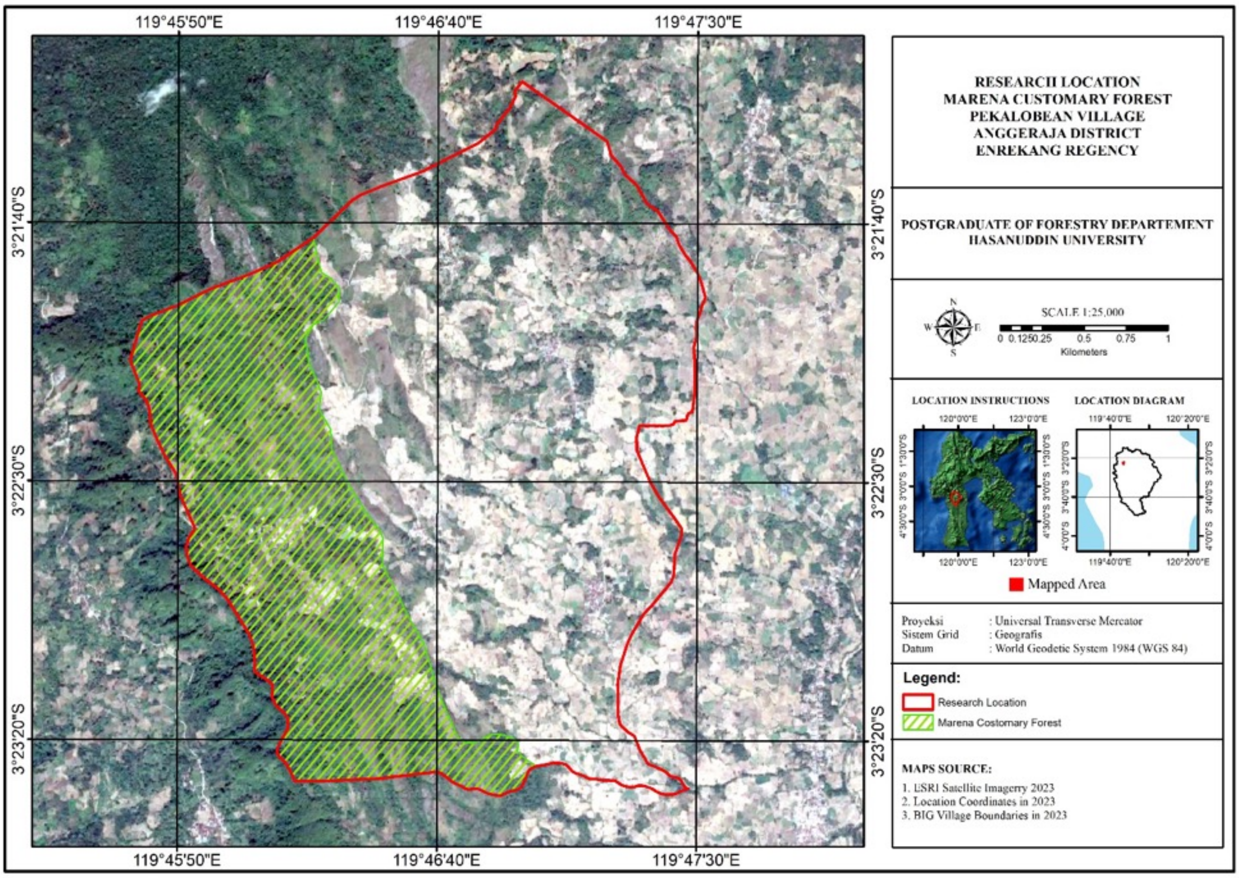

Fig. 1. Research location map.

The primary and secondary data collected in this study are primary and secondary. Primary data needed are the identity of respondents, land area, revenue, costs, and income of the Marena indigenous community. Secondary data were obtained from related agencies, research reports, literature, scientific papers, documentation, and other information related to this research. The observations were made using the open-plot method. Observation plots were made with a size of 20 m × 50 m (0.1 ha), as many as 15 plots at the location to determine the composition and measurement of the potential of trees in the MCF. Each plot identified the species, counted the number, and measured the diameter of trees based on the species.

2.3. Data Analysis

Data obtained from interviews and field observations were then analyzed descriptively. Descriptive analysis was used to get an overview of the utilization and management of customary forests with agroforestry systems. Qualitative data obtained from interviews are presented in the form of descriptions. Then, quantitative data was analyzed using descriptive statistics and presented as tabulations and diagrams.

The community income from the management of customary forests was calculated based on the value of direct economic benefits. The agroforestry system's income, revenue, and costs were calculated following Suratiyah (2015).

The income value of the agroforestry system was calculated using Equation 1.

$$I = TR - TC \tag{1}$$

where I is income, TR is total revenue, and TC is total cost.

Total revenue from the agroforestry system was calculated using Equation 2.

$$TR = P \times Q \tag{2}$$

where TR is the total revenue, P is the price, and Q is the amount of production.

The total cost of the agroforestry system was calculated using Equation 3.

$$TC = FC + VC \tag{3}$$

where TC is the total cost, FC is the fixed price, and VC is the variable cost.

Stand potential was determined by measuring the stand's diameter and height, and then the volume of the stand was calculated using Equation 4.

$$V = \frac{1}{4} \times \pi \times d^2 \times h \times f \tag{4}$$

where V is the volume (m^3), d is the diameter (cm), h is the height (m), f is the correction factor, and π with a value of 3.14.

The average mean annual increment (MAI) was calculated using Equation 5 (Ruchaemi 2016).

$$iv = \frac{v_t}{t} \tag{5}$$

where iv is the average annual volume increment (m^3/plant/year), v_t is the volume of the plant at the time of measurement (m^3), and t is the age of the plant at the time of measurement (year).

Land productivity is the capacity of land to absorb production inputs and produce outputs in production. The production value is obtained from the amount of production multiplied by the selling price. Land productivity was calculated using Equation 6 (Đokić et al. 2022).

$$Land\ Productivity = \frac{Production\ Value\ (IDR/Year)}{Land\ Area\ (Hectare)} \tag{6}$$

Land Equivalent Ratio (LER) calculation to determine the land productivity and efficiency value of agroforestry planting compared to monoculture. The increase in land production generated in this study was calculated using Equation 7 (Metwally et al. 2016).

$$LER = \sum_{i=1}^{n} \frac{LPAi}{LPMi} \tag{7}$$

where LPA is the land productivity of the agroforestry pattern, LPM is the land productivity of the monoculture pattern, and n is the number of plants. Cropping systems that produce LER > 1 indicate an increase in land productivity, and LER = 1 suggests no increase in productivity.

3. Results and Discussion

3.1. Characteristics of Respondents

The characteristics of respondents analyzed in this study are the level of education, age, and land area of respondents (**Table 1**). The three variables of respondents' characteristics in agroforestry land management studied are related to the respondents' ability to manage and utilize the land. Age dramatically affects the level of work productivity of farmers, and education will affect the knowledge and mindset of the community about land utilization and management. Area and ownership are essential factors in the agroforestry system because the agroforestry system is a business system that maximizes land use. The factors of age and land area significantly affect the total income of farmers (Desmiwati et al. 2021).

Table 1. Characteristics of respondents who manage Marena Customary Forest (MCF) with an agroforestry system

Characteristics	Category	Number of Respondents	Percentage (%)
Age	20–40	16	53.33
	41–60	13	43.33
	61–70	1	3.33
	Total	30	100
Education	Elementary School	13	43.33
	Junior High School	9	30.00
	High School	8	26.67
	Total	30	100.00
Land Area	< 1.5	11	36.67
	1.5–2.5	15	50.00
	> 2.5	4	13.33
	Total	30	100

Table 1 shows that the age level of respondents who manage the MCF is dominated by the young productive age level of 53.33%. Age is the human age measured from birth to the time of life. This age is one factor influencing a person's work productivity. Those still in the productive period usually have a higher level of productivity than those old, so their physical abilities are weak and limited. However, on the other hand, workers with younger ages tend to have lower work experience when compared to older workers, or this is due to different factors such as older workers being more stable, more mature, having a more balanced view of life so that they are not susceptible to mental stress or other problems at work (Parengkuan et al. 2019).

The education level of the people who manage the MCF is still relatively low/43.33% (**Table 1**). The low level of education dramatically affects the knowledge and mindset of the community about forest utilization and management. It will also affect farmers' openness to understanding and accepting new knowledge about optimal land management and utilization (Triwanto et al. 2022). Education is a forum for acquiring knowledge. A high level of farmer education is expected to understand and know how to choose the right commodity in determining planting patterns (Syahputra 2017). Education is one of the most important things in people's lives. Education can evaluate and guide the future and direction of one's life to be more advanced. Although not everyone will have this opinion, education is still the primary human need.

The respondents' land area presented in **Table 1** shows that 50% of respondents manage the land area between 1.5–2.5 ha in the customary forest. Its utilization and management always follow customary rules. Land managed by the community has a different area. Land tenure, including area and ownership, is an essential factor in the agroforestry system because the agroforestry system is a business system that maximizes land use (Suyadi et al. 2019). The land area has a very significant influence on farmers' income. The amount of production obtained by farmers is strongly influenced by the area of land managed (Andilan et al. 2021).

3.2. Cost, Revenue, and Income Analysis of Agroforestry System in Marena Customary Forest

Looking at the relationship between total costs, total revenue, and total income (**Table 2**) reflects whether an activity generates a net profit or incurs a loss and how significant the profit or loss is. In this study, total income is smaller than total revenue, indicating that significant costs must be incurred in land management activities with agroforestry systems in the MCF. The highest average revenue is from coffee, and the lowest is from turmeric. The cropping pattern applied in managing the MCF is a random pattern in which coffee plants dominate. In addition to coffee, there are several other species, namely gmelina (*Gmelina arborea*), suren (*Toona sureni*), avocado (*Persea americana*), jackfruit (*Artocarpus heterophyllus*), cloves (*Syzygium aromaticum*), cocoa (*Theobroma cacao*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), bananas (*Musa paradisiaca*), and cayenne pepper (*Capsicum frutescens* L.). When managing the MCF, this varied species composition greatly affects farmers' costs, revenues, and incomes.

Table 2. Average cost, revenue, and income of agroforestry system in Marena Customary Forest

Description	**Value (IDR/land area/ha/year)**
Agroforestry Revenue	
Coffee (*Coffea arabica*)	9,616,666
Avocado (*Persea americana*)	113,533
Jackfruit (*Artocarpus heterophyllus*)	87,733
Ginger (*Zingiber officinale*)	1,173,666
Cocoa (*Theobroma cacao*)	1,837,500
Bananas (*Musa paradisiaca*)	111,666
Cloves (*Syzygium aromaticum*)	9,570,000
Turmeric (*Curcuma domestica*)	78,666
Cayenne pepper (*Capsicum frutescens* L.)	1,667,000
Gmelina (*Gmelina arborea*)	3,095,833
Suren (*Toona sureni*)	8,473,000
Total Revenue	**35,825,266**
Cost	
Fertilizer and Pesticides	734,133
Tool	256,000
Worker	993,666
Total Cost	**1,983,800**
Income	**33,841,466**

3.2.1. Cost analysis

In managing and utilizing land in the MCF, costs must be incurred to produce goods and services. Based on interviews with respondents who own land in the MCF, the costs they must incur for maintenance consist of the purchase of fertilizers, pesticides, workers' wages, and the cost of depreciation of the tools used (**Table 3**). It can be seen that the costs incurred by farmers in managing land in the MCF with the agroforestry system are quite varied. The average cost incurred was IDR 1,983,800/land area/year or IDR 1,175,109/ha/year, where the total cost incurred by respondents was IDR 59,514,000/land area/year or IDR 35,253,267/ha/year. The cost incurred by farmers is influenced by several factors, including the area of land managed and the composition of the types of crops grown by farmers. In terms of land area, where the more significant the area of land is managed, the costs that must be incurred are likely to be high, and this is also inseparable from the composition of the types of constituents. In the economic evaluation, the costs incurred in agroforestry systems tend to be higher than in monoculture systems (Bishaw et al. 2022). The more land area is managed, the greater the land's ability to be planted with various plants, so the costs will also be more significant (Mando et al. 2022).

Table 3. Cost analysis of the agroforestry system in the Marena Customary Forest

Description	Fixed Cost (IDR /land area/year	Variable Cost (IDR /land area/year)				Total Cost
	Tool cost (IDR)	Fertilizer (IDR)	Pesticide (IDR)	Worker Wage (IDR)	IDR /land area/year	IDR/ha/ year
Total	7,680,000	12,115,000	9,909,000	29,810,000	59,514,000	35,253,267
Average	256,000	403,833	330,300	993,667	1,983,800	1,175,109

3.2.2. Revenue analysis

Revenue is the amount of production produced or obtained in a business activity where the results are multiplied by the selling price in the market or prevailing in the market. More details about the data analysis of revenue from farmers in the MCF with the agroforestry system can be seen in **Table 4**. Revenue from farmers is different due to the commodity factors produced and the land area of each farmer. Two types of revenue are obtained, namely from the forestry sector and the agricultural industry. For the forestry sector, revenue is obtained from gmelina (*Gmelina arborea*), suren (*Toona sureni*), avocado (*Persea americana)*, coffee (*Coffea arabica*), jackfruit (*Artocarpus heterophyllus*) and cloves (*Syzygium aromaticum*), cocoa (*Theobroma cacao*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), bananas (*Musa paradisiaca*), cayenne pepper (*Capsicum frutescens* L.) and Toraja chili (*Capsicum annum* L. *varian sinensis*).

Table 4. Revenue analysis of the agroforestry system in Marena Customary Forest

Description	Revenue from Agroforestry (IDR/land area/year)		Total Revenue	
	Forestry	Agriculture	IDR/land area /year	IDR/ha/year
Total	641,603,000	433,155,000	1,074,758,000	650,619,500
Average	21,386,767	14,438,500	35,825,267	21,687,317

This considerable acceptance is because the community applies the agroforestry system, where combining forestry and agricultural sector plants increases the potential for substantial income. Still, the income level is also strongly influenced by the productive level of its constituent components (Evizal et al. 2023). The selection of the type and number of plants that farmers develop on land with agroforestry systems also dramatically affects the amount of farmers' income (Ismail et al. 2019). The forestry and agriculture components majorly contribute to the Marena indigenous community. The agroforestry system in the MCF combines forestry and agricultural commodities on the same land. The community uses land in the customary forest for farming by developing several agricultural commodities. Agroforestry and agriculture are two concepts that are often intertwined. Agroforestry can be considered a sustainable form of agriculture, while agriculture is usually associated with large-scale, more technologically intensive production. However, both play an essential role in improving people's welfare.

Revenue from the forestry sector itself is obtained from several commodities in the form of both timber forest products and non-timber forest products, including results of gmelina (*Gmelina arborea*), suren (*Toona sureni*), avocado (*Persea americana*), coffee (*Coffea arabica*), jackfruit (*Artocarpus heterophyllus*). Revenue from the agricultural sector is also significant, where the types of commodities are quite varied, including cloves (*Syzygium aromaticum*), cocoa (*Theobroma cacao*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), bananas (*Musa paradisiaca*), cayenne pepper (*Capsicum frutescens* L.) and Toraja chili (*Capsicum annum* L. *varian sinensis*). The abundance of the constituent components of land indicates that the agroforestry system can provide revenue and benefits throughout the year with various product outputs (Hidayati et al. 2021).

3.2.3. Income analysis

Income is the amount of money business actors receive from their various activities. The income results from the difference between the costs incurred and the revenue from business actors. The amount of income obtained by farmers with the agroforestry system in the MCF can be seen in **Table 5**. The income obtained by farmers who implement the agroforestry system in the MCF is relatively high. This income is obtained from several commodities from the forestry and agricultural sectors managed with the agroforestry system, namely the type of gmelina (*Gmelina arborea*), suren (*Toona sureni*), avocado (*Persea americana*), coffee (*Coffea arabica*), jackfruit (*Artocarpus heterophyllus*), cloves (*Syzygium aromaticum*), cocoa (*Theobroma cacao*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), bananas (*Musa paradisiaca*), cayenne pepper (*Capsicum frutescens* L.) and Toraja chili (*Capsicum annum* L. *varian sinensis*). The amount of income earned is influenced by the type of commodity produced and the land area of each farmer. Applying the agroforestry system will contribute to the community's income from the results on forest land. This is because crops can be obtained quickly compared to waiting for an extended tree-felling period (Syamsudin et al. 2019). The benefits obtained from the agroforestry system and forest products also come from the agricultural sector.

Table 5. Income analysis of the agroforestry system in Marena Customary Forest

Description	Total Revenue (IDR/land area/year)	Total Cost (IDR/year)	Total Income (IDR/land area/ha/year)	Total Income (IDR/ha/year)
Total	1,074,758,000	59,514,000	1,015,244,000	615,366,233
Average	35,825,267	1,983,800	33,841,467	20,512,208

The income value presented in **Table 5** is the total income from the forestry and agricultural components of the agroforestry system in the MCF, so the income obtained is quite large. This significant income is strongly influenced by the composition of the types of plants planted, as well as commodities with a high economy. The income obtained by the community from agricultural products using agroforestry systems on forest area land is very useful in improving the community's economy (Yulian et al. 2016). The composition of species in agroforestry systems also affects the time to obtain income. This is because each type of product harvested has a different time (Roslinda et al. 2023). The application and development of agroforestry systems can provide many solutions and significantly impact farmers' income (Cialdella et al. 2023).

3.3. Land Productivity and Land Equivalent Ratio of Agroforestry in Marena Customary Forest

3.3.1. Land productivity of agroforestry in Marena Customary Forest

Land productivity is the capacity of land to absorb production inputs and produce outputs in the form of production. The production value is obtained from the amount of output multiplied by the selling price. The amount of land productivity in the agroforestry system in the MCF obtained from interviews with 30 farmer respondents who implement the agroforestry system can be seen in **Table 6**. Its productivity is IDR 20,512,208/ha/year. From this value, it is known that the productivity of the land managed by farmers produces a production value or output for each ha of IDR 20,512,208/ha/year. The value of this land productivity is obtained from various commodities produced. Communities that apply agroforestry systems can make much food because the composition of plant species is quite varied and has high economic value in the market. Comparing the agricultural system to a monocultural one, some characteristics of the former are more favorable regarding the economy, society, and environment. Forest products in the household economy of rural communities living in or around forests mainly support household needs and fulfill their living and consumption needs (Shrestha et al. 2020). Agroforestry can succeed if it can increase the average household's income while maintaining low labor productivity (Wattie and Sukendah 2023).

Table 6. Land productivity of agroforestry in Marena Customary Forest

Total Income (IDR/land area/year)	Total Income (IDR /ha/year)	Land Productivity (IDR /ha/year)
1,015,244,000	615,366,233	20,512,208

On equivalent land, the productivity of agroforestry systems can exceed that of monoculture systems. Agroforestry systems can improve land productivity so that the public can consistently manage the results; this depends on the number of crops combined in one field and the management method (Andrian et al. 2022). Agroforestry management requires careful planning and a deep understanding of the ecology and needs of the plants being grown. With the proper practices, agroforestry can be an effective method to increase land productivity sustainably. This is also in line with research conducted by Wahyu et al. (2018), where the agroforestry system is far more profitable than monoculture. Generally, agroforestry systems have superior yield potential than monoculture systems in agriculture and forestry systems (Huang et al. 2015; Liu et al. 2018; Maitra et al. 2021). This is because not only the diversity of commodities produced in one field of land but also the agroforestry system can provide benefits by covering the failure of one other component (Dori et al. 2022).

On managed land, annual crops and woody plants are planted together. Without proper management, the land will not be productive due to competition for water, nutrients, and light. The presence of shade on plants in the lower canopy strata will reduce land productivity. Generally, the Marena customary community manages indigenous forests with an agroforestry system using a random mixture pattern. In this pattern, the light obtained by plants is also irregular. Often, many plants are found to be depressed due to lack of light. The random mixture agroforestry pattern in the MCF can be seen in **Fig. 2**.

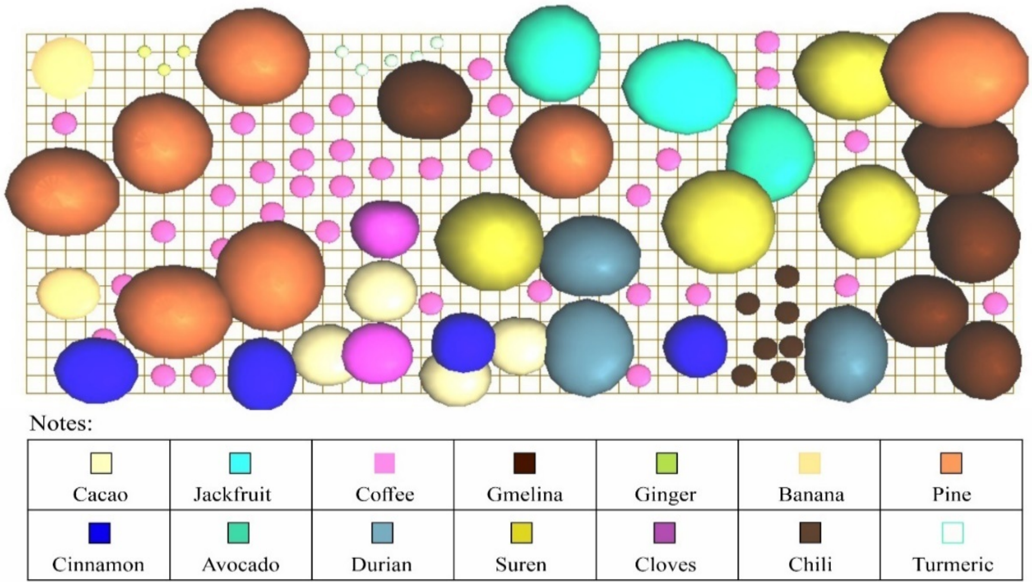

Fig. 2. Random mixture agroforestry pattern in Marena Customary Forest.

3.3.2. Land equivalent ratio of agroforestry in Marena Customary Forest

To improve the sustainability of the currently separated agriculture and forestry systems, more complex methods and concepts are needed to assess the performance of agroforestry systems (Van Noordwijk and Coe 2019). Land Equivalent Ratio (LER) calculation to determine land productivity and efficiency value of agroforestry planting compared to monoculture. The land equivalent ratio (LER) is a valuable productivity indicator to measure yield performance and land use efficiency (Unay et al. 2021; Seserman et al. 2019; Zaki et al. 2017). The Land Equivalent Ratio (LER) indicates the area required under monoculture cultivation to achieve the same function (Khasanah et al. 2020). In this study, the comparison is made with coffee monoculture. Coffee monoculture is land management with full sun and a combination of economic value crops (Nguyen et al. 2020). Coffee monoculture income is obtained from the Marena indigenous people, who manage their land with a coffee monoculture system with an income value of IDR 8,769,222.22 /ha/year. Land management with this monoculture system is on a different stretch of land from the agroforestry system applied to the MCF. More details on the LER value of the agroforestry system in the MCF can be seen in **Table 7**.

Table 7. Land equivalent ratio (LER) of agroforestry in Marena Customary Forest

No	Form of Land Cultivation	Income (IDR/ha/year)	LER
1	Monoculture (Coffee)	8,769,222.22	1.00
2	Agroforestry	20,512,207.78	2.34

A cropping system that produces LER > 1 indicates an increase in land productivity, and LER = 1 suggests no increase in productivity. It can be seen that the land equivalent ratio value with a monoculture system (Coffee) with a value of 1.00 indicates that 100% of the profit is obtained when planted as a monoculture crop. The land equivalent ratio value calculation in the agroforestry system is 2.34, meaning that producing the exact yield of 1 ha of agroforestry cropping system requires a total of 2.34 ha of monoculture cropping system land. This shows that the agroforestry cropping system can increase land productivity, making it more efficient than the monoculture system. The average economic efficiency level of monoculture farmers is lower when compared to farmers with agroforestry systems (Lanamana and Supardi 2021). In the agroforestry system, the increase in land productivity is strongly influenced by selecting the right combination of plant species (Octavia et al. 2023). The monoculture system can increase yields, but the ecosystem provides less or no benefit (Tondoh et al. 2015).

4. Conclusions

Applying agroforestry systems in the community-managed Marena Customary Forest (MCF) can increase land productivity. The combination of plants the community manages with the agroforestry system is complete and can support ecological balance. Land productivity in MCF management with an agroforestry system carried out by the community is IDR 20,512,208/ha/year. The land equivalence ratio value in the agroforestry system is 2.34. This shows that the agroforestry system can increase land productivity and sustainability compared to the monoculture system. Agroforestry systems have great potential and are recommended to be developed to increase the income of indigenous peoples.

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