

## RESEARCH ARTICLE

## Random Mixture Agroforestry Pattern: Economic Value for the Engkangin Village Community

Emi Roslinda\*<sup>ORCID</sup>, Bella Talita<sup>ORCID</sup>, Togar Fernando Manurung<sup>ORCID</sup>

Faculty of Forestry, Universitas Tanjungpura, Pontianak, Indonesia

\* Corresponding author: [eroslinda71@gmail.com](mailto:eroslinda71@gmail.com)

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### ABSTRACT

Traditional agroforestry systems developed by local communities play an important role in sustaining livelihoods and reducing pressure on protected forests, yet their economic significance and structural characteristics remain under-documented. This study analyzes the structure, composition, and livelihood contribution of a traditional random-mixture agroforestry system practiced by forest-adjacent communities in Engkangin Village, West Kalimantan, Indonesia. Data were collected in February 2025 through field observations and structured interviews with 68 agroforestry households and analyzed using descriptive and income-based approaches. The system represents a forest-based agroforestry model characterized by a non-systematic spatial arrangement integrating perennial trees, plantation crops, annual crops, and aquaculture components (agrisilviculture and agrosilvofishery). Fifteen commercial commodities were identified, dominated by paddy, oil palm, and rubber. Agroforestry generated a total annual economic value of IDR 2.89 billion. Net agroforestry income accounted for 94.22% of total household earnings, indicating a high dependence on this land-use system for livelihood security. The diversified species composition enables continuous harvests across temporal scales, enhancing income stability and food availability while maintaining tree cover in protected forest landscapes. However, the random spatial configuration limits productivity and management efficiency compared with more structured agroforestry designs. The findings demonstrate that traditional mixed agroforestry can function as a socio-ecological safety net and a locally adapted strategy for sustainable land use. Strengthening technical support, improving planting materials, and enhancing market access could substantially increase both economic returns and ecological benefits. These results provide evidence for integrating community-based agroforestry into rural development and forest conservation policies in tropical regions.

## 1. Introduction

Agroforestry is a system that combines crops or livestock on the same piece of land and implements management practices that are in accordance with local culture (Fitriani et al., 2019). This system is a form of land utilization that can be offered to communities to address issues arising from land-use change and food insecurity through sustainable land management practices. Agroforestry has advantages over other land-use systems, such as improving soil and water conservation, enhancing soil physical properties, and the combination of plants strengthening the root system, thereby reducing erosion and landslides and increasing farmers' income (Hani and Geraldine, 2018). Various forms of agroforestry, including mixed gardens, tree plantations, shrublands, home gardens, and community forests, can be applied for these purposes (Ardini et al., 2020). The agroforestry patterns commonly adopted by the Indonesian community are agrisilviculture, agrisilvopastoral, silvopasture, and silvofishery (Prastiyo, 2023). The selection of species, plant composition, and management practices

employed play a crucial role in determining the overall success of agroforestry (Puspasari et al., 2017). Implementing agroforestry within forest areas significantly helps reduce land degradation, allowing communities to utilise previously damaged land. Agroforestry also helps increase income and welfare, while meeting community needs.

Economic indicators in agroforestry include income, which directly affects the community's basic needs. Climate conditions, farming techniques, land size, land quality, labor time, and product market prices influence agroforestry (Naibaho et al., 2015). Community or farmers' income can be derived from on-farm, off-farm, and non-farm activities. On-farm income originates from rice farming, livestock, and aquaculture activities. Off-farm income is obtained from work or services related to agriculture but not directly from agricultural production.

In contrast, non-farm income refers to earnings generated from activities outside the agricultural sector (Prastiyo, 2023). To properly assess income, it is essential to consider active community involvement, such as contributions to forest management, and the quality of human resources, as these factors directly influence the effectiveness of agroforestry in supporting household livelihoods. The agroforestry system makes valuable contributions to household income by providing direct yields from forest land without requiring support during the logging period, as it generates yields from crops on a monthly or annual basis, depending on the crop type. There is strong community motivation to develop agroforestry land, especially to improve yields of agricultural (seasonal) and plantation crops, thereby generating annual income (Larasati et al., 2019). The dual benefits of agricultural and forestry crops have proven highly advantageous for farmers and communities. In addition, the contribution of agroforestry to the community's economy is focused on increasing economic income. Engkangin Village is one of the villages in the Air Besar Sub-district, located within the Protected Forest Area of KPH Sanggau Barat. The community has interacted with the natural resources available in that area both directly and indirectly. The people of this village have implemented an agroforestry system. However, there is still no information on the extent to which agroforestry contributes to the income of those who cultivate it. Furthermore, it is also not known what agroforestry patterns exist in Engkangin Village. Therefore, it is necessary to research the contribution of agroforestry to the community's income. This research aims to explain the agroforestry patterns and to calculate the contribution of agroforestry to the community's income in Engkangin Village, Air Besar District, Landak Regency. The benefits of this research are expected to serve as a reference for deepening knowledge of agroforestry and broadening the community's horizons.

## 2. Materials and Methods

### 2.1. Location and Time

This research was implemented in Engkangin Village, Air Besar Subdistrict, Landak Regency, West Kalimantan Province, Indonesia, in February 2025. This village borders a conservation area. Most of the residents work as farmers and engage in other land-based activities. As the population grows, the need for land increases, posing a threat to the existing conservation area. One solution to slow deforestation is to use existing land by implementing agroforestry systems in the village.

### 2.2. Data Collection

Data were collected through surveys and interviews using structured questionnaires, and field observations were conducted in Engkangin Village. While the village consists of four hamlets, this study specifically selected two: Engkangin Hamlet and Tabura Hamlet. These two locations were chosen because they are the only areas where the community actively implements agroforestry systems for land use, whereas the other two hamlets do not. The sampling method used was purposive sampling, targeting individuals who cultivate their land with agroforestry crops, resulting in a total of 68 respondents. The interview involved direct questions and answers with the selected community as the research sample, and the results were documented throughout the process. Field observations were conducted to see the existing agroforestry patterns, as well as to observe the types of agroforestry plants and livestock present on the community's land.

The data collected consists of primary and secondary data. The primary data required include the characteristics of respondents (age, education, occupation, number of family members, and land area owned), plant species, agroforestry patterns, and the community's income from commercial agroforestry plants sold, as well as non-agroforestry income. Meanwhile, the secondary data collected includes literature studies sourced from books, articles, and journals, as well as data from institutions in Engkangin Village. Additionally, market price data for commercial agroforestry products sold by the community, marketing systems, and other supporting data are available.

### 2.3. Data Analysis

The data obtained from field observations, including interviews and questionnaires, were then analysed descriptively to quantify the contribution of agroforestry. Additionally, the data were analysed descriptively and qualitatively regarding land ownership conditions, agroforestry patterns, and crop types. The data used to analyze income and assess agroforestry's contribution to community income were obtained using the following methods.

The average number of items taken is calculated using Equation 1 (Roslinda et al., 2023).

$$x = \frac{xi + xii + \dots + xn}{n} \quad (1)$$

where  $x$  indicates the average quantity of goods,  $xi$  is the quantity taken by individual respondents, and  $n$  is the number of collections per type of agroforestry crop.

The total collection per unit of goods can be calculated using Equation 2 (Roslinda et al., 2023).

$$TP = RJ \times FP \times JP \quad (2)$$

where  $TP$  is the total annual harvest,  $RJ$  represents the average harvest quantity,  $FP$  denotes the annual harvest frequency, and  $JP$  indicates the number of agroforestry product harvests.

The economic value of agroforestry products by commodity type can be calculated using Equation 3 (Roslinda et al., 2023).

$$NH = TP \times HH \quad (3)$$

where  $TP$  is the total extraction (unit/year),  $HH$  represents the price of agroforestry products, and  $NH$  represents the economic value of each type of agroforestry product.

The percentage of economic value can be calculated using Equation 4 (Roslinda et al., 2023).

$$\%NE = + \frac{NEi}{\sum NE} \times 100\% \quad (4)$$

where  $NEi$  is the economic value of agroforestry per type,  $NE$  is the total economic value of all agroforestry products, and  $\%NE$  is the percentage of economic value.

Revenue from agroforestry, from outside agroforestry, and total revenue can be calculated using Equation 5.

$$\text{Contribution (\%)} = \frac{\text{Income from agroforestry}}{\text{Total income}} \times 100\% \quad (5)$$

where revenue from agroforestry is the total economic value of all types of agroforestry products, revenue outside agroforestry is the income other than agroforestry, and total revenue is the total income from and outside of agroforestry.

The calculation results of the agroforestry product values show the community's income from all types of agroforestry products per year, thus allowing the contribution value of agroforestry products to be calculated in relation to community income.

The costs of agroforestry include fixed costs, tool costs, seed costs, replanting costs, fertiliser costs, maintenance costs, transportation costs, and labor costs. Agroforestry costs can be calculated using Equation 6.

$$TC = FC + VC \quad (6)$$

where  $TC$  is the total cost (IDR/year),  $FC$  is the fixed cost (IDR/year), and  $VC$  is the variable cost (IDR/year).

### 3. Results and Discussion

#### 3.1. Respondents' characteristics

The respondent characteristics analysed in this study include gender, age, occupation, family members, education, and land area owned. Respondents were selected from the community, totaling 68 families, using the Slovin formula. Characteristics of the respondents are presented in **Table 1**. Based on gender, the data shows that there are 43 males, representing 63.24% of the total, and 25 females, representing 36.76%. The researcher deliberately made males the dominant respondents, as males tend to seek their livelihoods primarily on land, thereby gaining more knowledge about the contribution of agroforestry to income. The age of respondents varies widely, ranging from 24 to 78 years old. The majority of respondents involved in managing agroforestry land were aged 46–55 (36.76%), indicating that they are in the productive age group to utilize the land.

**Table 1.** Respondents' characteristics of agroforestry in Engkangin Village

Characteristic	Category	Count	Percentage (%)
Gender	Women	25	36.76
	Man	43	63.24
	Total	68	100.00
Age (years)	< 25	1	1.47
	26–35	12	17.65
	36–45	19	27.94
	46–55	25	36.76
	56–65	7	10.29
	> 65	4	5.88
	Total	68	100.00
Work	Farmer	65	96.00
	Civil servants	1	1.00
	Teacher	2	3.00
	Total	68	100.00
Family dependents (person)	1–2	18	26.47
	3–4	41	60.29
	5–6	9	13.24
	Total	68	100.00
Education	No formal education	7	10.29
	Elementary	28	41.18
	Middle school	15	22.06
	Senior high school	14	20.59
	Bachelor's degree	4	5.88
	Total	68	100.00
Land owned (ha)	0.5–3.5	56	82.35
	3.6–6.6	9	13.24
	6.7–10	3	4.41
	Total	68	100.00

The agroforestry farmers are predominantly older farmers, with a small number of young farmers. Age affects a farmer's income. This is because the longer someone manages the land, the greater the income they will earn (Insusanty et al., 2017). The respondents' main occupation is generally farming, with 96% reporting farming as their main occupation. This suggests that most people in this village are farmers. There are also those whose main occupations are as civil servants and teachers. However, respondents hold various side jobs, including those of village officials, posyandu leaders, online shop owners, farmers, and daily laborers. The number of family members managing agroforestry is typically 3 to 4, accounting for 60.29% of the total. The number of family members involved in agroforestry will affect farmers' income and expenses (Insusanty et al., 2017). The educational level of respondents shows that the majority of the community has only graduated from elementary school (41.18%), the lowest level of formal education. This is due to economic factors within families, which lead many respondents not to pursue higher education. The size of agroforestry land owned by each respondent varies from 0.5 to

10 hectares. The residents' land is ancestral land, and most of it is located within protected forest areas. With the community-owned land, a wider range of agricultural and forestry crops can be managed and planted. As a result, the community's income also increases. However, a small area makes monitoring production easier, but crop productivity on small plots tends to decrease compared to larger areas (Insusanty et al., 2017; Phahlevi, 2013).

### 3.2. Agroforestry Pattern

The agroforestry patterns found on community lands in Engkangin Village fall under the agroforestry developmental stage classification, namely traditional or straightforward agroforestry. This is evidenced by the community's simple, traditional activities, which do not adopt external techniques or technologies. Instead, they utilise local seeds, adapting to market needs and natural conditions, ensuring sustainability and continuity from one generation to the next, optimising land use, and providing significant income for the community. According to Rokhmah and Sobari (2017), simple agroforestry involves planting trees in intercropping patterns with diverse planting arrangements, such as fences, random placement, or rows, reflecting a simple agroforestry system that has been passed down through generations and is integrated with local cultural values. This differs from modern agroforestry systems, where management is based on research tested with existing technologies (Samosir et al., 2021).

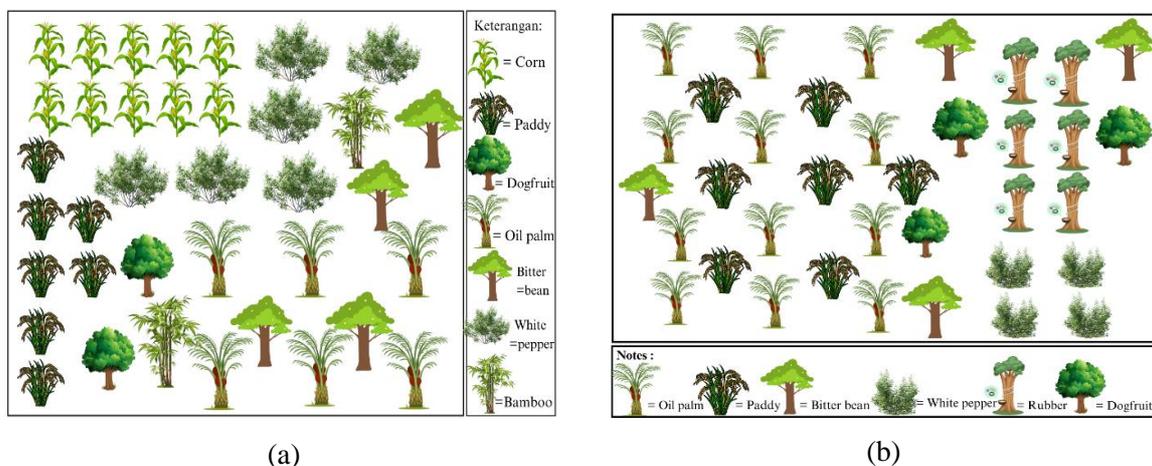
Agroforestry patterns based on production systems are classified as forest-based agroforestry. Communities clear parts of the forest or shrubland for plantation and agricultural activities. This approach is considered a sustainable farming system, as it utilises portions of forest land as a substitute for agricultural land without damaging the forest environment (Indriati and Ulfiasi, 2018). The community combines forestry and crops with differing economic values. This practice reflects the community's increasing knowledge of utilising vacant land to generate income from cultivable plants. The planting pattern is time-based (concomitant), with various crop types combined on a single plot according to their growth requirements and life cycles to maximise land use and achieve diverse benefits (Fig. 2).



**Fig. 2.** The agroforestry patterns in Engkangin Village are random mixtures: (a) corn with paddy, (b) fish pond, bitter bean, and oil palm, (c) oil palm with paddy, and (d) white paper with rubber.

The agroforestry planting pattern or spatial arrangement practised by the people of Engkangin Village includes a random mixture system. In this case, the people have not yet implemented agroforestry patterns in planting agroforestry plants, such as fences (atress along borders), rows (alternate rows), and alleys (alley cropping). Generally, the community plants with intercropping (random mixture). According to Irmayanti et al. (2019), conditions with mixed planting patterns have indeed been established previously because the land is inherited from ancestors, so they continue to manage it. Among 68 respondents, 14 types of plant commodities were grown on community land. The number of plant species in Engkangin Village is fewer than in Wanga Village, Motoling Subdistrict, South Minahasa Regency, where 20 types of plant commodities are found. This aligns with the view of trees as producers of woody, multifunctional plants that yield fruits, food crops, and spices (Oping et al., 2023). The planting pattern practised by the people of Engkangin Village is a random mixed pattern; the community utilises the land by planting both seasonal and perennial crops, allowing them to obtain income periodically (Fig. 2). According to Markum et al. (2021), Farmers utilize their land to plant various types of crops. They select crop types through careful planning; however, this depends on the seed varieties available in their area. In mixed plots, planting is done gradually. This will result in a variety of plants of different ages, and the number of trees will vary according to the community's preferences. This provides a sustainable and diverse income that can be received on a routine, daily, weekly, monthly, or yearly basis. The mixed random agroforestry pattern is visible in the image below.

The components in Engkangin Village are classified into two categories: agrisilviculture and agrosilvofishery. Most of the community applies the agroforestry pattern, with forestry components such as bitter bean (*Parkia speciosa*), dogfruit (*Pithecellobium jiringa*), mentawa (*Artocarpus anisophyllus*), durian (*Durio zibethinus*), and rubber (*Hevea brasiliensis*), as well as plantation components such as oil palm (*Elaeis guineensis*). Agricultural components include chili (*Capsicum annum*), cocoa (*Theobroma cacao*), paddy (*Oryza sativa*), corn (*Zea mays*), winter melon (*Cucumis melo*), cassava leaves (*Manihot esculenta*), mustard greens (*Brassica juncea*), and white pepper (*Piper nigrum*). Livestock components are carp fish (*Cyprinus carpio*) and pomfret fish (*Colossoma macropomum*). The agrisilviculture pattern currently involves the community embracing a new method where oil palm trees are planted among rice crops and other forestry plants (Fig. 3). The community adopts this method because they consider oil palm to bear fruit quickly, so there is no need to wait a long time for harvest compared to forestry plants such as bitter bean, dogfruit, rubber, durian, or mentawa. The community's choice of oil palm is due to its 3-year harvestability and its ability to provide a regular monthly income without waiting for forestry plants to mature. The land utilization for oil palm plantations is one effort to optimise dry-land farming. Planting rice in an intercropping pattern among oil palm trees can enhance land-use efficiency, production, and local farmers' incomes (Suriyanti et al., 2019).



**Fig. 3.** Sketch of the agroforestry pattern: (a) components of plants: corn, paddy, durian, oil palm, bitter bean, white paper, and bamboo, (b) components of plants: oil palm, paddy, bitter bean, white paper, rubber and dogfruit.

**Fig. 4** shows the result of an interview with a resident of Engkangin Village, who prefers to optimise land by creating fish ponds around agroforestry plants. This allows the community to utilise the production generated to meet their daily food needs in the form of horticultural plants, fruits, and fish. The community uses jengkol or petai plants to grow around the fish ponds to provide shade. The size of the pond owned by one resident is 15 m × 50 m, and the types of fish cultivated by the community in the pond are carp fish (*Cyprinus carpio*) and pomfret fish (*Colossoma macropomum*). This can also be found in Wanga Village, Motoling Subdistrict, South Minahasa Regency. To increase farmers' income, they utilise land with an agrosilvofishery pattern. The types of fish raised include tilapia, mujair, ornamental fish, and carp, with sizes varying from 15 cm × 20 cm to 25 cm × 30 cm. Farmers also carry out maintenance by feeding the fish twice a day, in the morning and afternoon, and then cleaning the ponds (Oping et al., 2023).

Based on socio-economic factors, it is classified as commercial agroforestry because in Engkangin Village, access to marketing for harvested crops is beginning to open up. The community conducts marketing that is still limited only to the Air Besar District and surrounding areas due to a lack of marketing information. Some of the harvest is used for daily needs, and the product prices are determined through agreements between farmers and collectors. A different situation was also found in the study by Fahrani (2015), which stated that limitations in marketing and a subsistence farming system led the community to prioritise daily needs. Corn sales are typically pre-ordered before harvest, so when the harvest arrives, farmers receive the proceeds immediately. Due to limited time and labor, they can only sell their harvest at the local market.

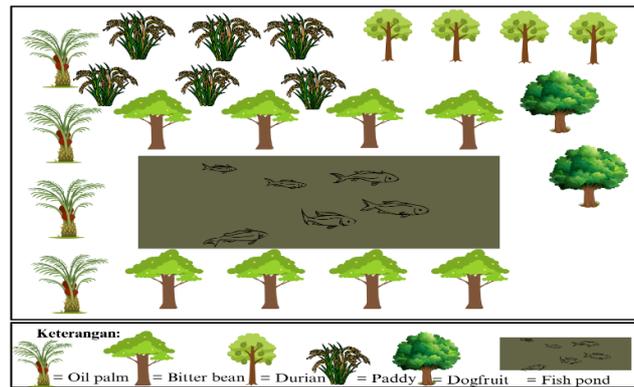


Fig. 4. Sketch of the agrosilvofishery pattern.

### 3.3. The Income from Agroforestry

The community of Engkangin Village depends on agroforestry products for both subsistence and supplementary income. A total of 15 commercial commodities are produced, including fruits, latex, leaves, seeds, and fish. Fruit-bearing tree species are particularly important because they fulfill economic, social, ecological, and cultural functions while remaining easy to market and consume (Roslinda et al., 2023). Rice is the dominant crop cultivated on agroforestry land, grown by 94.12% of respondents, reflecting its critical role in household food security, with a market price of IDR 12,000 per kg. Oil palm is the second most common commodity (88.24% of respondents), followed by rubber, both of which provide relatively stable cash income and adapt well to local environmental conditions. In contrast, cocoa, mustard greens, winter melon, cassava leaves, and fish are produced in limited quantities for sale (about 1.47%), as they are primarily intended for household consumption.

Forest products that are not sold by the community but are used to meet daily needs include bamboo shoots (*Dendrocalamus asper*), winter melon (*Benincasa hispida*), fern (*Stenochlaena palustris*), remudang roots, cassava (*Manihot esculenta*), bananas (*Musa acuminata*), *cepedak* (*Artocarpus integer*), and dayak eggplant (*Solanum ferox*) (Table 2). The community does not sell these forest products; they are used solely to meet their basic living needs. In addition to being directly used, some residents further process agroforestry products, such as durian, which is sold as durian lempok at IDR 70,000/kg and IDR 5,000 each, wrapped in corn leaves. Additionally, there are durians owned by the community that are not sold but processed into a byproduct called *tempoyak*.

Table 2. Results of the calculation on the utilization of agroforestry commercial products

No	Agroforestry product	Unit	$\bar{x}$	n (person)	FP	TP	Percentage (%)
1	Bitter bean	bunch	123	37	1	4,560	14.29
2	Dogfruit	kg	483.55	31	1	14,990	11.97
3	Rubber	kg	10.16	44	120	53,645	16.99
4	Durian	piece	660	5	1	3,300	1.93
5	Mentawa	piece	500	1	1	500	0.39
6	Oil palm	kg	437.833	60	24	630,480	23.17
7	Paddy	kg	873.13	64	1	55,880	24.71
8	Corn	kg	157.6	5	1	788	1.93
9	Cocoa	kg	2	1	12	24	0.39
10	Mustard greens	bunch	250	1	1	250	0.39
11	Winter melon	piece	100	1	1	100	0.39
12	Cassava leaves	bunch	1,250	1	1	1,250	0.39
13	Chili	kg	3	3	3	27	1.16
14	White pepper	kg	128	4	1	510	1.54
15	Fish	visitor	280	1	1	280	0.39
Total				259			100.00

Notes:  $\bar{x}$  = average number of harvests, FP = harvest frequency/year, n = number of respondents/product, TP = total harvest/year.

**Table 2** shows that agroforestry outputs serve as an income source for Engkangin villagers, as the resources derived from agroforestry systems have relatively high value. Therefore, almost the entire population of Engkangin Village manages and utilises agroforestry systems. According to the table, the economic value of an agroforestry product is influenced by the quantity harvested and the frequency of harvests for each agroforestry product type (Irmayanti et al., 2019). The type of agroforestry plant most utilised by the community, based on the quantity of agroforestry products harvested, is paddy, with a 24.71% share, followed by oil palm (23.17%) and rubber (16.99%). Paddy is a commodity that many people grow because it is an annual plant that can be harvested quickly, requiring little time. Paddy plants are also the main commodity for people to meet their living needs. Meanwhile, the agroforestry products least utilised by the community are mentawa, cocoa, mustard greens, winter melon, cassava leaves, and fish, with a combined percentage of 0.39%.

**Table 3** shows that the agroforestry product contributing most to the community's income is oil palm, with an economic value of IDR 1,387,056,000, accounting for 48.06% of the total. The next agroforestry product is paddy with an economic value of IDR 670,560,000 with a percentage of 22.24%. The third agroforestry product that contributes significantly to income is rubber, with an income of IDR 536,450,000, representing 18.59%. Furthermore, the agroforestry product that contributes the least is winter melon, with an economic value of IDR 400,000, accounting for 0.01% of the total.

**Table 3.** Percentage of the economic value of commercial agroforestry products

No	Agroforestry product	Unit	TP	Price (IDR)	NEi (IDR/year)	%NE
1	Bitter bean	bunch	4,560	5,000	22,800,000	0.79
2	Dogfruit	kg	14,990	12,000	179,880,000	6.23
3	Rubber	kg	53,645	10,000	536,450,000	18.59
4	<i>Durian</i>	piece	3,300	5,000	16,500,000	0.57
5	<i>Mentawa</i>	piece	500	5,000	2,500,000	0.09
6	Oil palm	kg	630,480	2,200	1,387,056,000	48.06
7	Paddy	kg	55,880	12,000	670,560,000	23.24
8	Corn	kg	788	4,500	3,546,000	0.12
9	Cocoa	kg	24	50,000	1,200,000	0.04
10	Mustrad greens	bunch	250	5,000	1,250,000	0.04
11	Winter melon	piece	100	4,000	400,000	0.01
12	Cassava leaves	bunch	1,250	5,000	6,250,000	0.22
13	Chili	ons	270	10,000	2,700,000	0.09
14	White pepper	kg	510	80,000	40,800,000	1.41
15	Fish	visitor	280	50,000	14,000,000	0.49
Total					2,885,892,000	100.00

Notes: TP = total annual harvest/year, NEi = income from each agroforestry product, %NE = income percentage.

Oil palm plants generate more income than other agroforestry crops, such as rubber, whose public perception is influenced by unstable or declining prices, which reduce farmers' income due to adverse weather conditions. This is supported by research from Herudin et al (2021). This illustrates the rapid growth of oil palm among the Indonesian people, particularly in Sekadau Regency. This has led to a decrease in rubber production because many believe that oil palm yields more promising income than rubber. Due to the low market price of rubber, farmers have converted rubber plantations into oil palm plantations in Belitang Hilir District, Sekadau Regency.

One of the residents, who utilises land by creating fish ponds, markets the fish, allowing buyers to pick them themselves according to their needs rather than by the kilogram, as is common practice. This is done so that the pond's yield can be marketed evenly and made accessible to the surrounding community. However, many residents actually grow crops. Still, these plants are cultivated to meet daily living needs rather than for sale, as the community does not plant these crops regularly but only when the land is empty, merely to fill the land. Another reason the community sells little of its produce is that prices are sometimes unstable, making it difficult for them to sell their harvest.

### 3.4. Production Costs and Labor Wages of Agroforestry Products

The community of Engkangin village incurs costs for managing agroforestry, including seeds, land clearing, plant maintenance, tools, and transportation. According to Muslichah et al. (2018), agricultural costs refer to the total amount of inputs and outputs required to finance agricultural activities and produce a specific quantity of products within a given period. The total costs incurred in managing agroforestry land can be broken down into fixed and variable costs. Fixed costs include the equipment costs incurred by the community. Meanwhile, variable costs include expenses for seeds, land clearing or plant maintenance, transportation, and purchasing fish seeds and fish feed.

**Table 4** shows that oil palm is an agroforestry crop with the highest costs among other crops. Fixed costs apply only to oil palm, as people need to purchase equipment such as *dodos* and *egrek* (tools for harvesting oil palm), totaling IDR 28,780,000 per year. The amount of this cost will depend on the number of tools used by the community. Meanwhile, for agroforestry crops, the variable costs are high, at IDR 105,592,000 per year. For other agroforestry crops, the community incurs no additional costs for maintenance or special equipment, as maintenance is naturally achieved through reliance on soil fertility, except for oil palm. The community engaged in fish farming in a pond incurs only limited operational costs, namely the purchase of fish seeds and feed. To save on expenses, some community members utilise plants such as water spinach and water hyacinth, intentionally grown in the pond as an additional food source for the fish. In terms of maintenance, the methods used are still traditional; the community only monitors the fish's condition during feeding, without employing any special treatments or modern technology in the fish farming process, resulting in a straightforward marketing approach.

**Table 4.** Recapitulation of the total production costs of commercial agroforestry products

No	Agroforestry products	Fixed cost (IDR/year)	Variable cost (IDR/year)	Total cost (IDR/year)
1	White pepper		140,000	140,000
2	Rubber		728,000	728,000
3	Corn		70,000	70,000
4	Cassava leaves		300,000	300,000
5	Oil palm	28,780,000	105,592,000	134,372,000
6	Carp, fish, and pomfret fish		22,720,000	22,720,000
Total		28,780,000	129,550,000	158,330,000

Notes: TC = total cost (IDR/year), FC = fixed cost (IDR/year), VC = variable cost (IDR/year).

Labor wages refer to the costs farmers pay to workers involved in activities such as spraying pesticides, planting, or clearing land. Farmers pay these wages in a specified amount, as agreed between the farmer and the worker. The wages paid by farmers to workers for clearing land are IDR 60,000 per day, for spraying pesticides IDR 80,000 per day, and for planting IDR 5,000 per stem. Typically, workers will work for 3 to 5 days, depending on the size of the land. **Table 5** presents labor wages for the maintenance of oil palm crops. Meanwhile, for agroforestry crops and fish ponds, the community prefers to manage them independently, involving only family members, without employing additional labor.

**Table 5.** Types of wages for oil palm labors

Types of wages for oil palm plantation work	Total (IDR/year)
Land cleaning wages	9,860,000
Pesticide spraying wages	18,820,000
Planting wages	5,550,000
Total	34,230,000

The total labor cost is IDR 34,230,000 per year, and the wage for spraying oil palm may change as the plants grow. Meanwhile, land clearing activities refer specifically to opening new land for oil palm planting, which is generally not done every year but only when the community plans to plant. The study by Susiana et al. (2023) found that the average labor costs for spraying amount to IDR 1,071,389/ha, while harvesting costs reach IDR 4,221,228/ha. This is due to harvesting being conducted regularly,

about every 15–20 days. This is due to regular harvesting every 15–20 days. Therefore, the net income from the community's agroforestry, after deducting production costs incurred during planting, harvesting, and labor, amounts to IDR 2,693,332,000 per year. This net income may fluctuate depending on the magnitude of expenses and revenues obtained from the sales of agroforestry commercial crops.

### 3.5. Contribution to Community Income

The villagers of Engkangin have a variety of professions, but all respondents have agroforestry land that they utilise to earn income from agroforestry products. Most residents earn their livelihoods through farming and gardening activities. In addition to agriculture, some respondents earn income from non-farming occupations. As shown in **Table 6**, the villagers' income sources come from both agroforestry and non-agroforestry activities.

**Table 6.** Agroforestry's contribution to community income

Income source	Annual income (IDR/year)	Average household income (IDR/year)	Percentage contribution (%)
Agroforestry	2,693,332,000	39,607,823.53	94.22
Non agroforestry	165,180,000	11,798,571.43	5.78
Total	2,858,512,000	51,406,394.96	100.00

**Table 6** indicates that net earnings from commercial agroforestry amount to IDR 2,693,332,000 per year, representing 94.22%. Non-agroforestry income can reach IDR 165,180,000 per year, representing 5.78%. This income is generated from various professions, including teaching, civil service, daily labor, and construction work. By comparing the community's income outside agroforestry with that from agroforestry, it is evident that the largest income is generated from agroforestry activities. In one year, the community's total income from both agroforestry and non-agroforestry is IDR 2,858,512,000. It can be seen that the implementation of agroforestry contributes the largest income compared to income from activities outside agroforestry. This indicates that the community is highly dependent on agroforestry, suggesting that the agroforestry system significantly contributes to the community's social and economic well-being. However, the research results of [Olivi et al. \(2015\)](#) show that agroforestry accounts for 88.31%, while non-agroforestry activities account for 11.71%, providing clear evidence that agroforestry significantly contributes to the income of communities engaged in it. The high value of agroforestry stems from how people manage and use land by planting a variety of economically valuable crops. Also, land management involves knowledge passed down from one generation to the next. The key to success in agroforestry development lies in selecting plant species, maintaining plant health, marketing agroforestry products, and establishing farmer organizations ([Roslinda et al., 2023](#); [Widiyanto and Hani, 2021](#)). The income from agroforestry remains significantly higher than that from non-agroforestry, making agroforestry a highly impactful source of income for communities. Below is a diagram illustrating the percentage contribution of agroforestry and non-agroforestry income.

## 4. Conclusion

The agroforestry system in Engkangin Village represents a traditional management model characterized by a simple forest-based structure and a random spatial arrangement. This study concludes that integrating diverse perennial and annual species, ranging from timber and fruit trees such as *Parkia speciosa* and *Durio zibethinus* to industrial crops such as rubber and oil palm, creates a resilient production system. The high economic reliance on this system, which provides the vast majority of household income, justifies its role as the primary engine of the local economy and a critical safety net for communities living near forest areas. The dominance of the random mixture pattern reflects a low-intensity management approach that prioritizes species diversity over structural order. While economically productive, there is significant potential to optimize land productivity through improved spatial regulation. Therefore, policy interventions should focus on transforming these random arrangements into more stratified, managed designs by providing superior, certified seedlings and technical assistance for intensive cultivation. Furthermore, establishing a farmer cooperative is essential

to improve market access and collective bargaining power. Future research should investigate the long-term ecological impacts of these patterns on soil health and carbon sequestration to provide a more comprehensive justification.

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