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RESEARCH ARTICLE

Agrobiodiversity of Talas Beneng (*Xanthosoma undipes* K.Koch)-Based Community Forest and Its Role in the Productivity Enhancement

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Abstract

The increasing intensification of agriculture, which often involves monoculture and overlooks diversity, has led to global challenges related to climate change and sustainability by affecting carbon sequestration, land productivity, and farmers' incomes. This study aimed to determine the role of agrobiodiversity in the talas beneng community forest in supporting sustainable agriculture that provides long-term benefits for the environment, economy, and community welfare. Using a vegetation survey, observations, and interviews with three key respondents, we conducted a case study on an agroforestry system based on taro cultivation in community forest land. The results showed that agroforestry-based taro cultivation has the potential to extend the timber harvesting cycle and maintain the ecosystem functions of community forests. Agrobiodiversity in community forest land based on taro cultivation is relatively low (H' <3), but it can positively impact agricultural land sustainability and potentially increase the local economy and farmers' income.

Keywords: agroforestry system, agrobiodiversity, community forest, talas beneng

1. Introduction

The availability of agricultural land and the decreasing carrying capacity of land following higher population growth are the main challenges in agricultural production [1,2]. Land shortages affect farmers' well-being, as land plays a key role in meeting their needs [3,4]. Limited land management is a challenge for optimizing agricultural yields [5]. For this reason, agrobiodiversity is one of the important aspects of maintaining agricultural productivity amid limited land because the diversity of crops supports food security and agricultural ecosystems [6].

Agrobiodiversity plays a crucial role in food and environmental sustainability because it includes not only plants but also other living organisms that support global food distribution [7–9]. Plant diversity is considered an indicator of sustainability because it provides the genetic richness and adaptability needed in the face of climate change and declining biodiversity [10,11]. By appreciating the cultural and economic value of agrobiodiversity, the global community can contribute to the maintenance of the environment and overall food sustainability [12–14].

As crops are rich in genetic variation, tubers significantly contribute to agrobiodiversity and play a role in adaptation to environmental changes [15–17]. Tuber species also have the potential to be alternative food sources and strengthen food security [18,19]. The results of studies [20] show that *kimpul* tubers (cocoyam) are a source of food that can be consumed directly, adding to the diversity of local food in the community. Likewise, talas beneng tubers (*Xanthosoma undipes*), which are planted in agroforestry, can be an important alternative food source to support food security [21] and play a role in food diversification, which can increase community income [22].

Talas beneng is a tropical plant that is important for maintaining local biodiversity and preserving natural resources [21,23]. Some types of taro generally have tubers underground. However, it differs from taro beneng, which lacks root bulbs. The tubers used are stem tubers. Some of the advantages of taro beneng compared to taro in general include its tolerance to shade, rapid growth, and the leaves can be processed into a substitute for tobacco, which is sold in the export market. Taro can produce tubers of 30-80 tons per ha and leaves of 200-300 grams per plant every month by diversifying the processing of tubers ranging from flour to processed functional foods [24]. Additionally, the harvest of tubers is environmentally friendly because it involves no soil demolition.

Planting talas beneng on community forestland can be interpreted as a small step in maintaining the balance of ecosystems and biodiversity. The results of previous research on talas beneng have been widely reported and published but are still limited to the postharvest aspect of tubers [25–31]. This study aims to determine the agrobiodiversity of talas beneng-based community forest land and its role in land productivity, local economy, and farmers' income in supporting sustainable agricultural policies.

2. Materials and Methods

2.1. Study site

This research was conducted in Ciamis Regency, West Java Province. The materials and tools include tally sheets, stationery, pegs, rapia ropes, tape meters, poles, and smartphones. Taro beneng planting in Ciamis Regency has started since 2019. However, there is no exact data related to the planting area of taro beneng. The development of taro beneng cultivation is not as massive because the trading system differs from that of other commodities. However, in some places such as Sukamaju Village, Bojongmengger Village, and Kutawaringin Village, taro beneng is still cultivated using an agroforestry pattern. The villages of Kutawaringin, Bojongmengger, and Sukamaju were chosen for the study because they are near forest edges and are important for studying how people interact with the environment. Data was collected in August and September 2022.

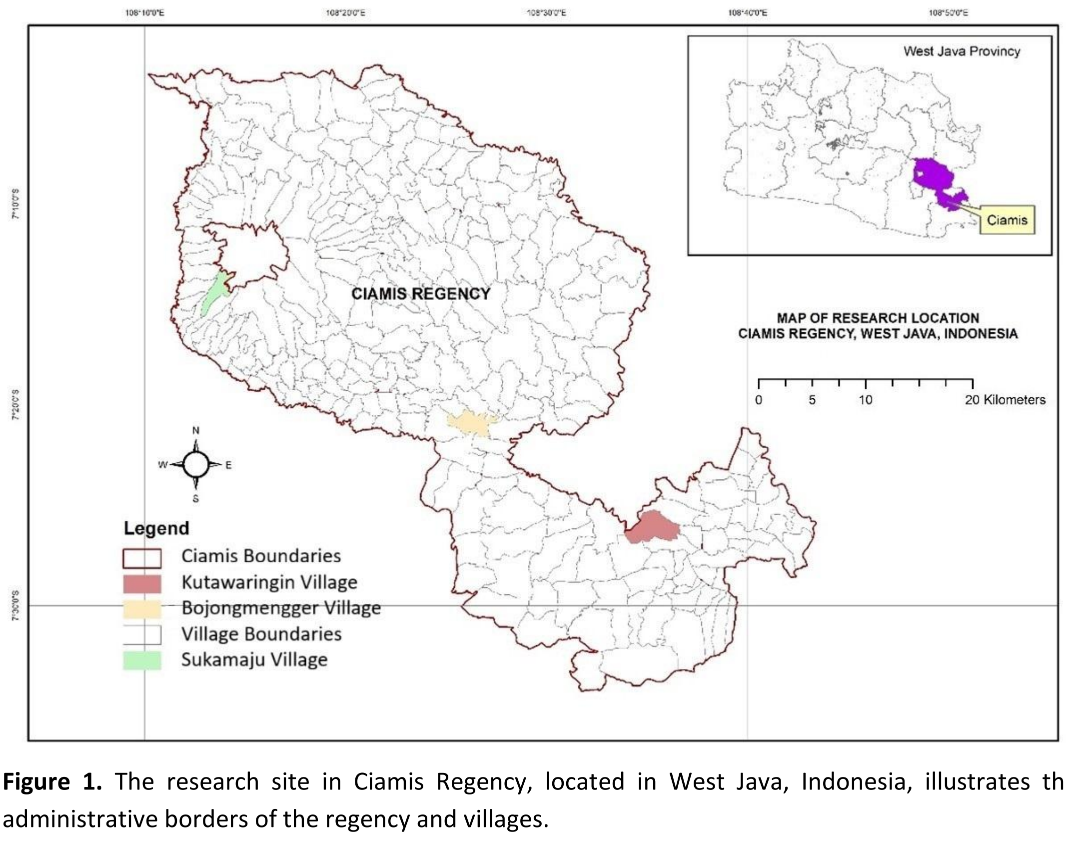

Figure 1. The research site in Ciamis Regency, located in West Java, Indonesia, illustrates the administrative borders of the regency and villages.

2.2. Data collection

This research was conducted on community forest land with a talas beneng-based agroforestry pattern in Ciamis Regency, West Java, Indonesia. Data was collected through observation, vegetation surveys, and interviews with key respondents. The vegetation survey was conducted by establishing observation plots of plant types, measuring 20 × 20 m, which were strategically placed in nine plots across three altitude zones: the highlands (Sukamaju Village), medium lands (Bojongmengger Village), and lowlands (Kutawaringin Village).

2.3. Data analysis

The data collected included community forest land use patterns, talas beneng forestry patterns, composition of vegetation types, and the input and output of talas beneng production. The vegetation analysis approach measures the number of species, density, frequency, and diversity index (H') [32].

Density = $\frac{\text{number of species i}}{plots\ area}$ (1)

Relative Density (KR) = $\frac{\text{density of species i}}{\text{dencity of total species}}$ x 100% (2)

Frequency = $\frac{\text{number of plots of species I found}}{\text{number of plots}}$ (3)

Relative Frequency (FR) = $\frac{\text{Frequency of species i}}{\text{Frequency of total species}}$ x 100% (4)

Diversity index (H') = $-\sum_{i-1}^{s}(pi\ Ln\ pi)$ (5)

pi = ni/N

Where H' = diversity index; N = number of total species; ni = number of species i; Ln = natural logarithm; and s = number of species in communities.

Furthermore, farm productivity was analyzed to measure the extent to which talas beneng increases land productivity and the income of community forest farmers.

Total cost =direct cost + indirect cost (6)

Total revenue=total product x price (7)

Total income=total revenue – direct cost (8)

Profit=total revenue – total cost (9)

R/C=total revenue/total cost (10)

Labor productivity (IDR/HOK) = $\frac{total\ income-indirect\ cost\ (family\ labors)}{number\ of\ family\ labors\ (HOK)}$ (11)

Rentability (%) = $\frac{Profit}{Total\ cost}$ x 100% (12)

Where R/C = Revenue Cost Ratio and HOK=number of working days

3. Results and Discussion

3.1. Results

3.1.1. Vegetation structure of community forest

The characteristics of the community forests in the three elevation zones revealed several similarities and differences, as shown in **Table 1**-**Table 3**. The data below illustrates the plant preferences for the altitudes at which they grow in various geographical zones. Community forests in the highlands are dominated by tree and multipurpose tree species, commonly referred to as MPTs. This is slightly different from community forests in the middle zone, which are dominated by tree species. In the lowland zone, community forest areas were dominated by plantation crops and MPTs.

Table 1. Composition and density of species by commodity.

No	Zone	Commodity	Species	Composition (%)	Density (stems/Ha)
1	Highlands	Trees	*Albizia falcataria, Toona sureni, Tectona grandis, Switenia mahagoni, Manglietia glauca, Maesopsis eminii, Hibiscus macrophyllus, Ficus benjamina, Albizia procera, Altingia excelsa, Oroxylum indicum, Gluta*	16.01	1,117

			renghas, Syzygium polyanthum		
		MPTs	*Artocarpus heterophyllus, Psidium guajava, Dimocarpus longan, Mangifera indica, Nephelium lappaceum, Garcinia mangostana, Persea americana, Parkia speciosa, Annona muricata*	0.03	308
		Plantation crops	*Syzygium aromaticum, Arenga pinnata*	1.67	117
		Food crops	*Xanthosoma undipes, Amomum compactum, Musa paradisiaca, Ananas comosus*	77.90	5,433
2	Middle lands	Trees	*Ochroma grandiflorum, Switenia mahagoni, Ficus callosa, Alstonia scholaris, Albizia falcataria, Hibiscus macrophyllus*	5.58	500
		MPTs	*Lansium domesticum, Archidendron pauciflorum, Mangifera indica, Parkia speciosa, Nephelium lappaceum*	1.21	108
		Plantation crops	*Cocos nucifera*	1.02	91
		Food crops	*Xanthosoma undipes*	92.19	8,266
3	Lowlands	Trees	*Albizia falcataria, Tectona grandis, Terminalia catappa, Hibiscus macrophyllus, Leucaena leucocephala*	1.46	156
		MPTs	*Mangifera indica, Artocarpus heterophyllus, Parkia speciosa, Persea americana, Psidium guajava, Dimocarpus longan, Garcinia mangostana, Nephelium lappaceum, Annona muricata*	4.10	438
		Plantation crops	*Hevea brasiliensis, Cocos nucifera, Coffea canephora*	0.29	31
		Food crops	*Xanthosoma undipes, Musa paradisiaca, Manihot esculenta, Carica Papaya*	94.15	10,056

Table 2. The composition and density of tree by classification.

No	Zone	Classification	Composition (%)	Density (stems/ha)
1	Highlands	Tree	15.05	175
		Pole	30.65	356
		Sapling	42.47	494
		Seedling	11.83	138
2	Middle lands	Tree	37.78	283
		Pole	41.11	308
		Sapling	21.11	158
		Seedling	2.22	16
3	Highlands	Tree	23.23	144
		Pole	37.37	231
		Sapling	32.32	200
		Seedling	7.07	44

Table 3. The composition and density of food crops sepecies.

No	Zone	Species	Composition (%)	Density (stems/Ha)
1	Highlands	Talas beneng	95.09	5,167
		Banana	1.69	92
		Cardamom	2.76	150
		Pineapple	0.46	25
2	Middle lands	Talas beneng	100.00	8,266.67

3	Lowlands	Talas beneng	83.90	8,438
		Banana	14.29	1,438
		Cassava	1.74	175
		Papaya	0.06	6

3.1.2. The diversity of talas beneng community forest

Surveys were conducted in three altitudinal regions: highlands, midlands, and lowlands, to capture differences in community forest ecosystems. This stratified method allowed for a more thorough assessment of forest conditions and ecological dynamics at various elevations. The study concentrated on vegetation density and the diversity index, which are crucial indicators for understanding the structural complexity and species richness within ecosystems. The findings are displayed in the following table, offering a comparative overview of ecosystem diversity levels across the three altitude-based locations.

Table 4. The diversity index of talas beneng-based community forest.

No	Zone	Density (stems/ha)	H' index	Category
1	Highlands	18,641.67	1.1	Low diversity
2	Middle lands	8,966.67	0.4	Low diversity
3	Lowlands	11,008.33	0.8	Low diversity

3.1.3. The contribution of talas beneng to farmers' income

The costs required for cultivating talas beneng are direct and indirect. Direct costs are incurred in cash, such as purchasing seeds, organic fertilizers, and land taxes. Indirect costs are non-cash expenses incurred by farmers, such as renting land and paying wages for family labor for planting, maintenance, and harvesting. The following illustrates the productivity potential of talas beneng farming on a 100-brick (1,400 m²) area scale.

Table 5. The productivity of talas beneng farming on a 100-bata scale for one year.

No.	Description	Volume	Unit	Price (IDR)	Total (IDR)
1	Cost				
	a. Direct cost				
	- seeds	1,000	stems	3,000	3,000,000
	- organic fertilizer	1,000	kg	500	500,000
	- land taxes	1,400	m^2	7,500	7,500
	b. Indirect cost				
	- rent own land/year	1,400	m^2	1,000,000	1,000,000
	- family labor	27.14	HOK	70,000	1,900,000
	c. Total cost				6,407,500
2	Production				
	a. taro leaves	1,600	kg	1200/kg	1,920,000
	b. taro tubbers	6,000	kg	1000/kg	6,000,000
	c. Total revenue				7,920,000
3	Farming income (total revenue-direct cost)				3,782,500
4	Profit (total revenue-total cost)				1,512,500
5	Farming productivity				
	Revenue cost ratio (R/C)	1.24			
	Labor productivity (IDR/HOK)	92,565			
	Rentability (%)	23.6			

3.2. Discussion

High species dominance in forest composition has a significant impact on local ecosystems and biodiversity [33–35]. The dense and dominant spacing of talas beneng planting also allows for changes in the structure of the natural ecosystem to occur, thereby reducing species diversity in community forests. Meanwhile, the dominance of tree species, especially in the highlands and middle lands, has implications for the availability of wood as a source of building and industrial materials. This can have an impact on local and regional economies, as well as on the sustainability of community forest management. On the other hand, the dominance of MPTs, such as fruits in the lowlands, can have a positive impact on diversifying agricultural production. Certain commercial crops, such as vegetables and fruits, have high economic value and can increase farmers' income [36,37].

According to the tree classification, the three community forest zones are equally dominated by the pole and sapling classes, as shown in Table 2. The varied tree diameters indicate that multi-species planting in community forests was not carried out simultaneously. A low seedling composition indicates poor natural regeneration [38]. This is possible because farmers usually prefer plant species that have higher economic potential [39].

Apart from talas beneng, other agricultural commodities, such as bananas, are widely cultivated on community forest land in both highland and lowland zones. This is slightly different from the cardamom found only in community forests' highlands, as this type of plant is more suitable for cultivation in highland climates. However, cassava was only found in community forest lands with low tree stand density. In community forests where the stands are not too dense, incoming sunlight allows cassava to grow.

Factors such as topography, altitude, and stand density influence farmer’s choices in determining the type of agricultural commodities [40–42]. In agroforestry of community forest management, a sustainable approach has significant positive environmental and economic impacts [43,44]. Crop diversification increases biodiversity and maintains the ecosystem balance [45,46]. Economically, diversification provides diverse income and reduces financial risks related to price fluctuations or crop failure for one type of crop [47–49]. Good community forest management also creates local jobs, increases the economic value of the community, and contributes positively to the national economy [50–52].

Based on biodiversity conservation, low diversity indicates a risk to biodiversity [53,54]. High biodiversity is essential for maintaining ecosystem balance and providing critical ecosystem services for human life [55,56]. The low tree density in talas, a community forest, suggests that the introduction of agricultural plants poses a risk of decreasing ecosystem function, which could impact environmental sustainability. However, from a land conservation perspective, talas beneng cultivation supports land conservation because it involves no land processing activities.

Apart from impacting ecosystem balance, low diversity can also impact climate change and global ecosystem functions [57,58]. Low forest density can reduce a forest's ability to absorb carbon because of the lower amount of biomass [59]. This can increase carbon dioxide emissions into the atmosphere, accelerating global climate change [60]. Therefore, low density could have long-term consequences for our planet's global climate and sustainability.

The impact on the economy and social welfare must also be considered. Low density can affect the availability of wood and non-timber resources, which are sources of income for local communities and industries. Therefore, maintaining forest density is essential for economic and environmental sustainability [61]. However, pressure on land and resources can affect supply chains and trade in natural resources [62]. Wise and sustainable forest management is the key to strengthening the carrying capacity of ecosystems [63,64] and ensuring economic and environmental prosperity [65,66].

Talas beneng leaves are typically harvested after four months of planting or eight harvests over the course of one year, with an average yield of 200 g per plant. The tubers were harvested at the end of the season, assuming that each plant produced 6 kg. Based on the analysis results, planting talas beneng on community forest land can generate positive income and profits for farmers with a return on capital (R/C) greater than 1, family labor productivity exceeding the average wage, and a fairly high rate of return. The R/C value> 1.24 indicates that every IDR 1 invested by farmers in talas beneng farming can produce IDR 1.24. The labor productivity of IDR 92,842 per HOK shows that farmers' wages in talas beneng cultivation activities are higher than the prevailing average wage for farm workers (IDR 70,000/HOK). Thus, working as a talas beneng farmer is better than working as a farm laborer elsewhere. Meanwhile, the capital productivity of 23.8% indicates that cultivating talas beneng on community forest land is feasible, as it is more profitable than saving money in the bank with a savings interest rate of 2-5%.

Planting talas beneng on community forest land has a significant economic impact at the local level, with the potential to increase farmers' incomes and diversify the regional economy. However, this may have a limited effect on the global economy. Factors such as production scale, global market competitiveness, and dependence on commodities are important [67–69]. If production can meet global demand with a high level of competitiveness, its contribution to international trade can impact the global economy positively [70,71]. However, the success of talas beneng farming is significant in the local economic context, helping to strengthen regional economic resilience and sustainability.

4. Conclusions

The introduction of commercial crops to community forest land using agroforestry can reduce the level of wood exploitation, extend the harvest cycle, and maintain the function of community forest ecosystems. The agrobiodiversity index on community forest land, based on Talas Beneng, is relatively low; however, it has a positive impact on the sustainability of agricultural land, the local economy, and the welfare of farmers.

Author Contributions

SHT: Conceptualization, Methodology, Investigation, Writing - Review & Editing; **TRY**: Writing - Review & Editing.

Conflicts of interest

There are no conflicts to declare.

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