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Tumpangsari-Agroforestry Practices and Its Socioeconomic Impact on Communities in the Gunung Arjuna-Lalijiwo Forest Reserve, East Java, Indonesia

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Abstract

The issue of poverty remains a significant and persistent challenge in Indonesia, particularly in rural areas. Agroforestry has been practised in the Gunung Arjuna Reserve Forest, which has been managed by Perhutani since the 1970s. However, the absence of effective oversight and guidance has hindered substantial socioeconomic progress. In 2016, the management of 544.74 hectares of this forest was taken over by Universitas Brawijaya (UBF). This study focused on the Karangploso sub-district, specifically within the Tawangargo, Donowarih, and Ngenep villages under UBF's management. The study aimed to assess the impact of the transition from Perhutani's management to UBF's current administration of the Gunung Arjuna Reserve Forest. It did so by (i) analyzing factors influencing the total area of cultivated land in the *tumpangsari*-agroforestry system and (ii) evaluating the socioeconomic consequences of this management shift. A quantitative approach and convenience sampling technique were employed, selecting respondents based on accessibility and proximity to the researcher on-site. The results indicated that 34% of respondents cultivated crops on land areas ranging from 1.0 to 1.5 hectares. The regression analysis demonstrated a strong relationship ($R2 = 0.847$) between factors such as work duration, plant diversity, education level, income, and the number of family members engaged in farming and the total cultivated land area. The study also found that the transition from Perhutani to UBF management had a significantly positive impact on socioeconomic aspects, such as total income, social interactions, and infrastructure, as perceived by 67% of respondents. Furthermore, 70% of respondents acknowledged their reliance on the agroforestry system for income, with 88.86% strongly agreeing that it contributed to family income, and 84.57% strongly agreeing that it was a vital source of raw materials for sustenance. The implication of transferring the 544.74-hectare reserve forest to Universitas Brawijaya had a favourable outcome, enhancing the living standards of the communities in the vicinity. The *tumpangsari*-agroforestry system not only improved socioeconomic conditions but also fostered social interactions, improved infrastructure, and preserved the forest's ecology. It is recommended that the community continue cultivating a variety of crops with guidance from UB Forest management and other stakeholders. Creating national awareness about the benefits of agroforestry in rural poverty reduction is vital, emphasizing the need to explore and adopt diversified livelihood strategies.

Keywords: Tumpangsari-agroforestry, socioeconomic, communities, livelihood, Indonesia

1. Introduction

The rural communities near forests are usually sizable, economically disadvantaged, and experiencing population growth. The rise in population, in particular, has contributed to an expansion while also putting a strain on the Earth's natural resources (FAO, 2018). The connection between food security and energy consumption is complex, playing a significant role in the utilization of natural resources (Mertens et al., 2000). With the growth of population and human ambitions, land is becoming a progressively limited resource, emphasizing the need for effective land-use planning. The purpose of land-use planning is to assist decision-makers and land users in selecting and implementing land uses that will best meet the needs of people while safeguarding natural resources and ecosystem services for current and future generations. Tools and

methods for land-use planning at appropriate scales should facilitate and aid the diverse and often competing users of land resources in selecting land-use and management options that enhance productivity, support sustainable agriculture and food systems, promote governance over land and water resources, and meet societal needs (FAO, 1993).

Forests play a crucial role in addressing global poverty through two primary mechanisms. Firstly, they function as a vital safety net, enabling rural populations to escape poverty or alleviate their hardships. Secondly, forests hold untapped potential to help specific rural communities break the cycle of poverty (Sunderlin et al., 2005). In the context of agroforestry, land-use planning involves the systematic evaluation of forested areas and their potential for various land uses. The impetus for land-use planning arises from the necessity for enhanced management and a revised pattern of land use, adapting to changing circumstances. To alleviate the escalating pressure on tropical forests, sustainable management practices can be implemented as a solution. The adoption of agroforestry, in particular, is regarded as a sustainable land management system, promoting increased production, ecological stability, and supporting sustainable development. This approach offers a spectrum of benefits in the short, medium, and long term for both local communities and the government. It generates cash income for communities and a diverse array of products. According to Mayers and Vermeulen (2002), forestry holds numerous advantages over other sectors as a potential means of alleviating rural poverty, also serving as a resource safety net. Furthermore, forest ecosystems provide various services such as timber supply, wood fuel (charcoal and firewood), non-wood forest products, water purification, climate stabilization, and biodiversity preservation (MEA, 2005).

The adoption of land-use systems through appropriate management practices, such as agroforestry, enables land users to maximise the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources. Agroforestry is a land-use system of natural resources management that integrates trees on farms in the agricultural landscape to diversify and sustain production (Molla, 2019). It is a cost-effective strategy for climate change mitigation (Baliton et al., 2017) and provides benefits for carbon sequestration (Zomer et al., 2016) and storage (Feliciano et al., 2018). Additionally, agroforestry increases ecosystem services (Shin et al., 2020) and simultaneously provides job opportunities (Borrella et al., 2015) to the community (Parhusip et al., 2019). In practice, agroforestry is often described as a suitable system for the community's needs in their land use systems.

Studying the *tumpangsari*-agroforestry system and its impact on the socioeconomic aspects of communities in Mount Arjuna-Lalijiwo forest reserve, East Java, Indonesia, holds significant importance for several reasons.

It acts as a driver for contributing to poverty reduction by providing alternative income sources and livelihood opportunities for rural communities. By integrating trees with agricultural crops and livestock, agroforestry systems can enhance productivity, diversify income streams, and improve food security for local communities. It also offers a sustainable land-use management approach that promotes biodiversity conservation, soil fertility improvement, and ecosystem resilience. Implementing agroforestry systems can contribute to mitigating climate change, preserving natural resources, and enhancing the long-term productivity and sustainability of agricultural landscapes. On the other hand, agroforestry diversifies income sources and reduces dependency on single commodities, making rural communities more resilient to market fluctuations and external shocks. By integrating trees into agricultural systems, agroforestry can provide additional sources of income from timber, fruits, nuts, medicinal plants, and other non-timber forest products, thereby enhancing the socioeconomic resilience of local communities. Last but not least, agroforestry promotes community involvement and local decision-making in land management. By incorporating traditional knowledge and local practices, agroforestry recognises and respects the role of local communities as custodians of natural resources. This empowerment and participation foster a sense of ownership, strengthen social cohesion, and contribute to sustainable development at the local level.

The establishment of the *tumpangsari* system in Indonesia has led to increased growth in the primary species of forest trees and improved yields of food crop species (Sukandi, 1993). This program has been evolving in various areas since 1970, encompassing both social forestry and casual *tumpangsari*. The positive trajectory of *tumpangsari* land use suggests a growing demand for participation among forest villagers. This trend is expected to make substantial contributions, both directly and indirectly, to the food security of rural households in forested regions. Farmers have the option to extend their contracts until the end of the forest tree rotation period. Under the *tumpangsari* program, rural forest villagers are permitted to cultivate annual crops like coffee, maize, cassava, and other vegetation contributing to their well-being. Therefore, the study aims to assess the impact of the transition from Perhutani's management to UBF's current administration of the Gunung Arjuna Reserve Forest. This involves (i) analyzing the factors influencing the total area of cultivated land in the

tumpangsari-agroforestry system and (ii) evaluating the socioeconomic consequences resulting from this shift in management.

2. Methodology

2.1 Study Site

The study was conducted within the University of Brawijaya Forest (UBF) located in Karangploso, Malang, East Java Province. The University of Brawijaya was granted a forest area by Indonesia's Ministry of Live Environment and Forestry (MLEF) on December 31, 2015. UBF operates as an educational and training forest under the oversight of Universitas Brawijaya, officially established in 2016. It is situated in three villages: Donowarih, Tawangargo, and Ngenep, within Karangploso District, Malang Regency. Specifically, it encompasses Sumbersari hamlet in Tawangargo village, Sumberwangi hamlet in Donowarih village, and Tumpangrejo hamlet in Ngenep village (Figure 1). The establishment of UB Forest was sanctioned by the Decree of the Minister of the Environment and Forestry of the Republic of Indonesia, Number: 676/MenLHK-Setjen/2015, initially covering approximately 514 hectares, which later expanded to a total of 544.74 hectares, designated as an Educational and Training Forest.

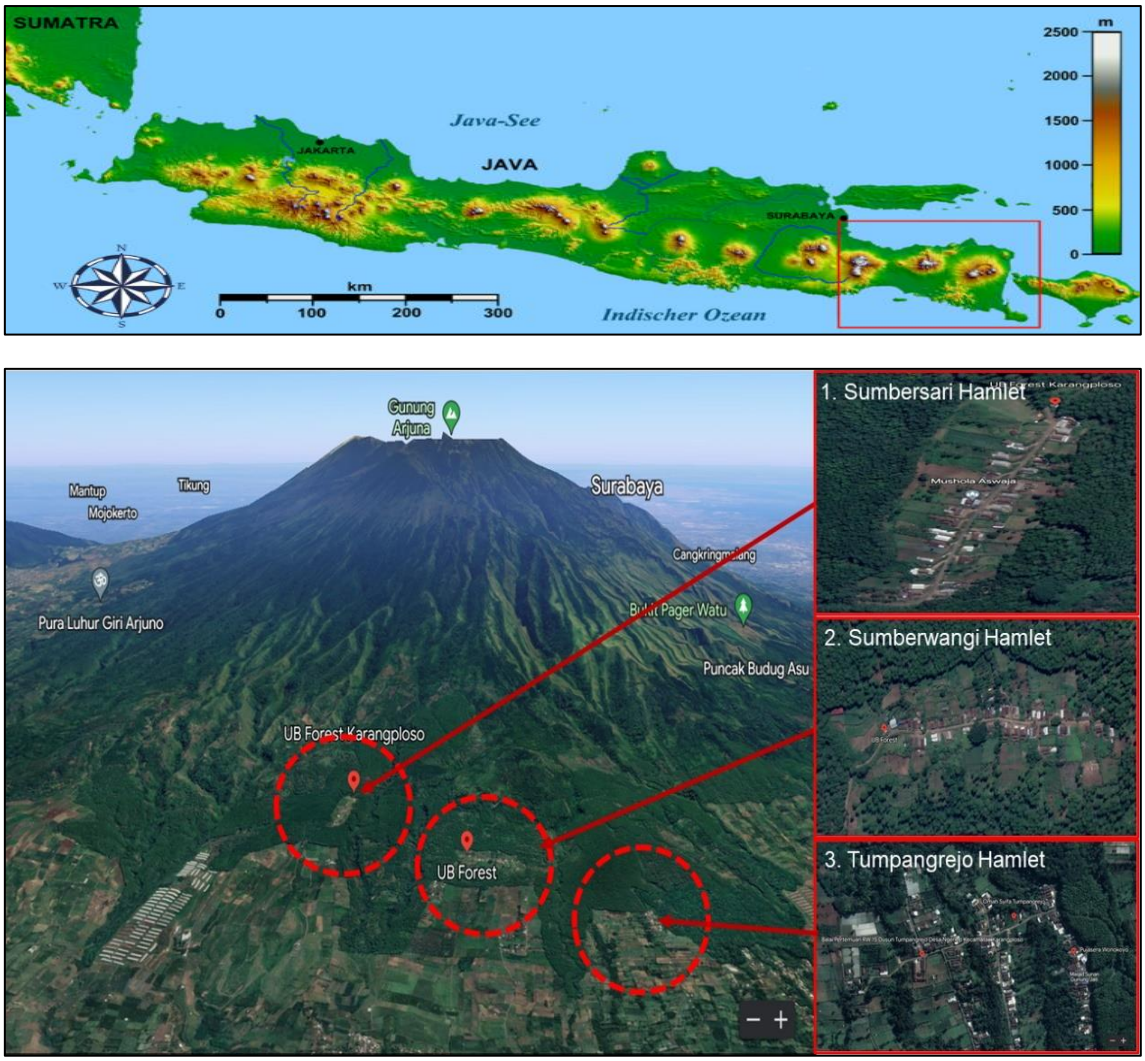

Figure 1. Study site -UBF at Gunung Arjuna-Lalijiwo, Malang, East Java, Indonesia

Universitas Brawijaya (UB), through its corporate social responsibility, actively supports the economic development and welfare of the local community within their educational forest in Karangploso. In pursuit of economic empowerment, they have provided technical and financial assistance to enable the community to effectively utilize the fertile land and implement the *tumpangsari* agroforestry system in UBF for sustaining their livelihoods. The selection of the study area was based on its ecological diversity, agroforestry potential,

opportunities for research collaboration, socioeconomic significance, and policy implications. The area's diverse ecological characteristics offer a valuable context for examining the interplay between agroforestry and the environment. Additionally, the geography and climate are conducive to the adoption of agroforestry practices, providing insights into sustainable land use strategies. The University of Brawijaya's expertise and resources further bolster research capabilities in the region. The socioeconomic importance of the study area informs sustainable development and community-based initiatives, while the forest's protected status underscores the significance of conservation policies. The distinctive interactions between the local population in the UB Forest area and forest land use in Tawangargo, Donowarih, and Ngenep villages, Karangploso District, Malang Regency, contribute to its unique character.

The total area of UBF, as stipulated in the Decree of the Minister of Environment and Forestry of the Republic of Indonesia Number: 676/MenLHK-Setjen/2015, encompasses approximately 514 hectares designated as Education and Training Forest. The topography and slope conditions of UB Forest are categorized into three classes: 0-8% covering an area of 40.97 hectares, > 8-15% covering 484.89 hectares, and > 15% covering 23.81 hectares. The average annual rainfall is 250 mm, with an average temperature of 27 ℃. The area features three types of soil: brown alluvial soil, brown latosol, and grey regosol. The land use within UBF management and distribution is depicted in Figure 2.

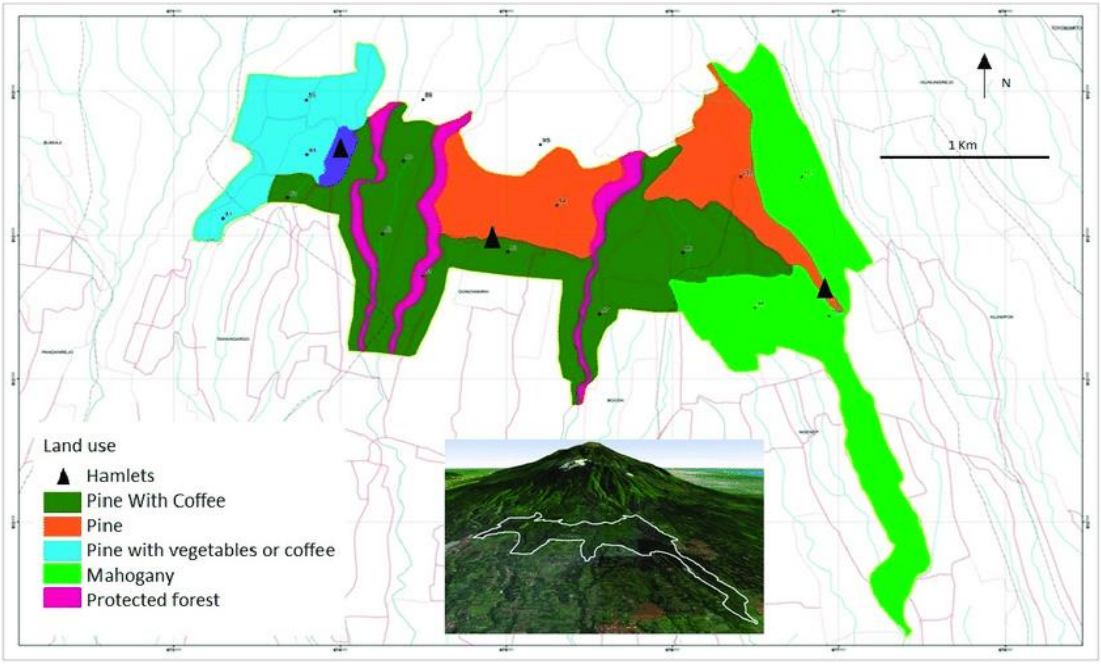

Figure 2. Land use map of the study site, KHDTK UB Forest.

2.2 Data Collection

Data collection took place from February 8, 2022, to March 19, 2022. Four distinct approaches were utilized, including questionnaire surveys, interviews, and on-site observations. Primary data was obtained through a questionnaire distributed to 350 selected respondents. To gather more comprehensive information, in-depth interviews and on-site observations were conducted. Additionally, secondary data was sourced through a literature review involving journals, articles, and government official documents.

The questionnaire has three parts, namely part A, part B and part C. Part A, was about respondents: examples like family members, age, status, educational background, occupation, and monthly income. Part B was about respondents' involvement in village community activity related to the forest. Lastly, part C was about forest products or socioeconomic activities by that particular village community's income dependency on forestland and agriculture. The data collected underwent analysis using both descriptive statistics and multiple linear regression. This analysis aimed to explore the socioeconomic factors influencing the total area of cultivated land and assess the impact of the transition in the forest management system on the local community's socioeconomic aspects, specifically focusing on income in the context of UBF.

Slovin's formula was used to determine an appropriate size of sample by taking into account the known population size (N) and the acceptable error value (e) to calculate the appropriate sample size (n). Fill the N and

e values into the formula n = N ÷ (1 + Ne^2). The resulting value of n equals the sample size to be used. According to Sugiyono (2014), in the sampling process, the Slovin formula must be represented by an adequate number so that the results can be generalized, and the calculations do not require a table of the number of samples. The Slovin formula for determining the sample is as follows:

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}\,(e^2)}$$

Where,

n = Sample size/ number of respondents

N = Size/number of populations

e = sampling error

The range of samples that can be taken from the Slovin technique is between 10%- 20% of the study population. Therefore, in this study, the error tolerance is used by 10% with a population of 824 household members from the combined number of household members in Sumbersari, Sumberwangi and Tumpangrejo hamlet. The specific sample size should be taken from each hamlet to ensure a proportional representation of the population in the study. This approach helps in obtaining a more accurate and representative sample from each hamlet, considering their relative sizes within the overall population. Table 1 shows the villages/hamlets at UBF and the number of respondents in the study area.

Table 1. List of village/hamlet at UBF and no. of respondent

Village	Hamlet	Active Farmer population number/ (Household Number)	Sample no.	Sample percent (%)
Tawangargo	Sumbersari	100 (KK 32)	75	21.43
Donowarih	Sumberwangi	120(KK39)	95	27.14
Ngenep	Tumpangrejo	604(KK300)	180	51.43
	Total	824(KK371)	350	100

3. Results and Discussion

3.1 Tumpangsari and Cultivated Crops

Residents of Sumbersari and Sumberwangi hamlets engage in crop cultivation within the UBF, while the community in Tumpangrejo hamlet, Ngenep village, not only utilizes arable land within the UBF but also owns and cultivates land outside the UB Forest area. The agricultural products of the community are typically sold directly to middlemen, with the exception of the coffee grown within the UB Forest area. The yields from coffee plants cultivated in the UB Forest area are instead handed over to UB Forest itself. The establishment of a farmer group and the active involvement of women in activities such as Posdaya in Sumbersari, Sumberwangi, and Tumpangrejo hamlets exemplify the strong community bonds and their willingness to embrace positive changes for the improvement of the community's economy. This commitment is evident through frequent socialization activities conducted within the village.

The predominant tree species cultivated in the UB Forest area include Pine *(Pinus)* and *Mahogany (Swietenia macrophylla)*. In addition, the area hosts a variety of annual and seasonal crops such as coffee, ginger, turmeric, carrots, green beans, mustard greens, cabbage, chillies, eggplant, banana, and corn. According to the data, these crops, managed through the *tumpangsari* agroforestry system, home garden agroforestry system, and forest product gathering, serve either for personal consumption or for sale to middlemen. Table 2 provides a detailed breakdown of the species managed and cultivated by respondents within the UB Forest. For example, Coffea Arabica, Coffea *canephora*, and *Persea americana Mill* are grown for their food, medicinal, and cosmetic value, while *Zingiber officinale Roxb*. and *Piper betle L*. are cultivated for both culinary and therapeutic purposes. *Bambusa sp.* is typically collected for handicraft and building materials. Meanwhile, *Musa paradisiaca L.*, *Manihot esculenta, Solanum lycopersicum*, and *Capsicum frutescens* are cultivated for sale, with many of them also being consumed by the community.

There are also seasonal crops such as canned fruit and vegetables such as tomatoes, garlic, ginger, cabbage, mustard greens, slada, beans, bloom cabbage, leek and others, and as partners of seasonal plants, also open farms and fisheries. The plantation sector in Sumbersari, Sumberwangi and Tumpangrejo hamlets is still dominated by smallholder plantations whose production is still traditional. There is UB Forest Management, which cooperates

with local people in 250 ha and is spread in UB Forest with coffee commodities (arabica and robusta). Those still in the development stage are garlic, and passion fruit macadamia *(Macadamia integrifolia L).* vetiver (*vertiveria zizanioides)* and patchouli *(pongostemon cablin).* These crops are mainly managed on smallholdings rather than large scale. In the UBF, not all farmers have the same size of cultivated area. This situation is a continuation after the transition of the management body from Perum Perhutani to UB Forest which took effect on 31 December 2015. Since Perum Perhutani management allowed farmers to cultivate various crops in the reserve forest, farmers have different areas of agricultural land cultivated, possibly caused by some significant factors. After the transition to UB Forest, the management did not change the status quo regarding the area that the farmers cultivated or make it a standard area of cultivated land for each farmer or group of farmers and still kept it like during the previous management.

Table 2. Crops types and forest products planted through *tumpangsari*- agroforestry system at UB Forest.

Crops types/forest products	Local name	Own consumption	Sale	Use for
Coffea canephora	Kopi Robusta	-	√	Food/cosmetic /medicine
Coffea arabica	Kopi Arabika	-	√	Food/cosmetic /medicine
Persea americana Mill	Alpukat	-	√	Food/cosmetic & Medicine
Zingiber officinaleRoxb.	Pisang/Laiya	√	√	Food & Medicine
Musa paradisiaca L..	Jahe/ Punti	√	√	Food & Medicine
Solanum lycopersicum	Tomat	√	√	Food
Manihot esculenta	Pucuk Ubi	√	√	Food
Allium sativum	garlic	√	√	Food & Medicine
Dimocarpus longan	mata kucing / longan	-	√	Food
Pometia pinnata	matoa/Longan		√	Food
Carica papaya L.	Pepaya/Kaliki	√	√	Food & Medicine
Annona muricata Linn	Sirsak	√	√	Food & Medicine
Brassica oleracea var.capitata	kubis	√	√	Food
Capsicum frutescens	Cabe/cili	√	√	Food
Daucus carota subsp.sativus	wortel	√	√	Food
Brassica	sawi	√	√	Food
Pomelo citrus maxima	Jeruk	-	√	Food
Citrus aurantifolia (Chrism) Swing	Jeruk nipis/ Lemo tadi	-	√	Food & Medicine
Piper betle L.	Sirih/Bolu	-	√	Food
Durio	durian	√	√	Food & Medicine
Hylocereus undatus	Buah Naga	√	√	Food & Medicine

The changes that have been made are more to the types of crops that are cultivated which is focusing on coffee growing under the pine stands and mahogany stands as well as eliminating sap tapping, collaboration in terms of knowledge in agriculture technology, building coffee collecting centre, coffee processing, packaging and marketing coffee product. From a socioeconomic standpoint, communities residing near the forest can benefit from the managed forest products, aiming for consistent economic growth and the generation of employment opportunities for future generations through enhanced forest management practices. Socially, this approach can fortify the cohesion of the community surrounding the forest and mitigate social inequalities among different community groups. On the environmental front, UB Forest serves as a conservation area, regulating ecological temperatures, humidity levels, functioning as a water reservoir, providing habitats for wildlife, supplying oxygen, inhibiting wind, preventing erosion, acting as a source of fruits and wood, and essentially serving as the lungs of the earth. The involvement of farmer groups in Dusun Sumbersari and Dusun Sumberwangi in UB Forest management encompasses (a) social aspects, taking the form of personnel actively participating in meetings and socialization activities, contributing responses and suggestions during these events. Moreover, they assist in providing information, lodging, and meeting the water needs of students engaged in research or practical activities; (b) economic aspects, predominantly in terms of profits derived from agroforestry activities, with a primary focus on coffee cultivation and the cultivation of other crops.

3.2 Factors Influencing the Overall Extent of Cultivated Land Within the Tumpangsari Agroforestry System

The land serves as a pivotal resource for agriculture. Respondents from Sumbersari, Sumberwangi, and Tumpangrejo hamlets engage in cultivating both annual and seasonal crops using the *tumpangsari* agroforestry method on forested land. However, the study reveals variations in the size of cultivated areas among the respondents in the UB Forest (Table 3). The majority of respondents (34% or 120 individuals) operate a cultivated crop in a land area ranging from 1.0 to 1.5 hectares in UB Forest. Following this, 29.9% (94 respondents) own an area of 0.5 to 1.0 hectares. Ninety-one farmers (26%) cultivate land areas ranging from 1.5 to 2.0 hectares, while 39 farmers (11.1%) cultivate land exceeding 2.0 hectares. Lastly, only six farmers (1.7% of respondents) cultivate land less than 0.5 hectares.

Table 3. Cultivated land area in the UB Forest Area

Cultivated Land Area	Respondents from three Hamlets	
In UB Forest (ha)	Number (Person)	Percentage (%)
< 0.5 ha	6	1.7
0.5-1.0 ha	94	26.9
1-1.5 ha	120	34.3
1.5-2.0 ha	91	26.0
> 2.0 ha	39	11.1
Total	350	100.0

The study employed multiple linear regression analysis to assess the extent of influence between the independent variable (size of land) and the dependent variable, examining the relationships between each positive or negative independent variable and the predicted value of the independent variable. In this analysis, the dependent variable (Y) is the size of the land, while the independent variables include the length of work in the forest (LB), the number of crop species (JT), the length of education (TP), income (PEN), and the number of family members (JAK). The results of the multiple regression analysis and the coefficient of determination (R2) are presented in Table 4.

Table 4. Results of Multiple Linear Regression and coefficient of determination (R^2).

Multiple Regression output					
Multiple R	0.92				
R2	0.847				
Adjusted R2	0.845				
Standard Error	0.397				
	ANOVA				
	df	Sum of Squares	Mean Square		
Regression	5	299.491	59.898		
Residual	344	54.169	0.157		
F = 380.382	Significance of F = 0.000				
COEFFICIENT TABLE (VARIABLES IN THE EQUATION)					
Variable	b	SE[b]	Beta (B)	T	Significance of T
Constant	0.512	0.159		3.217	0.001
Years of work (LB)	.202	.035	.162	5.839	.000
Number of plant types (JT)	.090	.046	.071	1.982	.048
Education level (TP)	-.294	.049	-.172	-5.950	.000
Gross Monthly Income (PEN)	.115	.057	.081	2.010	.045
Number of family members as farmers (JAK)	.783	.029	.804	26.767	.000

With the constant value of 0.512 and the regression coefficients as follows: LB (Years of Work (x1)) = 0.162, JT (Number of Plant Types (x2)) = 0.071, TP (Education Level (x3)) = -0.172, PEN (Gross Monthly Income (x4)) =

0.081, and JAK (Number of Family Members as Farmers (x5)) = 0.804, the equation for Arable land area (LA) is as follows:

Arable land area (Y) = 0.512 + 0.162(LB) + 0.071(JT) + (-)0.172(TP) + 0.081(PEN) + 0.804(JAK)

So, the equation can be simplified as:

Y = 0.512 + 0.162(LB) + 0.071(JT) - 0.172(TP) + 0.081(PEN) + 0.804(JAK)

Where,

Y = The area of land cultivated by the community in the UB Forest area (ha)

i = Respondent i (i = 1,2, ...n)

0 = Regression constant or intercept

1 - 5 = Regression coefficient

LB = Length of work in the forest (years)

JT = Number of plant species (number of plant species)

TP = Level of education (years)

PEN = Income (rupiah per month)

JAK = Number of family members (persons)

e = Standard error

Based on the model, a one-unit increase in Arable land area will result in an increase of 0.162 in LB, 0.071 in JT, 0.081 in PEN, and 0.804 in JAK. On the other hand, a one-unit increase in TP will lead to a decrease of 0.172 in the Arable land area. The equation shows the effect of each independent variable (length of work, number of types of plants, income, and number of family members) on the dependent variable (size of the area). Therefore, the regression coefficient can be interpreted as follows:

i. The constant value (0.512) indicates that when all independent variables (length of work, number of plant species, income, and number of family members) are zero, the area of arable land is constant at 0.512 hectares.

ii. The coefficient for the length of work variable (0.162) suggests that a one-year increase in the length of work will result in a 16.2% increase in the area of arable land, assuming all other independent variables remain constant.

iii. The coefficient for the number of plant species variable (0.071) indicates that a one-unit increase in the number of plant species will lead to a 7.1% increase in the area of arable land, assuming all other independent variables remain constant.

iv. The coefficient for the number of education level variables (-0.172) indicates that a one-unit increase in the education level will lead to a 17.2% decrease in the area of arable land, assuming all other independent variables remain constant.

v. The coefficient for the income variable (0.081) suggests that a one-unit increase in income will result by 8.1% increase in the area of arable land, assuming all other independent variables remain constant.

vi. The coefficient for the number of family members working as farmers variable (0.804) indicates that a one-person increase in the number of family members working as farmers will lead to 80.4% increase in the area of arable land, assuming all other independent variables remain constant. The coefficient of determination (R2) for the regression model is 0.847, indicating that approximately 84.7% of the variation in the area of arable land can be explained by the variation in the independent variables (length of work, number of plant species, level of education, income, and number of family members). The remaining 15.3% is attributed to factors outside the model that also influence the area of arable land in the UB Forest area.

The standard error of estimate (SEE) is calculated as 0.397, indicating the average distance between the observed values and the predicted values by the regression model. A smaller SEE value suggests that the regression model provides more precise predictions of the dependent variable.

The results align with previous research by Pasha & Susanto (2009) in Bukit Barisan National Park, which also identified socioeconomic factors (such as family members, length of stay, education level, income, land use duration, age, and land occupation) influencing forest land use. Their study found that these factors accounted for 48.4% of the variation in forest land use, while the remaining variation was attributed to other factors beyond

socioeconomic factors. The regression analysis provides insights into the relationships and impacts of various independent variables on the size of arable land in the UB Forest area, contributing to the understanding of the socioeconomic factors influencing land use.

4. Assessing the Impact Resulting from the Transition in the Forest Management System on Socioeconomic Aspects Categorized by income levels

Income plays a crucial role in assessing the socioeconomic conditions of households within the community. Based on surveys and interviews conducted with respondents from the Sumbersari, Sumberwangi, and Tumpangrejo hamlets, a significant difference in their income emerged during the transition from the Perhutani forest management system to the UB Forest management in 2016.

Initially, during the early phases of the transition, there was no notable difference in income for farmers associated with UB Forest. However, studies conducted in 2017 and 2018 revealed that some farmers reported a decline in their income due to the cessation of pine tapping by UB Forest management, leading to a loss of income that was previously available during the Perhutani management period. Nevertheless, the implementation of the UB Forest management master plan strategy, which includes knowledge sharing, collaboration, marketing strategies, exploration of new opportunities, and other factors, has resulted in an increase in farmers' income. As a result, the income of respondents from the three hamlets now varies from $35 to more than $280 USD per month under UB Forest management. Table 5 provides a breakdown of the respondents' income from the three hamlets under UB Forest management, while Table 6 showed the income during the Perhutani management period.

Table 5. Respondent's income (UBF management) from the three hamlets

Income (USD)	Respondents from three hamlets	
	Number(Person)	Percentage (%)
$7 to $70	7	2.0
$70 to $140	103	29.4
$140 to $210	198	56.6
$210 to $280	36	10.3
> $280	6	1.7
Total	350	100.0

Table 6. Respondent's income (PERHUTANI management) from the three hamlets.

Income (USD)	Respondents from three (3) Hamlets	
	Number (Person)	Percentage(%)
$7 to $70	40	11.4
$70 to $140	192	54.9
$140 to $210	110	31.4
$210 to $280	8	2.3
> $280	0	0.0
Total	350	100.0

The income distribution among the respondents from the three hamlets under UB Forest management can be explained as follows:

i. The majority of respondents, accounting for 56.6%, have an income between $140 to $210 USD.

ii. The next largest group, comprising 29.4% of the respondents, falls within the income range of $70 to $140 USD.

iii. Approximately 10% of the respondents report an income between $210 to $280 USD.

iv. The lowest income category, ranging from $7 to $70 USD, represents 2.0% of the respondents.

v. Finally, the highest income bracket, exceeding $280 USD, accounts for 1.7% of the respondents.

Results illustrate the distribution of income levels among the respondents, with the majority falling within the range of $140 to $210 USD. This is evident that the income distribution among the respondents differed significantly between the Perhutani management period and after the transition to UB Forest management in 2016. During the Perhutani management period, the majority of respondents, comprising 54.9%, earned a monthly income ranging from $70 to $140 USD. This indicates that a significant portion of the community members from the Sumbersari, Sumberwangi, and Tumpangrejo hamlets had relatively low incomes. The second most prevalent income category during the Perhutani period was between $140 to $210 USD, which accounted for 31.4% of the respondents. This suggests that a substantial number of individuals experienced a slightly higher income level within this range. On the other hand, a smaller proportion of respondents, representing 11.4%, earned less than $70 USD per month, indicating that some community members struggled with very limited income during the Perhutani management period.

In terms of the highest income category, only eight respondents, corresponding to a mere 2.3%, reported earning between $210 to $280 USD monthly. This implies that achieving a relatively higher income was challenging for the majority of respondents from these three hamlets under the Perhutani management system. In contrast, the transition to UB Forest management brought about notable changes in the income distribution. The specific differences in monthly income before and after the transition are illustrated in Figure 3.

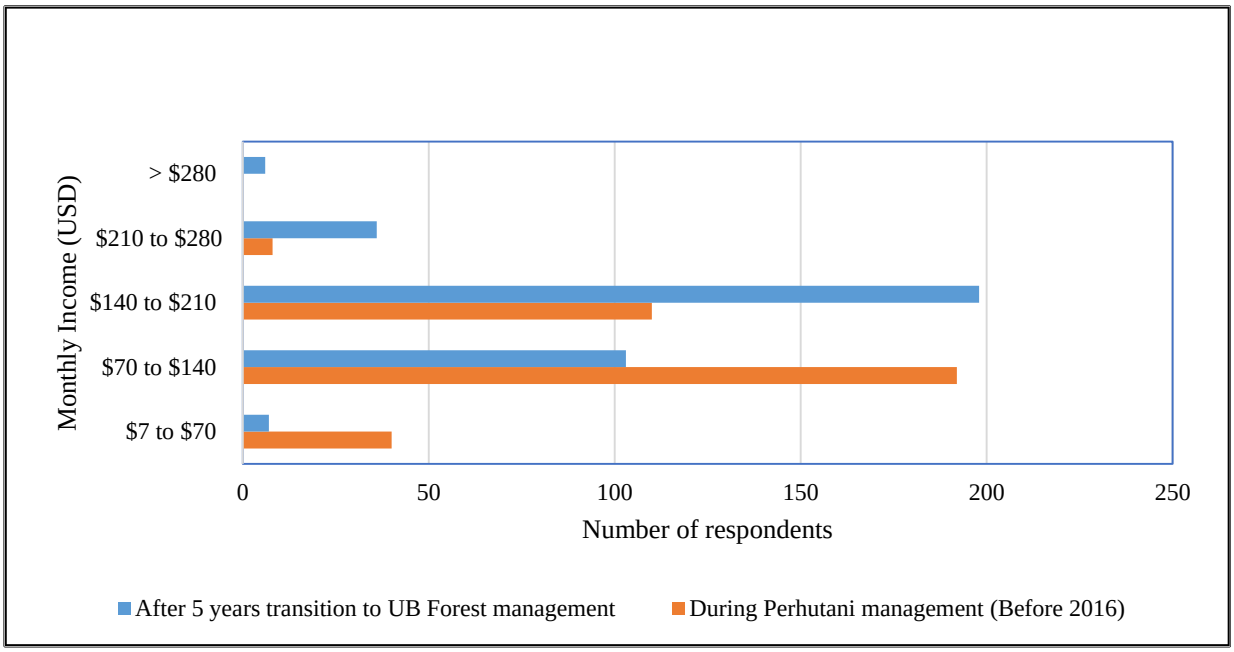

Figure 3. The difference in monthly income earned by the respondents during the Perhutani management period and five years after the transition to UB Forest.

However, it's important to note that not all respondents rely solely on income generated from farming activities. Some farmers supplement their monthly earnings through various other forms of employment. Those with lower monthly incomes primarily depend on selling crops like chayote and chilli plants, which can be harvested frequently. For instance, chayote plants can be picked every three days, yielding around 2 to 5 kg each time, while chilli plants yield approximately 7 to 10 kg every week. Additionally, some respondents work as agricultural labourers, which contributes to their overall income.

Respondents mentioned that male farm labourers typically earn between $3 to $3.50 USD per day, while women earn around $2.50 to $2.80 USD per day. Those aiming for a moderate income often seek additional employment opportunities. Besides working as farm labourers, they may engage in construction labour, earning up to $5.30 to $5.60 USD daily. Some respondents also find work as labourers in plantations outside the hamlet area, where wages are higher compared to farm labour. Moreover, a few respondents generate income through trading activities, such as selling fruits like bananas or operating a small stall offering snacks and groceries.

According to the information provided, respondents with higher incomes typically engage in work beyond the

hamlet's boundaries. They may work as motorcycle taxi drivers or engage in trading ventures. These additional sources of income contribute to their overall financial stability. It is evident that the transition from the previous forest management system to the UB Forest management has positively impacted the socioeconomic aspect, particularly in terms of economic improvement over five years.

5. Conclusion

The study reveals varying sizes of cultivated areas in the UB Forest among farmers. A majority (34%) work on plots ranging from 1.0 to 1.5 hectares, followed by 29.9% owning 0.5 to 1.0 hectares. Additionally, 26% cultivate areas between 1.5 to 2.0 hectares, while 11.1% manage plots exceeding 2.0 hectares. A small fraction (1.7%) cultivates plots less than 0.5 hectares. The regression's R2 of 0.847 indicates that 84.7% of arable land variation in the UB Forest can be explained by factors like work duration, plant species, education, income, and family involvement. The transition to UB Forest management significantly impacts farmers' income, demonstrating a notable increase due to strategic initiatives. Farmers now earn monthly incomes ranging from $35 to over $280 USD. The majority (90.3%) strongly agree that this transition positively affects their socioeconomic aspects, including income, social interactions, and infrastructure. The *tumpangsari* agroforestry study in Indonesia holds implications in managerial, theoretical, and empirical domains. On a managerial level, it emphasizes systematic land use management, community involvement, and equitable benefit distribution. Theoretically, it contributes empirical evidence to agroforestry's socio-economic benefits, emphasizing collaborative approaches and targeted poverty reduction. Empirically, it demonstrates the potential for socio-economic advancement through *tumpangsari* agroforestry, particularly with effective management. Lastly, the study suggests its success in Indonesia can serve as a model for ASEAN countries, promoting inclusive growth, poverty alleviation, and overall community well-being.

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Authors contributions

Mr. Azrilhisyam and Prof. Dr. Mohd Hasmadi were responsible for the study design and drafted of the manuscript. Assoc. Prof. Dr. Pakhriazad was responsible for study design, data collection and analysis. Assoc. Prof. Dr. Mohamad Azani was responsible for drafting and revising it. All authors read and approved the final manuscript.

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No additional data are available.