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The economic impact of agroforestry practice in production forest areas, Central Java province, Indonesia

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Abstract. The concept of Joint Community Forest Management in Indonesia is an effort to involve communities in forest management through agroforestry to support forest sustainability. Agroforestry (or persilan in local language) carried out by pesanggem in the KPH Kebonharjo and KPH Mantingan Working Areas significantly contributes to the pesanggem household income. This research wants to measure the provision of agroforestry on pesanggem household income and examine agroforestry factors that influence pesanggem household income. Data collection techniques through surveys and observations of 216 pesanggem households were carried out in the KPH Kebonharjo and

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KPH Mantingan areas, divided into eight villages respectively. The data was then analyzed descriptively and by multiple linear regression analysis. The research results found that the agroforestry pattern through land plots refers to agricultural activities by pesanggem in forest areas by utilizing forest land belonging to Perum Perhutani as agricultural/persilan for planting seasonal crops. Persilan contributions provide a moderate contribution to pesanggem households in KPH Kebonharjo and KPH Mantingan with a total contribution percentage of 38% or IDR 11,000,000 per household per year with details for each KPH Kebonharjo 44% (IDR 10,900,000 per household per year) and KPH Mantingan 33% (Rp. 11,200,000 per household per year). Based on the results of linear regression analysis, some variables significantly influence measurements with degrees of confidence of 85%, 95%, and 99%. The variables agricultural equipment (sig. 0.133), distance to agroforestry land (sig. -0.051), labor utilization (sig. 0.038), and land area of land persil (sig. 0.001) show an influence on the agroforestry income of pesanggem households in KPH Kebonharjo. In addition, the variables farming income (sig. -0.143), other income (sig. 0.048), area of land plots (sig. 0.037), and distance to agroforestry land (sig. 0.001) show an influence on the agroforestry income of pesanggem households, at KPH Mantingan. This research provides valuable insights into the complex relationships between agroforestry, production forests, and economic dynamics, providing a foundation for sound policy-making and encouraging environmentally conscious economic growth

Keywords: Agroforestry Practice; Household; Perhutani Areas; Pesanggem; Production Forest

INTRODUCTION

Forests play an essential role in maintaining ecosystem balance, supporting human life, and being a home for various plant and animal species. Forests are natural resources that can provide organic infrastructure, which plays a vital role in human life, maintains ecosystem balance (Liepa *et al.,* 2023), and reduces the risk of natural disasters (Mihardja *et al.,* 2023), including floods (Viezzer *et al.,* 2022), drought (Portela *et al.,* 2023), landslides and other extreme events. Forests are also able to mitigate climate change through carbon sequestration, contribute to oxygen balance, and protect river watersheds because they can supply 75% of freshwater worldwide (Bremer *et al*., 2019). As a home for various species of flora and fauna, forests are considered capable of providing organic infrastructure that is important for human life. Forests can offer multiple natural resources that are important for humans, including wood, bamboo, fruit, spices, and other non-wood products, which are sources of building materials, food, medicine, and other materials (Kusters & Belcher, 2004).

Forest areas in Indonesia have long been the nation's identity. Around 48.8 million Indonesians live in forest areas. Many people depend on forests for their livelihoods to provide food sources (Jendresen & Rasmussen, 2022), livelihoods (Akter *et al.,* 2022), and other activities. However, the facts show that according to the largest poor group in Indonesia has been identified as living in forest areas. Moreover, the forest has become an area of conflict between the community and the state, which has resulted in many cases of wood theft and at its peak in 1998, known as the "looting" period, which saw 300,000 hectares of forest become denuded. These problems are caused because forest areas are considered separate areas from communities and village areas. The community and forest officers seem to be chasing cats and dogs, so many conflicts often occur. Therefore, in 2001, the government initiated the Joint Community Forest Management (PHBM) program to overcome this problem (Sopaheluwakan *et al.,* 2023).

Joint Community Forest Management is a solution to bring communities closer to forests. The PHBM concept is an elaboration of social forestry, which is an effort to involve the community in forest management to support forest sustainability. Social forestry practices in Indonesia refer to government initiatives to involve local communities in the management and utilization of forest resources (Budi *et al.,* 2021). This approach allows communities to make decisions about forest use, such as harvesting non-timber forest products and agroforestry practices (Wong *et al.,* 2020). The implementation of PHBM is carried out by 57 Forest Management Units (KPH) throughout Java. One of the KPHs that implement CBFM practices in the Central Java Province Region is KPH Kebonharjo and KPH Mantingan, which have working areas in 113 villages divided into three districts, namely Rembang Regency (24,083.48 Ha), Blora Regency (7,345.60 Ha) in Java Province Central and Tuban Regency (3,057.44 Ha) in East Java Province. Forest utilization through agroforestry in KPH Kebonharjo and KPH Mantingan is known as "Persilan". Persilan is an agricultural activity carried out by pesantren farmers, where pesantren farmers use forests as cultivated land to meet their subsistence needs. Planting with corn, cassava, or nuts commodities is carried out in empty spaces between trees to maintain tree sustainability because Pesanggem farmers do not carry out haphazard logging (Owsianiak *et al.,* 2021).

Agroforestry practiced by pesanggem (forest farmers) in the KPH Kebonharjo Working Area makes a significant contribution to farmers' household income

(Public Summary of KPH Kebonharjo, 2022). Through diverse income streams, agroforestry allows farmers to enter profitable markets for timber and non-timber forest products (Luswaga, 2023). In addition, agroforestry-based businesses provide opportunities for added value and increased resilience, which further improves the financial welfare of farming households (Admasu & Jenberu, 2022). By embracing agroforestry, farmers can experience improved livelihoods and sustainable economic growth. Research related to forest communities, which is studied through socio-economic aspects, is exciting to discuss. Several studies have been carried out by Hardiyanti *et al.* (2021) to determine agroforestry management patterns and calculate the contribution to farmers' income. In this article, authors present a calculation of the gift of agroforestry to the household income of pesanggem farmers and assess the agroforestry factors that influence the agroforestry income of farmer households.

MATERIALS AND METHODS

Selected of Study Sites. This study was conducted to measure the economic impact of the Joint Community Forest Management (PHBM) program, which has been implemented in the Perum Perhutani area (the entire Java-Bali region) since 2000. Two working areas of the Perum Perhutani Forest Management Unit (KPH) in Central Java Province The focus of this research is KPH Kebonharjo and KPH Mantingan. Kebonharjo KPH has a geographical location between 111°20′00"-111°30 00" E 06°30′00"-06°60′00" South Latitude with an area of 17,734.6 Ha covering forest areas in Blora Regency and Rembang Regency, Province Central Java, Tuban Regency, East Java Province. Apart from that, Mantingan KPH has a geographical location between 111°10′00"-111°28′00" E 06°45′00"-06°56′00" South Latitude with an area of 16,751.92 Ha covering forest areas in Blora and Rembang Regency, Central Java Province, Pati Regency, Central Java Province.

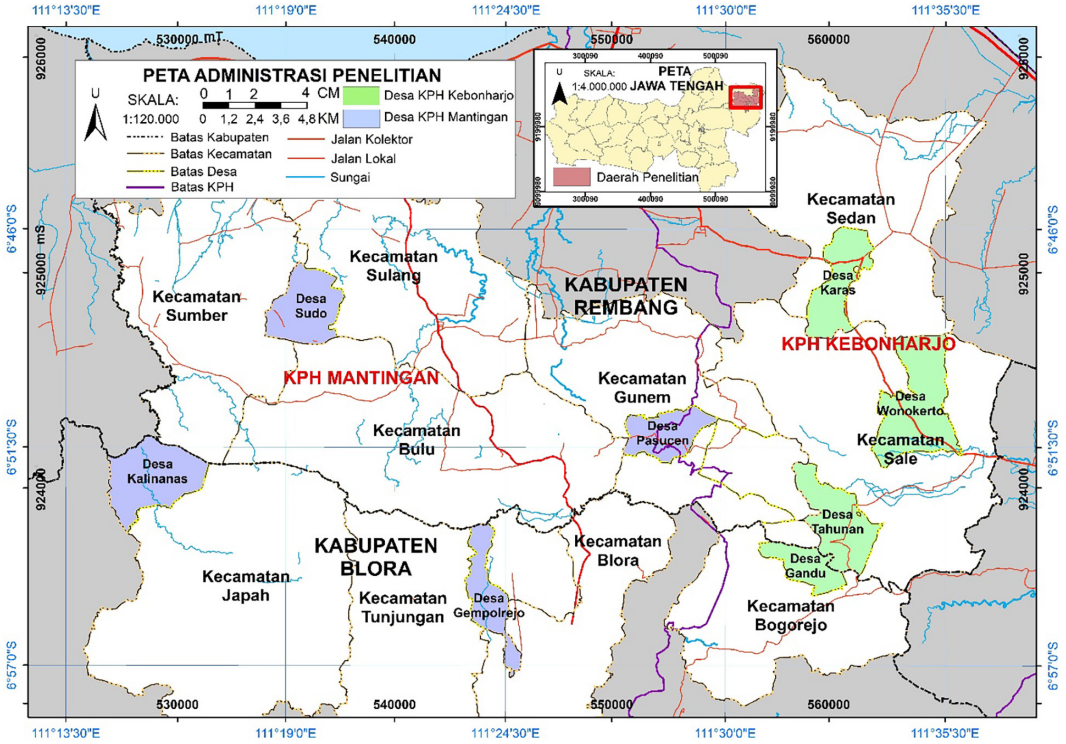

***Figure 1**. Location of field study*

***Note:** the Kebonharjo KPH area includes the villages of Karas, Wonokerto, Tahunan, and Gandu which are shown in green, Mantingan KPH includes the villages of Sudo, Pasucen, Gempolrejo, and Kalinanas which are shown in green*

***Source:** formed by authors*

Based on studies conducted at KPH Kebonharjo and KPH Mantingan, eight villages were selected for the survey. The selection of villages as research objects was carried out by looking at geographical conditions, forest existence, community characteristics, and population so that they were able to represent the entire KPH Kebonharjo and KPH Mantingan areas. The villages selected in the KPH Kebonharjo area include Karas, Wonokerto, Tahunan, and Gandu. Apart from that, the chosen villages in the KPH Kebonharjo area are Pasucen, Sudo, Gempolrejo, and Kalinanas.

Source of Data and Sampling. Data has been collected by collecting household data through survey techniques. The household survey was aimed at pesanggem households with a total of 213 respondents consisting of KPH Kebonharjo (N=116) and KPH

Mantingan (N=97), as in Table 1. The selection of respondents was carried out by calculating the survey's wealth ranking based on field data while still considering the area — forest land owned by pesanggem households. Questionnaires were also used to explore the demographic characteristics of the respondents' villages and families in more depth. Meanwhile, information related to agroforestry patterns, types of plants cultivated, information associated with the seasonal calendar, and income can be obtained through in-depth interviews and participant observation to know the household activities of pesanggem farmers directly.

***Table 1**. Selected Village and Respondents*

Forest Management Units	Regencies	Districts	Villages	Total Pesanggem Household	Samples	Percentage (%)
KPH Kebonharjo	Rembang	Sedan	Karas	25	14	12.07
		Sale	Wonokerto	97	28	24.14
		Sale	Tahunan	51	25	21.55
	Blora	Bagareja	Gandu	286	49	42.24
KPH Mantingan	Rembang	Gunem	Pasuscen	25	18	18.56
		Sulang	Sudo	28	21	21.65
	Blora	Tunjungan	Gempolrejo	41	19	19.59
		Japah	Kalinanas	78	39	40.20
Total	**2**	**7**	**8**		**213**	

***Source:** authors' development*

In addition, data collection through focus group discussions (FGD) was carried out twice in the KPH Kebonharjo and KPH Mantingan areas. Several stakeholders who participated in the FGD included the head of the KPH, the Head of the Forest Management Unit (BKPH), "Mantri", the Head of the Partnership Division, the Field Facilitator, the Village Head and Head of the Forest Village Community Institution (LMDH). Apart from that, critical secondary data was also collected from several sources used in this research, including KPH's annual socio-economic documents, forest product production data, village monographs, journals, and newspapers. In this study, agricultural and non-agricultural income are considered dependent variables. In contrast, age, household size, education, agricultural land area, non-agricultural income, agricultural training access to credit facilities, and participation in institutions, and etc are considered explanatory variables. The survey was conducted from February to March 2023.

Data Analysis: Calculation of Contributions and Influencing Factors. Based on the framework carried out by D. Desmiwati *et al.* (2021) in calculating total household income, this study decided to use a formula for adding up income from agroforestry products with other income, which includes on-farm and off-farm income., non-farm, to remittances. The total revenue of each pesanggem household surveyed is obtained from these calculations. This calculation is more clearly shown in the following formula:

$$Total\ Income = \sum(Agroforestry\ Income + Other\ Income). \quad (1)$$

Next, to calculate the contribution of agroforestry (% I_{gf}) in two regions (KPH Kebonharjo and KPH Mantingan), the data was analyzed by calculating the total income of pesanggem households for a year. In calculating the contribution of agroforestry (% I_{gf}), the following formula is used:

$$\% I_{gf} = \left(\frac{I_{gf}}{I_{tot}}\right) \times 100\%, \quad (2)$$

where % I_{gf}: Contribution of agroforestry income to total household income of pesanggem farmers (per year); I_{gf}: Total income from agroforestry activities (IDR/year); I_{tot}: Total income of pesanggem farmers (IDR/ year)

In measuring the significance of the influence of agroforestry factors on the income of pesanggem farmers, measurements are carried out through multiple linear regression analysis with the following formula:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + e. \quad (3)$$

To clarify the variables being measured, they can be explained in Table 2 as follows:

***Table 2**. Description and measurement of variables*

Variables	Description and Measurement	Expected Signs
Gender	Dummy: 1 if the household head is male and 0 other answers	±
Age	Actual number	+
Married	Dummy: 1 if the household head is married and 0 other answers	
Education	Education of household head is measured by level of study	+
Household Size	The total number of members in a household	+
Number of Livelihoods per Household	The number of types of livelihoods owned by one household	+

Table 2. Continued

Variables	Description and Measurement	Expected Signs
Land Area	The total area of agroforestry land owned by one household (m^2)	+
Number of Plants	The number of types of plants planted in one growing season	+
Agricultural tools	Dummy: 1 if complete agricultural equipment and 0 other answers	
Labor Utilization	The number of workers used for agroforestry production in one planting season	+
Non-Agroforestry Income	Non-agroforestry income includes non-agroforestry, non-farm on-farm and off-farm income, up to remittances (Rupiah)	-
Savings	Dummy: 1 if the household has savings and 0 other answers	-
Credit Access	Dummy: 1 if the household has access to credit and 0 other answers	+
Access training/ extension	Dummy: 1 if the household has access to training/ extension and 0 other answers	±
Participation in Institutions	Dummy: 1 if the household has participated in institutions and 0 other answers	±
Distance to Agroforestry Land	The total distance required by farmers to get to agroforestry land	±

Source: *authors' development*

The research was conducted in accordance with the rules of the Helsinki Declaration (1975).

RESULTS

Agroforestry practice in KPH Kebonharjo and KPH Mantingan Areas. Agroforestry is an agricultural system that combines tree crops with agricultural or livestock crops on the same land. The main goal of agroforestry is to create ecological, economic, and social sustainability through positive interactions between trees, plants, and livestock. This model offers a diverse and sustainable approach to land use, which can provide benefits such as increased productivity, biodiversity, and resilience to climate change. One form of agroforestry in Central Java province, especially in the KPH Kebonharjo and KPH Mantingan areas, is "Persilan".

The intercropping system implemented refers to the Joint Community Forest Management Program (Sahide *et al.,* 2020). Perlan refers to agricultural activities carried out by communities in forest areas who have access to utilize forest land owned by Perum Perhutani as agricultural/arable land for growing seasonal crops. Planting is carried out on forest land previously cut down and processed into land ready for planting. Planting is carried out by pesanggem in empty fields among replanted tree seedlings to preserve the forest simultaneously. The management community is responsible for maintaining and caring for the tree seedlings planted on the plot of land as compensation for cultivating the land. The plants planted on the plots of land, including corn, cassava, and nuts, do not require much water. Even though farming communities have large land areas, they still carry out land plots. This reason is that persilan has become a tradition deeply rooted in the lives of communities around the forest (Table 3).

Table 3*. The agroforestry pattern adopted by pesanggem in KPH Kebonharjo and KPH Mantingan*

Agroforestry	Intercropped Plants KPH Kebonharjo			Intercropped Plants KPH Mantingan		
	Primer	Secondary	Additional	Primer	Secondary	Additional
Type 1	*Zea mays*			*Zea mays*		
Type 2	*Zea mays*	*Arachis hypogaea*		*Zea mays*	*Manihot esculenta*	
Type 3	*Zea mays*	*Manihot esculenta*	*Allium cepa*	*Zea mays*	*Solamun melongena*	
Type 4	*Zea mays*	*Manihot esculenta*	*Musa paradisiaca*	*Zea mays*	*Oryza sativa*	
Type 5	*Zea mays*	*Manihot esculenta*	*Arachis hypogaea*	*Zea mays*	*Manihot esculenta*	*Solamun melongena*
Type 6	*Manihot esculenta*	*Arachis hypogaea*	*Capsicum annum*	*Manihot esculenta*	*Oryza sativa*	*Glycine max L / Arachis hypogaea*

Source: *authors' development*

The land managed by farmers cultivating the "pesanggem" forest is owned by Perum Perhutani or what people usually call "persilan" with an average area managed of 0.25 Ha per farmer. The main crops planted on agroforestry land are forestry plants (Jati Plus Perhutani (JPP), lamtoro (*Leucaena leucocephala*) intercrops, kosambi (*Schleichera oleosa*) filler plants, mahogany edge plants, Multiple Purposes Trees Species (MPTS), and secang (*Biancaea sappan*) hedge plants) with an age of 3-5 years. After the forest plants grow tall, the farmers must move to new land, according to the land where logging has been completed. Before working on logged-over land, farmers must clear the land and clean it independently. There are several types of crops

planted between forest plants, including corn (*Zea mays*), chili (*Capsicum annuum*), cassava (Manihot esculenta), eggplant (*Solanum melongena*), rice (*Oryza sativa*), shallots (*Allium cepa*), and peanuts (*Arachis hypogaea*) with different planting patterns based on suitability and location of arable land (Table 3).

The Contribution of agroforestry practice to pesanggem household income. Agroforestry income refers to financial resources generated through various activities related to agroforestry practices. Agroforestry systems are designed to integrate trees with crops and/or livestock, creating a diverse and sustainable land use system (Brandt & Staiss, 2019). This integration allows farmers to obtain income from various sources, thereby increasing the economic resilience and sustainability of the livelihoods of "pesanggem" farming households (Table 4).

***Table 4**. The Contribution of agroforestry practice to pesanggem household income*

Income per Household	KPH Kebonharjo		KPH Mantingan		Kebonharjo + Mantingan	
	Income	Contribution	Income	Contribution	Income	Contribution
Forest	10.9	0.44	11.2	0.33	11.0	0.38
Non-Forest	13.9	0.56	22.4	0.67	17.8	0.62
Total	24.8	1	33.6	1	28.8	1

***Note:** Income (million)*
***Source:** authors' development*

Table 4 shows the contribution of agroforestry to pesanggem household income in KPH Kebonharjo and KPH Mantingan. The contribution of agroforestry in KPH Kebonharjo reaches an average of 44% or an average of IDR 10,900,000 per household per year. Apart from that, the contribution of agroforestry to KPH Mantingan is 33% or an average of IDR 11,200,000 per household year. These results show that agroforestry contributes moderately to pesantren households in KPH Kebonharjo and KPH Mantingan, with a total contribution percentage of 38% or IDR 11,000,000 per household annually.

Factors of agroforestry practice that influence on the farmers' household income. Descriptive statistics of the explanatory variables in this study are explained by calculating the minimum value, maximum value, mean and standard deviation of eighteen factors that are thought to influence the agroforestry income of pesanggem households in two regions, namely KPH Kebonharjo and KPH Mantingan (as in Table 5). Based on the results of measurements on the age variable, in the KPH Kebonharjo area the average age of pesanggem is 52.71 years with a standard deviation value of 12.47. In comparison, in the KPH Kebonharjo area the average age of pesanggem is 50.07 years with a standard deviation of 11.94. In the married variable, in the KPH Kebonharjo and KPH Mantingan areas, the average number of people who have been married shows a mean value of 0.98 and 1, respectively. Hence, the standard deviation value is not visible, showing 0.13 and 0. Furthermore, the variable level of education possessed by pesanggem in the KPH Kebonharjo and KPH Mantingan areas respectively show mean figures of 1.04 and 1.12; this value indicates that the average pesanggem education in the KPH Kebonharjo and KPH Mantingan areas is still at elementary school level.

***Table 5**. Descriptive statistics on selected variables*

Variables	KPH Kebonharjo				KPH Mantingan			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Gender	0	1	0.88	0.88	0	1	0.78	0.41
Age (years)	25	81	52.71	12.47	26	75	50.07	11.94
Married	0	1	0.98	0.13	1	1	1	0
Education	0	4	1.04	0.76	0	3	1.12	0.86
Household Size	1	8	3.45	1.37	1	7	3.45	1.30
Number of Livelihoods	1	5	2.33	0.86	1	6	2.93	0.99
Land Area (Persilan)	0.3	4	0.57	0.60	0.13	2	0.68	0.51
Land Area Productive	0	1.5	0.09	0.21	0	5	0.25	0.58
Number of Plants	0	4	1.27	0.59	0	4	1.42	0.69
Agricultural tools	0	1	0.54	0.50	0	1	0.48	0.50
Labor Utilization	0	72	4.21	8.08	0	67	7.47	9.58
Farm Income (Rupiah-million)	0	48	1.23	5.64	0	40	1.79	5.62
Other Income (Rupiah-million)	0	67	12.65	14.92	0	144	20.65	27.56
Savings	0	3	0.22	0.48	0	1	0.16	0.37
Credit Access	0	1	0.43	0.50	0	1	0.44	0.50

Table 5. Continued

Variables	KPH Kebonharjo				KPH Mantingan			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Access training/ extension	0	1	0.40	0.49	0	1	0.24	0.43
Participation in Institutions	0	1	0.37	0.49	0	1	0.29	0.46
Distance to Agroforestry Land (km)	0	70	4.59	7.38	1	28	4.39	4.57

Source: *authors' development*

The pesanggem household income variable was other than agroforestry and is divided into income from paddy field farming and income other than farming in the KPH Kebonharjo and KPH Mantingan areas. Pesanggem household income from rice field/moor farming shows mean figures of 1.23 million and 1.79 million in Rupiah, respectively, with standard deviation values of 5.64 and 5.62. Besides that, other income of pesanggem households apart from agroforestry and paddy field farming are 12.65 million and 20.65 million in Rupiah, with standard deviations of 14.92 and 27.56 respectively. Based on Table 5 above, seven variables have standard deviation values less than the mean, including gender, age, marriage, education, household size, number of livelihoods, and number of plants, which shows that these variables have poor data distribution. Varies or the mean value can be used as a representation of the entire data. Meanwhile, eleven variables, including land area and income, have standard deviation values that are more than the mean, meaning that the distribution of the data varies or the mean value is a poor representation of the overall data. This result shows some outlier data (too extreme data) in the income and follow institutions variables.

The relationship between agroforestry factors and pesanggem household income from forest management in the KPH Kebonharjo and KPH Mantingan areas was analyzed using a multiple linear regression model, which is presented in Table 6, and the results of the multicollinearity test are shown in Table 7. Some of the variables analyzed include gender, age, marriage, education, household size, number of jobs in one household, land area, ownership of agricultural equipment, amount of labor utilization, household income, savings, access to loans, access to training/counseling, participation in institutions, to the distance variable towards agroforestry land. Confidence degrees of 85%, 95%, and 99% are used to measure the significance level between the variables analysed.

Table 6*. The linier regression analysis on selected independent variables*

Variables	KPH Kebonharjo				KPH Mantingan			
	Coef.	Std.Err.	t-value	Sig.	Coef.	Std.Err.	t-value	Sig.
Constanta.		8.445	-0.634	0.528		9.295	0.099	0.921
Gender	0.040	2.912	0.483	0.630	-0.007	2.709	-0.067	0.946
Age	-0.026	0.082	-0.292	0.771	-0.073	0.111	-0.626	0.533
Married	0.091	6.282	1.270	0.207	-	-	-	-
Education	0.117	1.345	1.320	0.190	0.053	1.427	0.489	0.626
Household Size	0.046	0.612	0.620	0.537	-0.108	0.890	-1.065	0.290
Number of Livelihoods	-0.037	1.054	-0.465	0.643	0.067	1.279	0.604	0.547
Land Area (Persilan)	0.691	1.878	7.020	0.001**	0.262	2.747	2.123	0.037*
Land Area Productive	-0.039	4.326	-0.506	0.614	0.081	2.438	0.645	0.521
Number of Plants	-0.010	1.556	-0.128	0.898	0.120	1.643	1.202	0.233
Agricultural tools	0.120	1.826	1.515	0.133+	0.122	2.257	1.229	0.223
Labor Utilization	0.176	0.119	2.102	0.038*	-0.109	0.144	-0.893	0.374
Farm Income	0.009	0.146	0.131	0.896	-0.157	0.215	-1.478	0.143+
Other Income	-0.038	0.061	-0.496	0.621	0.211	0.044	2.005	0.048*
Savings	-0.003	1.820	-0.040	0.968	-0.038	2.987	-0.385	0.701
Credit Access	-0.066	1.814	-0.846	0.400	0.143	2.247	1.451	0.151
Access training/ extension	-0.056	1.800	-0.731	0.466	0.069	2.754	0.665	0.508
Participation in Institutions	-0.058	1.735	-0.789	0.432	-0.063	2.451	-0.648	0.519
Distance to Agroforestry Land	-0.172	0.135	-1.973	0.051+	0.371	0.277	3.339	0.001**

Note: *+, *, ** indicates significant diference p < 0.15, p < 0.05, and p < 0.001 respectively*
Source: *authors' development*

Based on the results of the analysis, the variables that influence the agroforestry income of pesanggem households in KPH Kebonharjo, namely Land Area (Persilan) with p < 0.001, Labor Utilization with p < 0.05, as well as ownership of agricultural equipment and distance of agroforestry land from residence show

significance at p < 0.15. On the other hand, some variables influence the agroforestry income of pesanggem households in KPH Mantingan, including the distance from the house to the agroforestry land, which shows significance with p < 0.001, Land Area (Persilan) and other income, which shows importance at p < 0.05, as well as the variable income from paddy fields offers an effect at p < 0.15.

The land area of persil owned by pesanggem households in KPH Kebonharjo shows a significance value (Sig. 0.001) at p-value < 0.001, which means that the variable land area of land plots has a very significant influence on the agroforestry income of pesanggem households in KPH Kebonharjo. The same results were also shown in the variable land area of persil by pesanggem households in KPH Mantingan, which showed a significance value (Sig. 0.037) at p-value < 0.05, which means that the variable land area of persil had a very significant influence on household agroforestry income of pesanggem at KPH Mantingan. Pesanggem households with larger areas of forest land have more tremendous opportunities to increase their household income. Land productivity is also closely related to farmer capacity, access to resources, and access to markets, so a more expansive land tenure policy will provide benefits to forest farming communities, increasing farmers' income and welfare.

The variable for completeness of agricultural tools owned by pesanggem at KPH Kebonharjo shows a significance value (0.133) at p-value < 0.15. This value means that the completeness of agricultural equipment is essential in increasing the income of pesanggem households from the agroforestry sector. However, the variable for completeness of agricultural equipment owned by pesanggem in KPH Mantingan did not show any influence even though the p-value was < 0.15, so it can be said that the variable for completeness of agricultural equipment did not influence increasing the income of pesanggem households from the agroforestry sector. The variable utilization of labor by pesanggem in agroforestry in KPH Kebonharjo significantly influences pesanggem household income with a significance value (Sig. 0.038) at p-value < 0.05. These results show that the more workers are utilized in the Kebonharjo KPH area agroforestry, the higher the income pesanggem households will receive. This labor utilization variable is directly proportional to the more significant the average area of land managed by pesanggem households, that the greater the land area owned by pesanggem eating households, the greater the utilization of labor will be. It will influence the increase in income of pesanggem households from the sector agroforestry.

The variable farm income and other income of pesanggem households in KPH Mantingan shows the influence on the income of pesanggem households from the agroforestry sector. The results of the analysis show that there is an influence of the farm income variable with a value (Sig. 0.143) at p-value < 0.15 and other income variables with a value (Sig. 0.048) at p-value < 0.05. These results conclude that pesanggem household income from agroforestry will increase if income from other agricultural industries (rice fields/moorland) is decreased. On the other hand, pesanggem household income from the agroforestry sector will increase if they get income from other income (i.e. non-agroforestry income and not from rice fields/moors) (Table 7).

***Table 7**. Multicolliniearity test for independent variables*

Variables	Collinearity Statistics			
	KPH Kebonharjo		KPH Mantingan	
	Tolerance	VIF	Tolerance	VIF
Gender	0.638	1.568	0.737	1.358
Age	0.552	1.812	0.532	1.881
Married	0.857	1.166	-	-
Education	0.559	1.788	0.619	1.615
Household Size	0.812	1.232	0.693	1.443
Number of Livelihoods	0.704	1.421	0.575	1.738
Land Area (Persilan)	0.454	2.200	0.468	2.136
Land Area Productive	0.727	1.375	0.456	2.193
Number of Plants	0.684	1.463	0.722	1.386
Agricultural tools	0.700	1.428	0.721	1.387
Labor Utilization	0.626	1.598	0.484	2.068
Farm Income (Non-Agroforestry)	0.847	1.181	0.636	1.572
Other Income	0.736	1.360	0.643	1.554
Savings	0.768	1.301	0.746	1.340
Credit Access	0.715	1.398	0.736	1.359
Access training/ extension	0.744	1.344	0.668	1.496
Participation in Institutions	0.821	1.218	0.743	1.345
Distance to Agroforestry Land	0.583	1.715	0.579	1.726

***Source:** authors' development*

The distance of residence to agroforestry land is a variable that influences the income of pesanggem households in both KPH Kebonharjo and KPH Mantingan. The variable distance from residence to agroforestry land in the KPH Kebonharjo area shows (Sig. 0.051) at p-value < 0.15, meaning that there is an influence between the distance from residence to agroforestry land on increasing the income of pesanggem households from the agroforestry sector. The negative coefficient value on this variable means that the income of pesanggem households from the agroforestry sector in KPH Kebonharjo will increase if the distance between residence and agroforestry land is closer, thus providing effectiveness in agroforestry management. The average distance to agroforestry land in KPH Kebonharjo is 4.59 kilometers. On the other hand, the distance from residence to agroforestry land in the Mantingan KPH area shows (Sig. 0.001) at p-value < 0.001, meaning that there is an influence between the distance from residence to agroforestry land on increasing the income of pesanggem households from the agroforestry sector. The coefficient on this variable gives a positive value, which means that the income of pesanggem households from the agroforestry sector in KPH Kebonharjo will increase if the distance between the residence and the agroforestry land is further. The average distance to agroforestry land in KPH Mantingan is 4.39 kilometers. Table 7 shows the multicollinearity test on the variables, showing each variable's variance inflation factor (VIF). There is a high level of tolerance between variables, indicating no severe multicollinearity between the variables used in the analysis.

DISCUSSION

Agroforestry reflects awareness of preserving the environment while meeting food and other resource needs. Studies on the economic impacts of agroforestry practices in production forest areas are critical to explore the potential benefits obtained in economic, social, and environmental ecosystems. First of all, from a financial perspective, agroforestry can significantly contribute to the income of farmers and local communities (Desmiwati *et al.,* 2021; Kauppi *et al.,* 2022). The integration of tree crops with agricultural or livestock crops can create additional sources of income through the sale of forest products, timber, or agricultural products. Agroforestry also has the potential to create new jobs. Planting, maintaining, and harvesting trees and related activities can provide employment opportunities for local communities. This potential can improve living standards and reduce poverty, especially in areas dependent on agricultural and forestry activities. The economic impact of agroforestry also involves the development of local markets. Agroforestry products, such as fruit, wood, and other agricultural products, can be an attraction for the local economy. Increased access to markets and promotion of local products can significantly boost local and regional economic development. It is also important to note that agroforestry can benefit the ecosystem in the long term (Zada *et al.,* 2022; Kilonzo, 2022). Farmers can maintain their production and income by creating a sustainable agricultural system without damaging the surrounding environment. This attempt can help prevent land degradation and sustain long-term productivity, ultimately supporting economic sustainability.

Agroforestry is essential in increasing community employment opportunities because it creates a sustainable and multifunctional agricultural system (Sulistiyowati *et al.,* 2023). First, agroforestry can increase food production by combining crops, forestry plants, and livestock, creating jobs in various agricultural sectors. Second, sustainable agroforestry requires sustainable land care, creating job opportunities in forest and environmental maintenance. In addition, planting multiple types of crops provides diverse results, which can increase the community's economic sustainability. Agroforestry also creates employment opportunities for planting, maintaining, and harvesting crops. Apart from that, the industrial sector related to forest product processing can also provide additional employment opportunities. By implementing agroforestry, communities can develop new skills in natural resource management and sustainable agriculture, opening up training and education opportunities to increase their capacity. Overall, agroforestry is not only about increasing agricultural productivity but also positively impacts the environment and creates sustainable employment opportunities for people.

Agroforestry plays an essential role in diversifying farmers' income sources (Jagger *et al.,* 2022; Jamison *et al.,* 2023). By combining crops, plantations, and trees on one land, farmers can expand their portfolio. First, agroforestry produces various products that can be sold, such as fruit, wood, and non-timber forest products. This method provides more stable economic opportunities because it does not depend on just one type of plant. In addition, agroforestry can increase land productivity by utilizing positive interactions between plants. Trees planted with crops can provide shelter, provide nutrients through fallen leaves, and reduce soil erosion. This effort increases agricultural yields and reduces the risk of crop failure. In addition to direct income from agroforestry products, farmers can also access incentive programs and government assistance that support these sustainable practices. For example, reforestation or environmentally friendly programs can provide financial incentives for farmers to implement agroforestry. Overall, agroforestry is an agricultural method and a long-term investment strategy for farmers. By harnessing the diversity of natural resources on their land, farmers can create systems more resilient to climate and economic change while improving their well-being.

Agroforestry plays a vital role in climate change mitigation and adaptation efforts. In terms of mitigation, this system functions as an effective carbon store, helping to reduce greenhouse gas emissions by sequestering and storing carbon in trees and soil (Viezzer *et al.,* 2022; Moreda, 2023). In addition, integrating livestock in agroforestry can minimize methane emissions from livestock. Meanwhile, in a conservation context, agroforestry helps overcome climate challenges by increasing plant resilience through production diversification. The trees in this system can protect from high temperatures and winds while improving air and soil conservation. To care for degraded land, agroforestry contributes to ecosystem restoration and increases resilience to natural disasters. Thus, agroforestry is a sustainable agricultural model and an integral solution to reduce climate change's impact and increase community agriculture's adaptability.

However, the mindset of forest farmers in Central Java Province, dependent on seasonal farming in the forest, can negatively impact environmental sustainability, food security, and community welfare. Farmers who rely too heavily on seasonal farming in forests (such as corn, cassava, and rice) may face risks from weather and winter climates (Robinne, 2021; Ruba & Talucder, 2023). Annual cropping patterns tend to be vulnerable to seasonal changes or natural disasters, increasing the risk of production and income losses. Dependence on agriculture for one season can also create a cycle of poverty that is difficult to end. Farmers who rely on one growing season for their primary income may face high financial risks if crops fail. These practices can hinder economic development and the welfare of the agricultural community (Akpan & Zikos, 2023). Farmers accustomed to seasonal farming may need more knowledge and skills to switch to sustainable farming practices. It is essential to change the mindset of farmers by educating them about the diversification of agricultural benefits, sustainable resource management, and the use of enabling technology. Encouraging passion and resilience must be a focus so farmers can better face future challenges.

Specific case studies or the presentation of success stories of agroforestry initiatives in Central Java are important to deepen the understanding of the implementation and impact of sustainable agricultural practices at the local level. Through this research, authors can gain in-depth insight into the factors that influence the success of agroforestry from an economic, ecological, and social perspective. These success stories inspire and can guide farmers and policymakers in selecting and implementing sustainable farming models. By understanding the local context, this research can identify specific solutions to the challenges facing agricultural communities in Central Java. In addition, research results can form the basis for development policies that support the implementation of agroforestry and sustainable agriculture at regional and national levels. In other words, this case study research not only provides a comprehensive picture of the potential of agroforestry in Central Java but also plays a crucial role in outlining practical steps to achieve more sustainable agriculture in the future.

Increasing the economic impact of agroforestry in Central Java requires active involvement from policymakers, practitioners, and stakeholders (Octavia *et al.,* 2022). First, developing training and education programs is key to increasing farmers' understanding and skills in implementing agroforestry effectively. Community empowerment should also be a focus by encouraging active participation in the planning and implementation of agroforestry practices. Strong partnerships between government, the private sector, and NGOs can provide support in terms of capital, technology, and market access, which is a strong foundation for the success of agroforestry. The importance of recognition and incentives cannot be understated; Rewards for farmers who implement agroforestry, such as sustainable certification and tax incentives, can be a strong incentive to implement this model. In addition, business diversification in the agroforestry sector and local market development can help create added economic value. A good monitoring and evaluation system must also be implemented to provide positive impacts and identify improvement areas. Effective outreach and education campaigns can play a key role in increasing public awareness of the economic benefits of agroforestry. By accepting this recommendation, it is hoped that agroforestry in Central Java can develop as a pillar of a sustainable economy and improve the welfare of local communities.

CONCLUSIONS

Studies on the economic impacts of agroforestry practices in production forest areas are critical to explore the potential benefits obtained in economic, social, and environmental ecosystems. The results of research conducted through a survey of 216 pesanggem households in the KPH Kebonharjo and KPH Mantingan areas show the contribution of agroforestry to the income of pesanggem households in KPH Kebonharjo and KPH Mantingan. The average contribution of agroforestry in KPH Kebonharjo reaches 44% or an average of IDR 10,900,000 per household per year. Apart from that, the contribution of agroforestry to the Mantingan KPH is 33% or an average of IDR 11,200,000 per household per year. These results show that agroforestry significantly contributes to Islamic boarding school households in KPH Kebonharjo and KPH Mantingan, with a total contribution percentage of 38% or IDR 11,000,000 per household annually.

Based on the analysis results, several variables significantly affect measurements with confidence levels of 85%, 95% and 99%. The variables agricultural tools

(sig. 0.133), distance to agroforestry land (sig. -0.051), labor utilization (sig. 0.038), and land area (sig. 0.001) show an influence on the agroforestry income of pesanggem households, at KPH Kebonharjo. In addition, the variables farming income (sig.-0.143), other income (sig. 0.048), land area (sig. 0.037), and distance to agroforestry land (sig. 0.001) show an influence on agroforestry income. pesanggem household, at KPH Mantingan. These results indicate the need to increase the area of agroforestry land management in the two KPH areas (KPH Kebonharjo and KPH Mantingan) so that it is likely to increase agroforestry income significantly. However, this research also suggests that there needs to be an understanding effort for pesanggem households to only sometimes depend on seasonal crop farming so that they do not cause losses due to uncertain climate changes, which will result in financial losses.

This research provides valuable insights into the complex relationships between agroforestry, production forests, and economic dynamics, providing a basis for sound policy-making and encouraging environmentally conscious economic growth. However, this research still has limitations, so there is a need for further research that presents success stories of agroforestry initiatives that play an essential role in deepening the understanding of the implementation and impact of sustainable agricultural practices at the local level. Through this research, authors can gain in-depth insight into the factors that influence the success of agroforestry from an economic, ecological, and social perspective. These success stories not only provide inspiration but can also serve as practical guidance for farmers and policymakers in selecting and implementing sustainable farming models and can form the basis for development policies that support the implementation of agroforestry and sustainable agriculture at regional and national levels.

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CONFLICT OF INTEREST

This article contains no elements of conflict of interest.

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Анотація. Концепція спільного ведення лісового господарства громадами в Індонезії – це спроба залучити громади до управління лісами через агролісомеліорацію для підтримки стійкості лісів. Агролісомеліорація (або персілан місцевою мовою), яку здійснюють песанггем у робочих зонах КРН Кебонхарджо та КРН Мантінган, робить значний внесок у дохід домогосподарств песанггем. Це дослідження має на меті виміряти вплив агролісомеліорації на доходи домогосподарств песангемів та вивчити фактори агролісомеліорації, які впливають на доходи домогосподарств песангемів. Збір даних здійснювався шляхом опитування та спостереження за 216 домогосподарствами песангемів у районах КРН Кебонхарджо та КРН Мантінган, розділених на вісім сіл відповідно. Потім дані були проаналізовані описово та за допомогою множинного лінійного регресійного аналізу. Результати дослідження показали, що модель агролісомеліорації через земельні ділянки відноситься до сільськогосподарської діяльності песанггема в лісових районах шляхом використання лісових земель, що належать Perum Perhutani, як сільськогосподарських/персілан для посадки сезонних сільськогосподарських культур. Внески персілан забезпечують помірний внесок домогосподарств песангем у КРН Кебонхарджо та КРН Мантінган із загальним відсотком внеску 38 % або 11,000,000 індонезійських рупій на домогосподарство на рік, з деталізацією для кожного КРН Кебонхарджо 44 % (10,900,000 індонезійських рупій на домогосподарство на рік) та КРН Мантінган 33 % (11,200,000 індонезійських рупій на домогосподарство на рік). За результатами лінійного регресійного аналізу, деякі змінні суттєво впливають на вимірювання зі ступенем достовірності 85%, 95% та 99%. Змінні сільськогосподарське обладнання (sig. 0,133), відстань до агролісомеліоративних земель (sig. -0,051), використання робочої сили (sig. 0,038) та площа земельної ділянки персіл (sig. 0,001) демонструють вплив на дохід від агролісомеліорації домогосподарств песанггем в КРН Кебонхарджо. Крім того, змінні дохід від фермерства (sig. -0,143), інші доходи (sig. 0,048), площа земельних ділянок (sig. 0,037) та відстань до агролісомеліоративних земель (sig. 0,001) демонструють вплив на дохід від агролісомеліорації домогосподарств песангемів у КРН Мантінган. Це дослідження надає цінну інформацію про складні взаємозв'язки між агролісомеліорацією, виробничими лісами та економічною динамікою, забезпечуючи основу для розробки обґрунтованої політики та сприяння екологічно свідомому економічному зростанню

Ключові слова: практика агролісомеліорації; домогосподарство; райони Перхутані; Песанггем; виробничі ліси