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THE ROLE OF AGROFORESTRY FOR FARM HOUSEHOLD'S WELFARE: EVIDENCE FROM INDONESIA

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ABSTRACT
The role of agroforestry on socio-economic and environmental conditions has been widely documented in the literature. However, its role in farmers' households remains low, especially in Indonesia. The objective of this study is to understand the determinant of agroforestry and analyze the role of agroforestry on farmers' welfare. This study was collected from 301 farmers in East Java of Indonesia and used cross-sectional data. A logit The method employs regression analysis to estimate the factors affecting farmers' decision to adopt agroforestry, and propensity score matching (PSM) to investigate the welfare effect of agroforestry adoption, which was measured by farming income and non-farming income. The results indicated that farmers adopting agroforestry were significantly affected by education, farming experience, and farmers' ethnicity. Furthermore, the PSM analysis reveals that agroforestry improves farmers' income significantly. Farmers who adopt agroforestry have a better farming income than the farmers who did not adopt. On the other hand, the non-farm income shows otherwise. Therefore, these findings imply that farmers should implement agroforestry continuously to improve their welfare conditions.

KEY WORDS
Agroforestry, welfare, income, logit, PSM, Indonesia.

In the over two decades that have passed since the beginning of this century, the world community has made significant efforts to come up with solutions in order to minimize worldwide destitution and famine at the same time sustaining principle of ecosystem. The use of agroforestry, in particular in agricultural operations that are more integrated and sustainable, is one of the ideas and solutions that is suggested and proposed more frequently than any other one. Agroforestry is a land management method that has been praised for a long time as being capable of maintaining rural lifestyles, adapting to climate change, diversifying revenue streams, and reducing risk. Agroforestry is a catchall term that can refer to a broad variety of method at a variety system that involve the interaction of trees with agriculture and the management of those interactions by farmers in order to achieve monetary and environmental benefits (Foresta et al., 2015; Lundgren & Raintree, 1983; Nair, 1993).

Agroecology is collection of activities that integrate woody components with crops and/or animals. Despite the fact that this typically involves highly multifarious relation among humans and crops, which necessitate scheme analysis to explain there are individuals embrace various techniques, agroforestry is considered to be at its most fundamental level a collection of activities that integrate woody components with crops and/or animals. Depending on spatial and temporal patterns, as well as the proximity of tree and agricultural components, agroforestry systems can be categorized as either simultaneous or sequential. This decision is made based on the contiguity of woods and agricultural aspect. In synchronously activities, entire of the aspect are being integrated together, whereas in series

order, the elements are occupying terrain at distant moment (Sánchez et al., 1994; Sinclair, 1999).

Agroforestry has earned a well-deserved reputation as a method for promoting environmentally responsible land utilization (Rahman et al., 2010). Agroforestry, as was mentioned before, is one of humanity's best prospects for achieving climate-precision farming, enhanced food safety, reduction in rural hardship, and genuine ecological development (Garrity & Stapleton, 2011). On the other hand, Agroecology is usually regarded as a viable practice. for assisting farmers in mitigating repercussions of global warming and adapt these changes, enhancing agriculture output, and making a contribution the food protection of households (Luedeling et al., 2014; Mbow et al., 2014). Agroforestry is way to use land where woody plants are planted alongside agriculture and/or domesticated animals, which results in a lot of positive, natural, and financial relations within woods and elements that are not trees. This system has been characterized as "agroforestry" (Idumah et al., 2021).

In addition, the practice and study of agriculture and forestry at multiple scales, including farmers, animals, trees, and forests, is referred to as agroforestry. On terrace (where timber and fodders coexist), on lands (where brushwood may give feed for livestock, energy source, edibles, protection, or profit from commodities such as logs), and in area (where farmland and timberland usages of integrated in defining of environmental services), symbioses between greenwood and other agrarian aspects may be important. These interactions could be substantial on multiple of size, including terrace, farms, landscapes (Noordwijk et al., 2016).

A low-cost land-use technique that is favourable to smallholder farmers, agroforestry has been aggressively promoted throughout the entirety of the country of Indonesia for over 30 years now. Even though it is fraught with major risks, the traditional agroforest system is still practiced by hundreds of thousands, if not millions, of smallholder farmers in Indonesia (Kusters et al., 2008). In addition, although there are many different kinds of agroforests in Indonesia, the ones that cover the most land are the rubber agroforests, the damar agroforests, and the tree crop agroforests (such as the ones that produce coffee). small-scale planters have depended on several of these tactics for many decades, with some of them reaching back to the early 1900s.

Activities that take place on farms and activities that take place in forests are the two basic classifications that agroforestry techniques fall under. Shade agriculture, tree growing on through agricultural area, timber, and industrial crop intercropping with commercial timber are examples of farm-based initiatives. The collection of food, fruits, and gums by farmers is an example of an agricultural practice that is directly related with woodlands and is known as forest-based activities (Tejwani & Lai, 1992).

Farmers decide whether or not to use agroforestry practices based on how hard it is for them to get accurate information about the benefits of these innovations. (Ajayi & Place, 2012; Rodriguez et al., 2009), as well as farmers' opinions of the risks and problems that come with planting trees, or their proficiency in agroecology methods (Pontara, 2019). In addition, socioeconomic factors such as the size of a family, the amount of labor available, the amount of social capital available, the size of a land holding, money, age, and experience are thought to have a systemic influence on the chance of adopting an agroforestry practice (McGinty et al., 2008).

Adopting agroforestry is significantly more difficult than practicing conventional farming as a typically entails setting up a new mix of annuals, perennials, green manure, fodder, and other inputs and outputs, in addition to contour hedgerows, alley cropping, and enriched fallows are some of the new ways to save land (Rafiq et al., 2000). Adopting agroforestry is also significantly more expensive than practicing conventional agriculture, besides that farmers have limited access to farm-based natural resource management (NRM) alternatives and packaged agroforestry systems when compared to the options available for traditional agriculture (Barrett et al., 2002).

The overwhelming majority of studies lend credence to the idea that decisions to use less of a resource strategies such as agroecology as primarily motivated with projected

benefits to increase efficiency, output stability by lowering risks, and economic growth. feasibility in comparison to alternative strategies (Arnold & Dewees, 1995; Sain & Barreto, 1996; Salam et al., 2000; Scherr, 2000). The production of fodder, fruit, and fertilizer trees, as well as farms where trees are grown through use multi-strata and intercropping systems, are all ways that agroforestry can increase the likelihood of a nation's having access to sufficient food. Agroforestry is essential for increasing food production as well as the supply of nutrients because it diversifies products (Kiptot et al., 2014; Maliki et al., 2012; Mbow et al., 2014; Place et al., 2009).

Agroforestry, on the other hand, not only increases the production of food and animal feed, but it also helps keep the forest alive, which in turn creates employment opportunities for people who are economically disadvantaged or unemployed. Agroforestry also helps alleviate rural poverty by generating income and assets through locally-led tree farming systems that are driven by the market, as well as by using integrated conservation and development solutions based on agroforestry technologies to protect biodiversity. These two aspects of agroforestry work hand in hand to make agroforestry a significant factor in the fight against rural poverty (Kandji et al., 2006; Rahman et al., 2010). Additionally, it is able to maintain forest habitats through agroforestry, aid rural underprivileged populations in responding to change and make money from the growing carbon market by growing trees. All of these benefits can be realized through agroforestry (Ajayi & Catacutan, 2012; Oelbermann & Smith, 2011; Rahman et al., 2010).

When farmers have access to information and labor, as well as stable land tenure, the likelihood of adoption increases (Adesina & Chianu, 2002; Bannister & Nair, 2003). The decisions that farmers make regarding adoption are significantly influenced by social factors, such as the farmers' tastes and attitudes, the cultural or societal limits that they face, and the local expertise that is available (Meijer et al., 2015). These factors could be grouped together under the headings of farmers' adoption capacity and adoption willingness (Mills et al., 2017).

Every racial and ethnic group possesses its own distinct set of religious tenets, morals, and resources, all of which have an effect on their perspectives, social norms, and behavioral restraints with regard to agricultural progress (Inwood, 2013). If communities are viewed as being homogeneous, then the perspectives of only a few people have a lot of power may be considered, as a consequence, how interventions are made intended for ostensibly privileged persons may be flawed (Chomba et al., 2015).

The use of agroforestry is still relatively uncommon, particularly among farmers with small holdings, despite the enormous potential it offers. There are many different types of agroforestry systems, ranging from cattle and pastoral systems used for subsistence shade agriculture, alley intercropping, biofuel plantations. Each of these types of agroforestry systems has biophysical and socio-ecological characteristics that are specific to the environment in which it is used (Zomer et al., 2014).

One of the ways in which this goal can be accomplished is through the implementation of agroforestry, which "diversifies and sustains production by integrating trees on farms and throughout the agricultural landscape" The implementation of agroecology can result in elevated community and all land users benefit economically and environmentally. (Nair et al., 2009; Wilson & Lovell, 2016).

This is first study to examine the effectiveness of agroforestry on direct outcomes. This study looks at the effect that agroforestry has on the amount of money that farmers make from their crops. Previous research has examined the effect that certain types of agroforestry methods have had on intermediate outcomes such as soil fertility, crop yields, poverty and subjective well-being (Akinnifesi et al., 2010; Idumah et al., 2021; Odhiambo et al., 2001; Seruni et al., 2021; Sjögren et al., 2010; Wijayanto et al., 2022).

METHODS OF RESEARCH

The respondents are the farmers and household heads in Malang and Probolinggo, the partner districts. The number of farmers who respond is determined using a basic random sample procedure. In the first step, a list of all potato growers in four villages in the two

districts will be compiled, which will then be utilized to create a sampling frame for the study. The following phase will involve selecting at random, from the list of farmers obtained, approximately 75 farmer respondents from each village, for a total of 301 potato farmer respondents.

Determine, through the use of probit regression the factors responsible for adoption of agroforestry systems. Agroforestry adoption systems serves as the dependent variable for the purpose of this investigation, while socio-demographics serve as the independent component. Models of probit regression can be formulated in the following order:

$$A_i^* = X_i\alpha + u_i;\ A_i^* = 1 \text{ if } A_i^* > 0 \text{ and } 0 \text{ otherwise} \quad (1)$$

Where: A_i^* is a dummy variable that takes the value 1 if agroforestry is being practiced and the value 0 otherwise. A vector that represents the variable whose value is being evaluated, and the error term is denoted by u_i. The aspect of a farmer's operation that plays a role in the farmer's decision to use an agroforestry system is denoted by the vector X_i.

The use of propensity score matching will be employed in order to investigate how the adoption of agroforestry affects the well-being of farmers (PSM). This technique is used to determine how much of an impact the rate of agroforestry adoption has on the revenue of farmers. The PSM method was used because it reduces the problem of effect evaluation selection bias difficulties created by the unobserved counterfactual. When the findings of a comparison group of non-group therapies and treatments are as similar as possible, this bias can be reduced. PSM technique seeks to uncover traits that match treatment and non-treatment.

This technique employs three types of variables, including variable PSM treatments, farmer characteristics, and outcome variables. The degree of adoption of agroforestry systems will be categorized as either farm income or non-farm revenue over the course of this study's variable treatments. Although members of the household, age, education, farming experience, non-farm occupation, total area, farmer group, terrace, location, and ethnicity are all examined, total area, farmer group, terrace, and location are also taken into account. One outcome variable, specifically the income of farmers. Following the establishment of comparable groups, a comparison was carried out in order to discern between the groups that adopted and those who did not adopt. The PSM technique began with the measurement of each respondent's individual propensity score as the first stage. This can be performed by doing an analysis of the probability that farmers will embrace the agroforestry system. In the PSM technique, probability is stated in the form of a "propensity score," and here is how this score can be written:

$$P(X_i) = Prob\ (A_i = 1/X_i) \quad (2)$$

Where: $P(X_i)$ is the probit score that regresses agroforestry on farmer specific factors.

Agroforestry is the practice of growing trees on agricultural land. The selection of a matching algorithm that would be employed to carry out the covariate matching procedure was the second phase of the process. There have been a number of different algorithms created in order to match similar adoption and non-adoption groups. Approaches to matching that are widespread include kernel-based matching and matching to the nearest neighbor. Each treatment individual (one who has adopted a child) is contrasted with the control individual (one who has not adopted a child) whose propensity score is the closest. In most cases, it is used in the control units as a replacement for something else.

After determining the differences that existed between each set of units that were considered to be identical, the Average Treatment Effect on the Treated (ATT) was determined by taking the mean of all of these disparities. The disparity in propensity ratings between the treatment and control groups is used to provide a negative weight to the treated individuals and a positive weight to the controls, creating a weighted average to compare them all against (Becerril & Abdulai, 2010). This is done using a kernel-based technique.

In this study, two different matching procedures were used. One of them was called the nearest neighbor matching method. The following stage was to determine areas of overlap and support that were shared. A handful of the observations had to be thrown out at this point because of differences in the propensity ratings they had (excessive). A balance test was then used to compare adoption and non-adoption outcomes on average. The outcome variable difference is the average household group difference. This difference is commonly referred to as the average effect of treatment for the treated (ATT), moreover it may be phrased as follows:

$$ATT = E\{Y_{1i} - Y_{1i}\,\mathrm{A}_i = 1\} = E[E\{Y_{1i} - Y_{1i}\,\mathrm{A}_i = 1, p(\mathrm{X}_i)\}] = [E\{Y_{1i}\,\mathrm{A}_i = 1, p(\mathrm{X}_i)\} - E\{Y_{0i}, \mathrm{A}_i = 0, p(\mathrm{X}_i)\}\,\mathrm{A}_i = 1] \quad (3)$$

Where: the outcome variables for farmers who adopted children and farmers who did not adopt children are represented by Y_1 and Y_0, respectively, and *i* stands for farmers. During the process of determining the ATT, this study makes use of a bootstrapped standard error in order to take into consideration the disparity brought about by the matching estimate.

RESULTS AND DISCUSSION

In these discussions, the statistics based on the mean, standard deviation, minimum, and maximum values for each household feature will be described. Standard deviation is the value that is used to determine the distribution of data, where a high standard deviation value implies that the data distribution is skewed to the right. Table 1 contains descriptive statistics on Malang and Probolinggo potato farmer households.

Table 1 demonstrates that there was a significant amount of variation among the respondents in this study with regard to agroforestry adoption, age, education, family members, farming experience, off-farm employment, farmer group, total area, terrace, location, ethnicity, farm income, and non-farm income. Additionally, there was a significant amount of variation in total area. The respondents had an average income from farming of $904.4 per month, whereas their average revenue from non-farming activities was $1,027.8 per month. The responders who planted their own potatoes had, on average, reached the age of 48. The average education level of respondents is six years, or the level of elementary school. The farmers have an average of 28 years of experience. The average household contained three persons. The average land area used by farmers to cultivate potatoes is 1.6 hectares. Moreover, the majority of respondents in this survey are members of farmer groups.

Table 1 – Descriptive statistics

Variables	Measurement	Mean	Std. Dev
Agroforestry	Dummy 1 if farmers adopt the agroforestry, 0 Otherwise	0.532	0.500
Age	Age of farmers	48.432	12.198
Education	Number of years of formal education	6.226	2.412
Family Members	Number of members in family	3.492	1.261
Farming experience	Number of years farming experience	27.851	13.918
off-farm job	Dummy 1 if farmers have an off-farm job, 0 Otherwise	0.233	0.423
farmers group	Dummy 1 if farmer participate in farmers group, 0 Otherwise	0.757	0.429
total area	Total area for farming activity (Ha)	1.614	1.784
Terrace	Dummy 1 if farmer applied Terrace in farming activity, 0 Otherwise	0.419	0.494
location	Dummy 1 for Probolinggo, 0 for Malang	0.498	0.501
ethnic	Dummy 1 if farmers from local ethnic, 0 otherwise	0.671	0.471
Farm income	Farmers income from farming activity (USD per-month)	900.375	1090.132
Non-farm Income	Farmers income from non-farming activity (USD per-month)	1027.816	2425.857

Researchers found that a significant relationship existed between each of the predictor variables and the rate at which farmers adopted agroforestry when using a probit model to analyze the effect of socioeconomic variables on agroforestry adoption. At a significance level of 1%, farmer education, off-farm employment, farmer group, and ethnicity influence the

agroforestry adoption rate. The agroforestry adoption is influenced by a substantial level of 10%, as well as by age and region.

The connection between each predictor variable and the variable agroforestry adoption is classified as either positive or negative. According to the attached data, adoption of variable agroforestry was favorably connected to education, farmer group, geography, and ethnicity. Despite the negative link between variable agroforestry uptake and age and non-farm employment.

Positive correlations possessed by the agroforestry adoption variable indicate that more advanced education degree, more like to adopt agroforestry. Negative link between age and agroforestry adoption indicates that a person's age will decrease their likelihood of adopting agroforestry. This is reinforced by data indicating that as people age, their overall output will decline. Even a single day of nonproductivity is nonetheless consumptive. To avoid being a burden on others, young individuals have begun saving in various forms of backup when they were young.

When a farmer has employment outside from the family farm, he is at a disadvantage when it comes to adopting agroforestry practices because of the negative correlation between off-farm employment and the practice.

Table 2 – Determinant of agroforestry estimation

Variable	Coef.	Std. Err	z	*p* > |z|
Age	-0.020	0.011	-1.750	0.081*
Education	0.119	0.038	3.170	0.002***
Family Members	0.002	0.071	0.020	0.982
Farming experience	0.004	0.011	0.380	0.700
off-farm job	-0.624	0.219	-2.850	0.004***
farmers group	0.618	0.204	3.030	0.002***
total area	0.092	0.067	1.390	0.165
Terrace	-0.028	0.230	-0.120	0.903
location	0.429	0.248	1.730	0.083*
ethnic	0.787	0.259	3.040	0.002***
_cons	-1.019	0.599	-1.700	0.089
The number of obs	301			
LR chi2(12)	108.44			
Prob. > chi2	0.000			
Pseudo R2	0.2606			

*Note: *, **, *** denote the significance of 10%, 5%, and 1% respectively.*

Through this research, Propensity Score Matching (PSM) method is utilized to examine the impact level agroforestry adoption has depend on amount of money earned by potato farmers in Malang and Probolinggo. Table 3 displays the results of the investigation into propensity score matching. In order to evaluate the impact that agroforestry practices have had on PSM, this research made use of a couple of different matching strategies, namely nearest neighbor matching (NNM) and the kernel matching methodology. The impact that different levels of agroforestry adoption have had on the income of potato growers is compared in Table 3, which uses the matching approach. The adoption of agroforestry techniques has a positive and significant effect on farm income. Farmers who use agroforestry have a greater farm income than those who do not. Interestingly, the implementation of agroforestry had no substantial impact on the off-farm income.

The NNM matching strategy produced data that indicated the Average Treatment Effect on the Treated (ATT) was 559,609, but the kernel matching approach produced results that were 559,737. Both approaches were used. New insights into importance have been gained, and it has been determined that two different matching strategies both have 1% significance. These data demonstrate that agroforestry is widely practiced and has a substantial positive effect on farmers' income.

This result is consistent with prior research by Raj and Chandrawanshi (2016), who discovered a correlation between agroforestry and the decrease in poverty. Additionally, a

study by Nasielski et al. (2015), Indicated that agroforestry has a positive effect on agricultural productivity.

Table 3 – The impact of agroforestry adoption on income

Matching Algorithm	Outcome	Treated	Control	ATT	Std. Err	*t*-Value
Nearest neighbor Matching	Farm Income	160	56	559.609	140.093	3.995***
	Non-farm income	160	56	-629.472	964.411	-0.653
Kernel-based matching	Farm Income	160	118	518.737	188.872	2.746***
	Non-farm income	160	118	-371.497	418.726	-0.887

*Note: *, **, *** denote significance on 10%, 5%, and 1% respectively.*

CONCLUSION

The implementation of Agroforestry has a considerable and positive effect on farm income. Farmers who use agroforestry have a higher agricultural income than those who do not. However, the adoption of agroforestry had no substantial effect on non-farm revenue. This research implies that small-scale farmers should use agroforestry practices. The government can assist farmers in adopting agroforestry by enhancing their understanding of the benefits of agroforestry, providing access to agroforestry information, establishing farmer groups to increase farmer capacity to share, and promoting agroforestry adoption, so that farmers can live better lives.

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