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# Does Agroforestry Adoption Affect Subjective Well-Being? Empirical Evidence from Smallholder Farmers in East Java, Indonesia

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**Abstract:** Agroforestry has an essential role in reducing global poverty and maintaining environmental sustainability. However, little is known about the association between agroforestry and farmers' welfare. This study aims to estimate the factors affecting agroforestry adoption and its impact on smallholder farmers' welfare. The cross-sectional data were collected from 301 potato farmers in East Java, Indonesia. The factors affecting farmers' decision to adopt agroforestry were estimated using probit regression analysis. The subjective well-being was proxied by life satisfaction and happiness. The effect of agroforestry adoption on subjective well-being was measured by propensity score matching (PSM). The findings indicated that agroforestry adoption was positively and significantly affected by whether the land is terraced, farmers' age and education level, and farmers' participation in social activities, cooperatives, and farmers' groups. The PSM analysis shows that agroforestry adoption has a significant and positive impact on both subjective well-being indicators. Farmers who adopted agroforestry were happier and more satisfied than those who did not. The findings imply that farmers should implement agroforestry in the long term to improve their well-being.

**Keywords:** agroforestry; happiness; Indonesia life satisfaction; probit; propensity score marching; well-being

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## 1. Introduction

In the last few decades, agroforestry has drawn much attention from stakeholders in the forestry sector as it is considered a solution to climate change, poverty, and food insecurity [1]. Agroforestry is an economically viable land-use option for environmental rehabilitation and sustainable agriculture [2] as it integrates trees into crop production systems [3]. Agroforestry practice is not classified as forestry in terms of land use management, but rather as a system that provides tree products and services [4]. Agroforestry is a sustainable way to diversify land use, which can increase farmers' livelihood while maintaining natural resources and biodiversity [5–7]. Agroforestry practices enable farmers to achieve self-sufficiency by diversifying their output, e.g., fodder, fruit, and fertilizer trees, using multi-strata farming and intercropping techniques [8]. Therefore, agroforestry can be a critical practice to increase food production and nutritional supplies that contribute to food security [9–11]. Additionally, agroforestry protects the existing forest, provides jobs, and improves the local economy, especially in rural areas, by creating revenue and assets through market-driven, locally led tree farming systems [12,13].

For more than 30 years, in Indonesia, agroforestry practice has been applied as a low-cost land utilization that helps smallholder farmers maintain their livelihoods [14]. Hundreds of thousands of smallholder farmers in Indonesia manage a traditional agroforest system, although they are often faced with challenges [15]. Agroforests in Indonesia vary, but the majority consist of rubber, damar, and tree crop agroforests (e.g., coffee). For decades, smallholder farmers have relied on these methods, with some dating back to the early 1900s.

Past research has documented the positive impact of agroforestry on environmental conditions [13,14,16,17]. For instance, Smith [13] pointed out that agroforestry practices can overcome soil erosion and degradation and improve soil quality and health. In Indonesia, Nöldeke et al. [14] showed that agroforestry could increase biodiversity and sequester carbon more effectively. Similarly, a study by Kay et al. [17] in Europe shows how agroforestry could cut down carbon and improve ecosystem and biodiversity. De Zoysa and Inoue [16] pointed out that agroforestry can be a climate-change adaptation strategy by increasing tree cover in the forest and reducing greenhouse gas emissions. Overall, given the important role in maintaining environmental sustainability, agroforestry can support the sustainable development goals (SDGs) number 13, namely, 'climate action'.

Another important role of agroforestry is in improving farmers' well-being [2,18–20]. For instance, Cerda et al. [19] showed how cocoa agroforestry increases household income significantly by producing a variety of fruit and wood from canopy shade plants. Using cross-sectional data from 281 farmers in Fahmi et al. [20] indicate that farmers who applied the agroforestry system have a better economic return, such as net present value. Likewise, Kassie [2] showed that agroforestry increases income by diversifying the sources. Meanwhile, Refs. [1,21,22] showed how agroforestry improved household food security by producing a variety of fruit and trees for food consumption.

Although the impact of agroforestry on well-being has been researched extensively, studies have focused on objective well-being, such as income and food security [1,21,22]. Past research has not explored the role of agroforestry on subjective well-being. Objective well-being, such as income, is considered one-sided and unable to account for non-monetary aspects of life. Therefore, this study aims to fill the gap in the literature by investigating the effect of agroforestry adoption on farmers' subjective well-being. In other words, the study also aims to investigate the impact of agroforestry on SDGs goal number 3, namely, 'good health and well-being'. Aside from this, the novelty of this research lies in the employment of the propensity score-matching approach to address the selection bias in the estimation.

## 2. Materials and Methods

### *2.1. Research Data*

Multistage sampling was used to determine the research location. The first step is to determine the province and select the two districts. Probolinggo and Malang were purposively selected (Figure 1), considering the high agroforestry activities in these two districts in East Java province. Secondly, the sub-district sampling was determined based on the information from related institutions (agriculture offices, forestry agencies, and farmer groups). One sub-district from each district was randomly selected: Puncokusumo, representing Malang Regency, and Sukapura, representing Probolinggo Regency. Additionally, one village was purposively selected by considering its closeness to the forest area.

The respondents were horticulture farmers determined by simple random sampling. Firstly, we made a list of the horticulture farmers who had adopted the agroforestry system and who had not. The list was used for a sampling framework. Secondly, from the sampling framework, 150 farmers were randomly chosen from each subdistrict, so we obtained 300 farmers as our sample. In the research surveys, we hired enumerators from a local university who spoke Bahasa and Javanese. The data collection was conducted via interview using a structured questionnaire, with questions divided into three parts. The first asked about the farmers' characteristics, i.e., age, education, family members, and farming experience. The second part contained agroforestry-related questions covering (a) farmers' understanding of agroforestry and (b) whether or not the farmers had adopted the system. The last part of the questionnaire asked about subjective well-being, i.e., happiness and life satisfaction, with questions adapted from Rahman et al. [23].

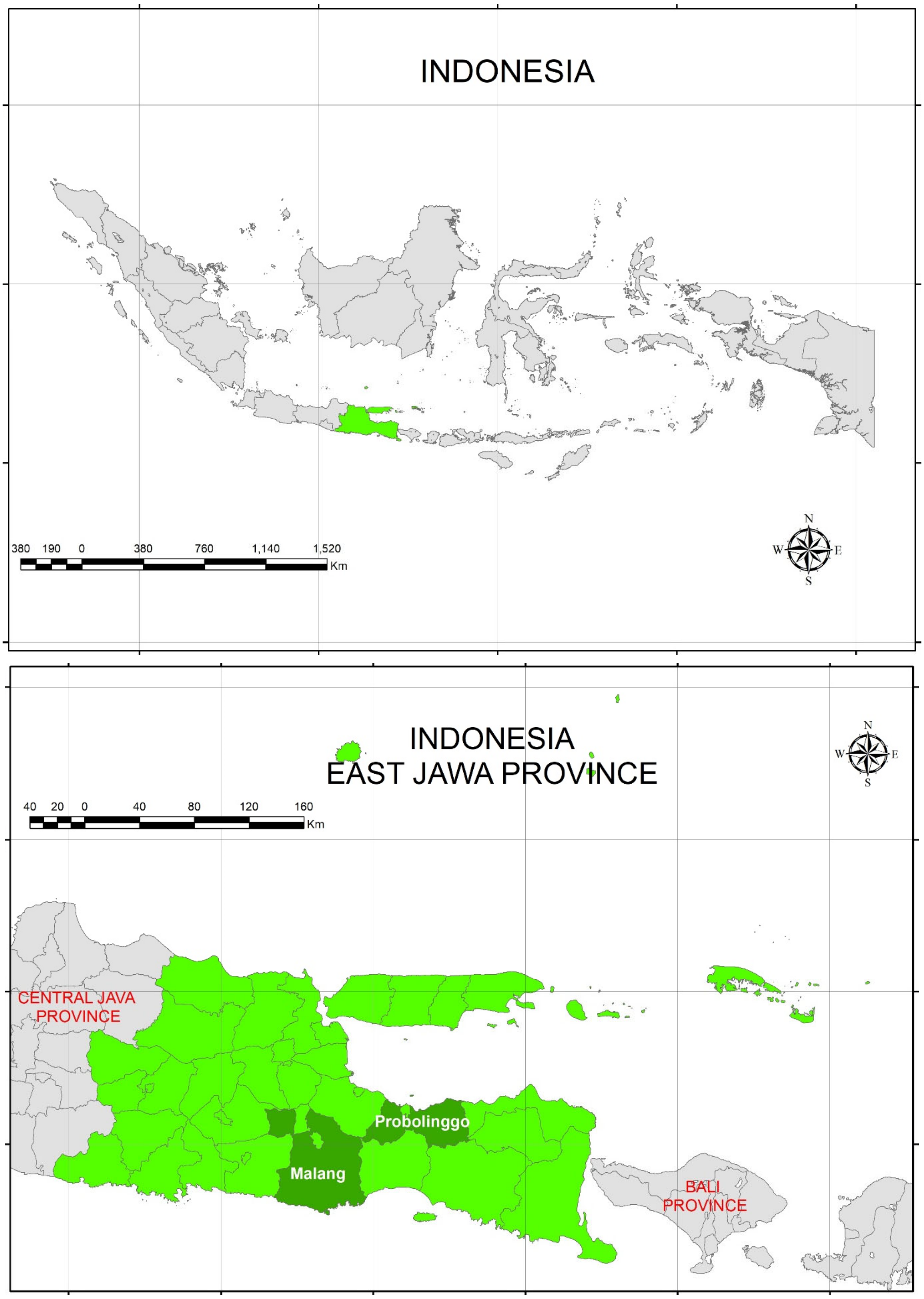


**Figure 1.** The location of the study area in East Java, Indonesia.

## *2.2. Data Analysis*

### 2.2.1. Analysis of Factors Affecting Agroforestry Adoption

Probit regression analysis was used to determine the factors influencing agroforestry adoption. The dependent variable is agroforestry adoption, and the independent variable is socio-demographics. The probit regression models in this study are as follows:

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

where $A_i^*$ is a dummy variable equal to 1 if agroforestry adoption and 0 otherwise, $\alpha$ is a vector of the variable to be assessed, and $u_i$ is the error term. The vector $X_i$ represents the characteristics that affect farmers' decisions to adopt the agroforestry system.

#### 2.2.2. Impact Analysis of Agroforestry Adoption to Farmers' Subjective Well-Being

To estimate the impact of agroforestry on farmers' subjective well-being, we used the propensity score matching (PSM) approach for its ability to address the self-selection bias. The PSM approach estimates the impact of treatment—in this case, the adoption of an agroforestry system—by comparing the adopters and non-adopters with the same characteristics, using a propensity score value from each respondent [24].

In the PSM approach, the research variables are divided into three categories. The first is the treatment variable, the agroforestry adoption, measured by a dummy variable (1 if the farmers adopt the agroforestry; 0 otherwise). The second is the control variables, namely, family members, age, education, farming experience, off-farm job, total area, farmers' group's participation, using terraced land, domicile, and ethnicity. The third is the outcome variable, namely, subjective well-being, i.e., happiness and life satisfaction, following Rahman et al. [25], and Toiba et al. [26].

After estimating the determinant of agroforestry adoption using a probit model, the PSM procedure calculates the respondents' propensity score, which is measured by the following equation:

$$P(X_i) = Prob\ (A_i = 1/X_i) \tag{2}$$

where $P(X_i)$ is the respondents' propensity score which is executed after estimating Equation (1). The next procedure is the matching algorithm: in this step, respondents with different propensity will be dropped from the analysis, and the respondent with the same propensity will be kept for further estimation. Several matching algorithms have been used in the PSM approach, including the nearest neighbor matching (NNM) and kernel-based matching (KBM). The NNM approach compares each adopter with the non-adopter with the closest propensity score. It is typically used as a substitute in the control units.

Finally, the PSM procedure was used to calculate the Average Treatment Effect on the Treated (ATT) to compare the different outcome (happiness, and life satisfaction) between adopter and non-adopter groups [27]. The ATT formula is written as follows:

$$\begin{aligned} \text{ATT} &= E\{Y_{1i} - Y_{1i}\ A_i = 1\} = E[E\{Y_{1i} - Y_{1i}\ A_i = 1,\ p(X_i)\}] \\ &= [E\{Y_{1i}\ A_i = 1,\ p(X_i)\} - E\{Y_{0i},\ A_i = 0,\ p(X_i)\}\ A_i = 1] \end{aligned} \tag{3}$$

where the subjective well-being (happiness, and life satisfaction) indicators of adopters and non-adopters is written as $Y_1$ and $Y_0$, respectively, and $i$ refers to farmers. Likewise, the ATT was calculated by a bootstrapped standard error that accounts for a discrepancy caused by the matching estimates. Finally, this study employed STATA-17 software (Stata Statistical Software: Release 17. StataCorp LLC, College Station, TX, USA) for the data analysis.

## 3. Results and Discussion

### *3.1. Agroforestry in Bromo Tengger Semeru (BTS)*

In general, the agroforestry plant that has been cultivated in Bromo Tengger Semeru (BTS) areas is *Casuarina junghuhniana*. Figure 2 illustrates the agricultural land with an agroforestry system (a) and a non-agroforestry system (b). *Casuarina junghuhniana* is the dominant vegetation in the Tengger and Semeru areas that can live at an altitude of 1800 to 3000 m. According to Latiff [28], *Casuarina junghuhniana* is a native endemic tree species from Indonesia distributed from East Java to the Nusa Tenggara islands. It can grow quickly and is ecologically a pioneer species on land degraded by volcanic ash and sand, so it has an important role in the succession of mountain forests. Moreover, it is a fire-resistant plant [29].

(**a**) (**b**)

**Figure 2.** Agroforestry and non-agroforestry land in the research location. (**a**) Agroforestry land in the research location; (**b**) non-agroforestry land in the research location.

According to Hakim et al. [30], the BTS areas are the main habitats for *Casuarina junghuhniana*, and the Tengger tribe, who live in the valleys, consider it an important commodity with economic, ecological and traditional functions. Farmers plant *Casuarina junghuhniana* as a land divider on their farms, which can double up as a wind and landslide barrier. The wood can be logged for housing or civil construction, firewood, or wood charcoal. As a part of the agroforestry activities, the tree is also considered a legacy for the next generation of the Tengger community. Their principle is cutting down one tree means replacing it by planting ten trees [31].

### 3.2. Descriptive Statistics

Table 1 presents the descriptive statistics of the respondents, with variables' measurement, mean and standard deviation. The treatment variable, namely, agroforestry adoption, has an average value of about 0.585. Since this variable is a dummy, this means that 58.7% of our respondents adopted an agroforestry system, and 41.3% did not (illustrated in Figure 3). The agroforestry system integrates the trees into the agricultural crops. Aside from pines (*Casuarina junghuhniana*), there are also teaks (*Tectona grandis*) and sengon (*Albizia chinensis*). Meanwhile, the main agricultural crops were potatoes and Welsh onions.

**Table 1.** Descriptive statistics of the selected variables.

| Variable | Measurement | Mean | Std. |
|---|---|---|---|
| Agroforestry | Dummy, 1 if the farmer adopts the agroforestry system; 0 otherwise | 0.587 | 0.493 |
| Terrace | Dummy, 1 if the farmer's land is terraced; 0 otherwise | 0.505 | 0.501 |
| Age | Age of farmers in years | 48.205 | 11.109 |
| Education | Education of farmers in years | 7.020 | 4.142 |
| Experience | Farming experience in years | 27.828 | 13.882 |
| Off-farm work | Dummy, 1 if the farmer has an off-farm job; 0 otherwise | 0.356 | 0.480 |
| Land status | Dummy, 1 for owning land; 0 otherwise | 0.766 | 0.424 |
| Social Activity | Dummy, 1 if the farmer participates in a social activity; 0 otherwise | 0.469 | 0.500 |
| Cooperative | Dummy, 1 if the farmer participates in a cooperative; 0 otherwise | 0.446 | 0.498 |
| Farmers Group | Dummy, 1 if the farmer participates in a farmers' group; 0 otherwise | 0.574 | 0.495 |
| Location | Dummy, 1 if the farmer is located in Probolinggo; 0 otherwise | 0.528 | 0.500 |
| Irrigation | Dummy, 1 if the farmer's land has irrigation access; 0 otherwise | 0.677 | 0.469 |
| Non-agri land | Number of non-agriculture land in Ha | 0.037 | 0.237 |
| Life satisfaction | Life satisfaction level (1 for not satisfied at all to 5 very satisfied) | 2.611 | 1.287 |
| Happiness | Happiness level (1 for very unhappy to 5 for very happy) | 2.337 | 1.165 |

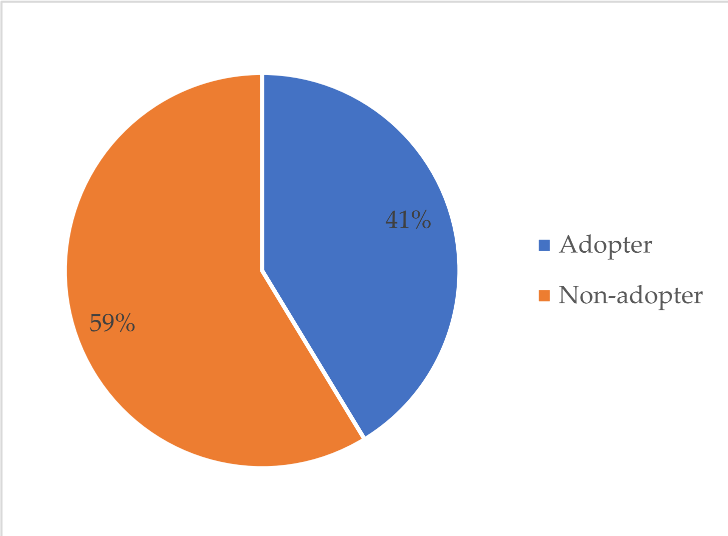


**Figure 3.** The percentages of agroforestry adopters and non-adopters.

The control variable data shows that 50.5% of respondents cultivated their crops on terraced land. The average age of our respondents was 48 years old, with an education level of around seven years, which means graduating from elementary school. Additionally, the average farming experience is about 27 years, and 35.6% have an off-farm job to fulfill their daily needs. The majority of our respondents own farmland (76.6%). Regarding social capital, the result shows that 46.9% of the respondents participated in a social activity, either cultural or religious; 44.6% participated in an agricultural cooperative; and 57.4% participated in a farmers' group. Regarding domicile, 52.8% of the respondents lived in Probolinggo and 47.2% in Malang. The outcome variable in this study, i.e., subjective well-being proxied by life satisfaction and happiness, provided an average value of 2.611 and 2.337, respectively, suggesting a medium level.

The farmers' characteristics were different between the adopter and non-adopter groups, as shown in Table 2. The adopter group consists of older, more educated farmers with better social capital. The outcome variable data also shows that the adopter farmers are happier and more satisfied than the non-adopter farmers. However, the results cannot be generalized as an impact of agroforestry on farmers' subjective well-being because the comparison does not capture farmers' characteristics holistically.

**Table 2.** Mean difference in selected variables in this study.

| Variable | Adopter | Non-Adopter | Different | *t*-Value |
|---|---|---|---|---|
| Terrace | 0.669 | 0.272 | 0.397 | 7.358 *** |
| Age | 45.270 | 52.384 | −7.114 | −5.775 *** |
| Education | 8.410 | 5.040 | 3.370 | 7.599 *** |
| Experience | 25.298 | 31.432 | −6.134 | −3.874 *** |
| Off-farm work | 0.230 | 0.536 | −0.306 | −5.742 *** |
| Land status | 0.792 | 0.728 | 0.064 | 1.297 |
| Social activity | 0.792 | 0.008 | 0.784 | 21.178 *** |
| Cooperative | 0.685 | 0.104 | 0.581 | 12.220 *** |
| Farmers' Group | 0.798 | 0.256 | 0.542 | 11.113 *** |
| Location | 0.567 | 0.472 | 0.095 | 1.640 * |
| Irrigation | 0.713 | 0.624 | 0.089 | 1.641 * |
| Non-agri land | 0.041 | 0.031 | 0.011 | 0.379 |
| Life satisfaction | 2.927 | 2.160 | 0.767 | 5.335 *** |
| Happiness | 2.652 | 1.888 | 0.764 | 5.928 *** |

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

### 3.3. The Determinants of Agroforestry Adoption

The probit regression reveals the factors affecting farmers' decision to adopt an agroforestry system. The results are presented in Table 3, indicating that the farmers' decisions to adopt the agroforestry system are positively and significantly affected by the use of terraced land, farmers' age, education level, participation in a social activity, cooperative membership, and farmers' group participation. The adoption is also significantly and negatively affected by the involvement in an off-farm job.

**Table 3.** The determinants of agroforestry adoption: probit estimation.

| Agroforestry | Coef. | Std. Err | z | $p > \|z\|$ |
|---|---|---|---|---|
| Terrace | 1.436 | 0.491 | 2.920 | 0.003 *** |
| Age | 0.045 | 0.026 | 1.760 | 0.079 * |
| Education | 0.153 | 0.065 | 2.360 | 0.018 ** |
| Experience | −0.012 | 0.018 | −0.690 | 0.491 |
| Off-farm work | −1.210 | 0.424 | −2.850 | 0.004 *** |
| Land status | 0.555 | 0.416 | 1.340 | 0.182 |
| Social Activity | 3.980 | 0.689 | 5.780 | 0.000 *** |
| Cooperative | 1.395 | 0.423 | 3.300 | 0.001 *** |
| Farmers Group | 1.907 | 0.433 | 4.400 | 0.000 *** |
| Location | −0.223 | 0.484 | −0.460 | 0.646 |
| Irrigation | 0.419 | 0.484 | 0.870 | 0.386 |
| Non-agri land | −0.098 | 1.457 | −0.070 | 0.946 |
| _cons | −5.910 | 1.709 | −3.460 | 0.001 |
| Number of obs | 303.000 | | | |
| Log-likelihood | −36.453 | | | |
| LR chi2 (12) | 337.820 | | | |
| Prob > chi2 | 0.000 | | | |
| Pseudo R2 | 0.823 | | | |

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

The terrace variable shows a positive and statistically significant 1% level, suggesting that farmers with terraced land are more likely to adopt the agroforestry system. The main reason is that terraced land is prone to erosion, especially by the extreme weather events caused by climate change. Using an agroforestry system will make the land more resilient to soil erosion. These results align with a study by Smith [13], summarizing that an agroforestry system can overcome soil erosion and degradation problems. The age variable has a positive and statistically significant 10% level, implying that the older farmers tend to adopt the agroforestry system more than their younger counterparts. The older farmers are more aware of the environmental change and understand their location problems better, such as soil erosion and land degradation. Therefore, they are more likely to adopt the agroforestry system. The off-farm job variable shows a positive and significant effect on farmers' decisions to adopt the agroforestry system. An off-farm job is a diversification strategy to maintain livelihood, but this can reduce farmers' activities to improve agricultural practices such as agroforestry adoption. Rahman et al. [25] also pointed out that having a side job makes farmers less likely to apply an agricultural innovation.

Overall, the social capital variables show an essential contribution to the farmers' decision to adopt the agroforestry system. For instance, social activity involvement has a positive coefficient with a statistically significant 1% level. Farmers participating in social activities are more likely to adopt the agroforestry system. This is likely because farmers obtain more information from their fellow farmers. Rahman et al. [24] pointed out that social activity involvement is a medium to transfer useful information. Cooperative membership also shows a positive and significant effect on farmers' decisions to adopt the agroforestry system, suggesting that farmers who become cooperative members are likely to adopt the agroforestry system. According to Syafrial et al. [32], a cooperative is one of the agricultural institutions that provide useful information and training, including agroforestry. Therefore, by joining a cooperative, farmers are more aware of the importance of the agroforestry system. Finally, participation in a farmers' group shows a positive and significant effect on farmers' decisions to adopt the agroforestry system. This finding is not surprising because farmers' groups are social capital for farmers to share and learn agricultural-related activities, including the agroforestry system. Therefore, it improves the probability of adopting the agroforestry system, in line with previous studies on technology adoption [33–35].

### *3.4. The Impact of Agroforestry Adoption on Subjective Well-Being*

The subjective well-being impact of agroforestry adoption is estimated by propensity score matching (PSM). In comparing the subjective well-being (happiness and life satisfaction) between the adopter group and non-adopter group, we employed two approaches, namely, nearest neighbor matching, and kernel-based matching method. The results are presented in Table 4. The nearest neighbor matching shows that the average treatment effect for the treated (ATT) value is about 1.787 for the life satisfaction indicator, statistically significant at a 1% level. Additionally, the ATT value for happiness is about 1.556, which was statistically significant at 1%. Similar findings from the kernel-based matching show the ATT value is about 1.702 and 1.507 for life satisfaction and happiness, respectively. The coefficient was statistically significant at a 5% level. The result confirms our research question that agroforestry has a positive and significant impact on farmers' life satisfaction and happiness. According to Zheng and Ma [36] and Rahman et al. [23], life satisfaction is a long-term subjective well-being indicator. On the other hand, happiness is a sorter subjective well-being indicator. Therefore, based on our results, we argue that the agroforestry system not only improves farmers' short-term but also their long-term subjective well-being.

**Table 4.** The impact of agroforestry adoption on farmers' subjective well-being.

| Matching Algorithm | Outcome | Treated | Control | ATT | Std. Err | *t*-Value |
|---|---|---|---|---|---|---|
| Nearest neighbor matching | Life satisfaction | 178 | 13 | 1.787 | 0.441 | 4.048 *** |
| | Happiness | 178 | 13 | 1.556 | 0.413 | 3.766 *** |
| Kernel-based matching | Life satisfaction | 178 | 47 | 1.702 | 1.059 | 1.607 * |
| | Happiness | 178 | 47 | 1.507 | 0.513 | 2.937 ** |

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

Agroforestry enables farmers to earn more income and food supply by diversifying their output, e.g., fodder, fruit, and fertilizer trees [8,9]. Agroforestry is also a sustainable practice in farming that not only improves farmers' productivity but also maintains environmental sustainability, such as preventing erosion and land degradation [5,19]. Without agroforestry, farmers usually worry about environmental threats such as landslides and floods, which can cause crop failures and risk their personal safety. By adopting agroforestry, these threats could be minimized. Additionally, agroforestry can help prevent climate change by reducing greenhouse gasses (Carbon dioxide ($CO_2$), Methane ($CH_4$), and Nitrous oxide ($N_2O$)) [1]. On the whole, the finding of this study complements previous research on the impact of agroforestry on objective well-being such as income and food security [1,2,19,20]. Additionally, this study is relevant not only for Indonesia but also for other countries with similar demographics and economic conditions [37].

## 4. Conclusions and Policy Recommendations

This study aims to estimate the determinants of farmers' decisions to adopt the agroforestry system and analyze the impact of agroforestry on farmers' subjective well-being. The cross-sectional was collected from 303 farmers in East Java of Indonesia. Two statistical approaches were employed: probit regression and propensity score matching (PSM). The findings indicate that farmers' decision to adopt the agroforestry system is positively and significantly affected by the use of terraced land, farmers' age and education level, and farmers' participation in social activities, farmers' groups, and cooperative membership. The decision is also significantly and negatively affected by an off-farm job. The results from PSM reveal that agroforestry adoption has a positive and significant impact on subjective well-being indicators, i.e., life satisfaction and happiness. This finding confirms that agroforestry has an essential role in maintaining farmers well-being.

Given the essential role of agroforestry adoption in farmers' subjective well-being, we suggest that it should be prioritized in the policy development; for example, by requiring smallholder farmers to implement agroforestry continuously. The government can help the farmers to develop agroforestry adoption by improving the knowledge about the benefits of implementing agroforestry in terms of welfare. For example, the government can provide agroforestry information access, establish more farmers' groups to increase knowledge sharing, and promote agroforestry adoption. Finally, the government also can subsidize tree seeds in the early adoption of the agroforestry system.

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