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Socio-Economic Determinants of Smallholder Tree Plantation in Basona-Werana *Woreda* in the North Shoa of Amhara Regional State, Ethiopia

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Abstract

Tree growing by smallholders is an emerging livelihood strategy in Basona-Werana *Woreda* of the North Shoa Zone of Amhara Regional State. The objective of this study was to identify socio-economic determinants of the smallholder tree growing in the study area. Data were collected from the household survey, key informants and focus group discussions. The binary logistic regression model was employed to identify the socio-economic determinants of smallholder tree growing behavior. According to the study, about 55% of tree growers generated their livelihood income from tree planting whereas 72% of non-growers generated income from livestock. Family size of the household and age positively and significantly affected tree planting decisions at $P < 0.10$ and $P < 0.01$, respectively. Meanwhile, livestock ownership and distance to the market were negatively and significantly influenced the decision to tree planting at $P < 0.01$ and $P < 0.05$, correspondingly. Similarly, total household income positively and significantly ($P < 0.01$) affected tree planting decisions. This study concluded that the socio-economic circumstances of smallholder farmers must be taken into account in the formulation of initiatives and policies aimed at encouraging smallholders to grow trees in their farming systems to improve livelihood and sustainable agricultural production.

Keywords: growers; non-growers; North Shoa; smallholder plantation

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INTRODUCTION

In recent debates, tree planting has gotten a lot of positive press (Nigussie et al., 2021). It has a variety of roles in rural communities, providing important economic and ecological advantages (e.g., they decrease soil degradation). Smallholder farmers have generally taken the major initiatives in tree planting (Kalame et al., 2011; Derkyi et al., 2013; Osei-Tutu et al., 2015; Boafo et al., 2016). Smallholder trees planting has the potential to strengthen economic growth and improve rural livelihoods (Obidzinski et al., 2012; Phimmavong and Keenan, 2020). The importance of tree planting has been emphasized due to the extent of the consequence of climatic variability and change on food security and smallholder farmer livelihood strategies. Farmers can also overcome crop failure owing to climate change (Linger, 2014) and soil degradation by combining trees with annual crops (Leakey, 2020). Effective plantation management can boost household earnings and help to alleviate poverty. Widespread tree plantations (such as Eucalyptus, tropical Acacia and oil palm) increase farm income from wood and biofuel production (Schoneveld et al., 2011). Polyculture, unlike monocultures with a single

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goal, has the potential to achieve a variety of objectives (Paquette and Messier, 2010), including increased income, reduced vulnerability to volatile global markets for forestry products, improved regulatory services and nature conservation (Paquette and Messier, 2010; Ahrends et al., 2015; Zheng et al., 2019).

Ethiopia has a long history of tree plantation. Tree planting by smallholders is currently seen as an alternative livelihood strategy, particularly in the study area. The large majority of plantation (about 80%) is comprised of plantation forests created through smallholder plantations, government rehabilitation programs, community-based watershed development programs and trees in the traditional agroforestry systems. Ethiopia has one of the largest percentages of biomass fuels in total energy consumption in the world, accounting for more than 90% of overall energy consumption and nearly 100% in rural areas (Alem et al., 2015). Tree planting has also significantly contributed to the production of non-timber forest products, such as honey and beeswax production (Hartmann, 2004). Tree planting also provides food; construction materials for traditional farm implements, houses, household furniture, medicine and fodder for animals (Gebreegziabher et al., 2010). In addition to the economic benefits, several studies also indicated that tree planting can improve environmental degradation through improved undergrowth regeneration, reduced erosion, reclamation of degraded landscapes and buffering of natural forests from further deforestation; maintain and support environmental quality; reduce flood hazards; as well as maintain and improve water conditions (Lemenih and Bongers, 2010; Kallio, 2013; Sudrajat et al., 2016; Osei et al., 2019). This will further help the smallholders for sustainable use of agricultural production and integrate tree crops in the farming systems (Mekonnen et al., 2007).

The development and management of smallholder tree plantations are influenced by various internal and external factors from smallholder farmers as landowners. These internal and external factors will influence smallholder farmers in making decisions about developing their smallholder tree plantations. Internal factors are related to farmers and their families, such as education level, number of family members, type of work and land ownership. External factors are the facilities and infrastructure, as well as policies from the government that support or weaken the development of smallholder tree plantations (Achmad et al., 2015). Despite such indispensable benefits, smallholder tree plantations have not been reached at the desired level due to various socio-economic constraints. These constraints come from the internal factors of small farmers, related to the social status of small farmers in the community as reflected in the level of education, type of work, number of family members and land ownership (Achmad et al., 2015). The magnitude of benefits is influenced at the household level by decisions to plant and invest in tree management. Different variables (socio-economic, policy-related and institutional) influence tree plantation by smallholders. Various studies have been conducted to identify the socio-economic determinants of smallholder tree planting (Abiyu et al., 2012; Kallio, 2013; Osei et al., 2019). However, few aspects have been researched in the study area and there is inadequate literature on the socio-economic actors of smallholder tree planting.

How the socio-economic factors affect the households' decision to plant or not to plant trees remains unclear. Thus, this study was aimed to analyze the factors influencing smallholders' decision to plant or not to plant trees. The main objective of this study was to identify the socio-economic determinants of smallholders' decision to plant trees or not to plant trees in Basona-Werana *Woreda* in the North Shoa Zone of Amhara Regional State. The study contributed to the existing literature in the following ways. First, the study analyzed the policy-relevant variables and this allowed policymakers to devise appropriate interventions to overcome those obstructing the smallholder plantation. Second, empirical evidence at the local level was vital since potential interventions would differ accordingly.

MATERIALS AND METHOD

Description of the study area

Wayu *Kebele* is part of Basona-Werana *Woreda* in the North Shoa Zone of Amhara Regional State, Ethiopia. It is located 30 km east of the zone's main town Debre-Birhan. Geographically location between 9°27'52.938" N to 9°36'20.201" N and 39°37'41.212" E to

39°40'50.264" E and center coordinate of 9°32'42.961" N and 39°38'59.37" E, as presented in Figure 1.

The area is characterized by dissected topography, with mountain peaks and deep valleys, intersected by a few gentle slopes with an average altitude of 3,000 m above sea level. Estimation obtained from surveys carried out by the development agents working in the *kebele* has shown that about 50% of the *kebele's* topography is mountainous, 38% of the area constitutes flatlands extending from mountains foot ending up in escarpments of valleys. The rest 12% is generally categorized as miscellaneous land-use type. The mountainous landscapes are grouped into three catchment areas ('Chare', 'Agam-Jema' and 'Chew-Bele'), which are currently set aside for rehabilitation programs. Wayu *Kebele* has a total of 6,301 residents (3,243 male and 3,058 female). The dominant means of livelihoods exercised in the *kebele* are crop cultivation and livestock rearing. Major crops produced in the *kebele* are *Hordeum vulgare*, *Triticum aestivum*, *Eragrostis tef* and beans, in the high and mid-altitudes. *Sorghum bicolor*, *Zea mays*, *Guizotia abyssinica* and *Sesamum indicum* are some of the crops grown in low altitudes (*Kola*).

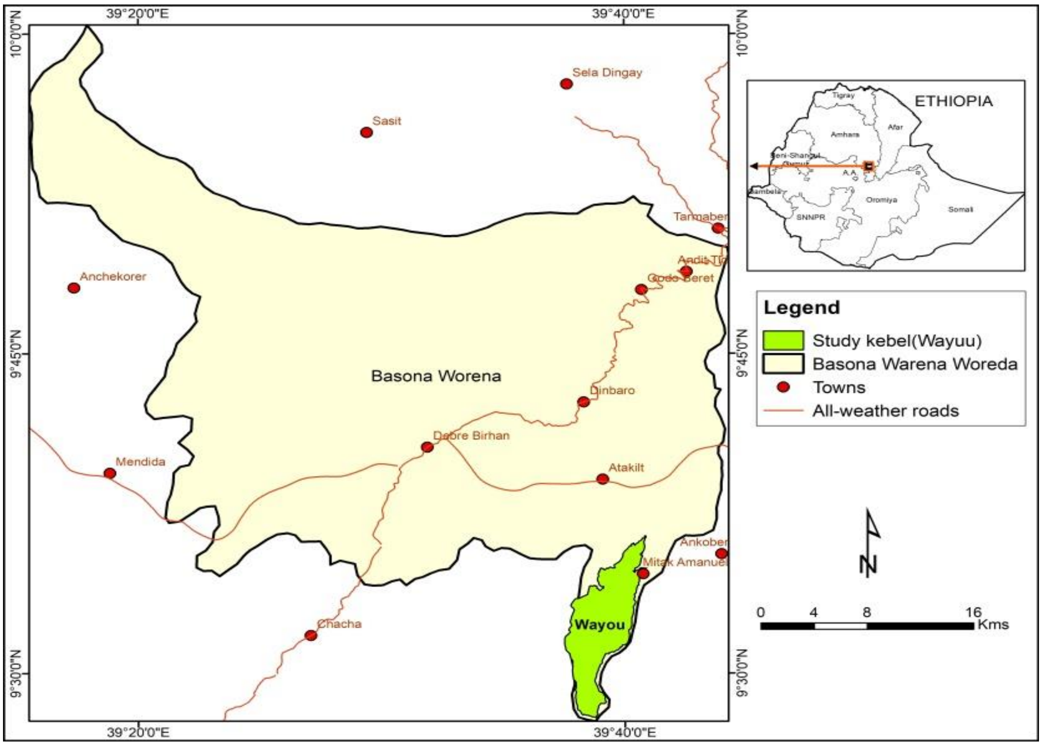

Figure 1. Map of the study area

Data collection and sampling procedures

The data used for this study were based on a cross-sectional household survey conducted in Wayu *Kebele* of Basona-Werana *Woreda* of Amhara Regional State. Quantitative and qualitative data were collected from both primary and secondary sources for this study. Secondary data were obtained from relevant sources of published and unpublished documents to gain a general insight on the issue of inquiry. Then, primary data were gathered from household heads and community leaders through household interviews, key informants interviews and focus group discussions.

A three-stage sampling technique was used to select sample households. In the first stage, Basona-Werana *Woreda* was selected purposively based on the extent of tree planting practices and the structural complexity of landscapes. In the second stage, one *kebele* of the *woreda*, namely Wayu, was purposively selected in consultation with *woreda's* Agriculture Office due to the prevailing expansion of tree growing on farmlands. The study communities were stratified into two groups based on the ownership of smallholder plantations. The first group of respondents included households owning smallholder plantations and utilizing their trees and tree products, while the second group of respondents consisted of households having not established woodlots on their farmlands. In the last stage, representative households from sample *kebele* were determined by using a formula suggested by Yamane (1967). This simplified formula required sample size at 95% confidence level, degree of variability = 0.5 and level of precision = 5%. Finally, a total of 150 households (90 tree growers and 60 non-growers) were randomly selected for face-to-face interviews by using a simple random (lottery) method.

Data analysis

Various analysis methods had been used to analyze the data gathered from quantitative and qualitative sources using various tools, such as the STATA 14 software. The quantitative data were cleaned, coded, entered, sorted and analyzed. To interpret quantitative data, descriptive and inferential statistics were used. The descriptive analysis covered frequency, percentage, mean and standard deviation. Continuous data were examined via one-way ANOVA and T-test in inferential statistical analyses, while categorical data were estimated using the Chi-square test. To analyze the quantitative data, the binary logistic regression model was used. Qualitative data produced from in-depth interviews, focus group discussions, observations and document analysis were thematically summarized, narrated, and then analyzed and discussed

Econometric estimation: Binary logistic regression model

Various options of econometric models were available for analyzing the factors affecting the decision to engage in smallholder plantation. The linear regression model is one of the commonly used methods in many studies; however, it is applied when the dependent variable is measured on a continuous scale. For a dichotomy variable, discriminant analysis and logistic regressions are usually applied but they have particular shortcomings. Discriminant analysis is used if all predictors are continuous and normally distributed. Logistic regression is often chosen if predictors are mixed and/or if they are not nicely distributed (Karl, 2011). The probit model is an alternative to the logistic model because either of them can be used for a categorical dependent variable. However, probit is based on the standard normal distribution, and the logit is based on the standard logistic distribution. These two models often lead to the same conclusion and are most difficult to choose between the two on a theoretical basis (Greene, 2012). Given the binary nature of the outcome variables, this paper follows the widely used logistical regression model to identify the factors influencing the smallholder plantation.

Table 1. Definitions and summary statistics of the variables used in the analysis

Variables	Description of variables	Expected sign	Types of variables
Plantation	1 = if the household growing tree		Dependent
Age	Age of the household in years	-	Independent
Sex	1 = if the household head is male	-/+	Independent
Edu	1 = if the household heads are literate	+	Independent
Hh_size	The number of household size	+	Independent
Land size	Landholding size in hectare (ha)	+	Independent
Livestock	Livestock herd in tropical livestock unit (TLU)	-	Independent
Crop_qt	Crop harvested in quintal (qt)	-	Independent
Dis_res	Distance to nearest market from their residences (km)	-	Independent
Mar_acc	1 = if the household has easy access to market	+	Independent
Crop_inc	Total income from crop sell (Ethiopian Birr/ETB)	-	Independent
Livestock_inc	Total income obtained from livestock sell (ETB)	-	Independent
Tree_inc	Total income from selling trees and tree products (ETB)	+	Independent
Off_farm_inc	Income obtained from off-farm activities (ETB)	-	Independent
Total_inc	Total annual income from all income sources (ETB)	+	Independent

The functional form of the logit model can be specified as follows. Pi denotes the probability that the respondent is a tree grower performing those activities with Yi = 1 and exp (Zi) stands for the irrational number to the power of Zi (Gujarati, 2009). The models can be written as the following Equations 1 and 2.

$$Pi = E\left(Y = \frac{1}{X_i}\right) = \frac{1}{1 + e^{-(\beta o + \beta 1 X1)}} \quad (1)$$

$$Li = \ln\left(\frac{Pi}{1-Pi}\right) = Zi = \beta o + \beta 1\ X1 + \beta 2\ X2 + \ldots + \beta i\ Xi + \varepsilon i \quad (2)$$

Where P_i = is a probability of a respondent performing those activities ranging from 1 to 0; Z_i is a function of *i* explanatory variables (X); β_o is an intercept; β_1, β_2, β_i are slopes of the predictors in the model; L_i is the log of the odds ratio, which is linear in the parameters; X_i is the vector of relevant respondents' characteristic and ε_i = error term.

RESULTS AND DISCUSSION

Characteristics of sample respondents

The summaries of descriptive statistics of the hypothesized variables of the study are presented in Table 2. The descriptive results in Table 1 show that the mean household size of tree growers (5.24) was slightly smaller than that of non-tree grower households (5.43). The non-tree growers had significantly ($p < 0.05$) higher household size than tree growers. The average age of tree growers (47.63 years) was higher than non-tree growers (45.17 years). However, there were no significant differences between the age group of tree growers and non-grower. The average livestock possession for the tree grower household (2.63 TLU) was slightly greater than the non-tree grower households (2.58 TLU). The average landholding size of tree grower households (2 ha) was smaller than those of non-tree growers (2.28 ha). The average annual crop production of non-tree growers' households (7.83 qt) was lower than the production of tree growers' households (11.73 qt). The average distance of the tree grower to the nearest market (4.41 km) was longer than the average distance of the non-tree grower (1.95 km). The tree growers had significantly ($p < 0.01$) longer market distance than non-tree growers.

Among 98% of sample households, 58% of tree growers were male, while 40% of non-tree growers were male. The Chi-square test depicted that there was no significant ($p < 0.10$) difference between the groups. Out of 71% of households, 44% belonged to tree grower households and 27% belonged to non-tree grower households. Similarly, among 86% of sample households accessing markets, 53.3% were tree growers and 32.7% were non-tree growers. However, the Chi-square test indicated no significant ($p < 0.10$) difference between the two groups (Table 2).

Table 2. Characteristics of the sample respondents

Explanatory variables	Growers (n = 90)		Non-growers (n = 60)		Overall (150)		T-test
	Mean	SD	Mean	SD	Mean	SD	
Family size (no.)	5.24	2.04	5.43	1.39	5.32	1.80	4.617**
Age (year)	47.63	10.91	45.17	9.64	46.65	10.46	0.625
Crop harvested (qt)	11.73	6.28	7.83	5.18	10.17	6.15	0.395
Livestock (TLU)	2.63	1.82	2.58	1.25	2.61	1.61	0.597
Distance (km)	4.41	8.82	1.95	1.44	3.43	6.98	2.002***
Farm size (ha)	2.00	0.678	2.28	0.663	2.11	0.684	1.100
% of respondents to given choices for dummy variables							χ^2
Sex (male)	58.0		40.0		98.0		2.041
Education (literate)	44.0		27.3		71.3		0.44
Market access (yes)	53.3		32.7		86.0		1.56

Notes: ***, **, denote to statistically significant at 1%, 5%

Sources of income and their relative contribution of growers and non-growers

The source of annual incomes of an individual household categorized under non-growers and grower group came from the sale of the crops, livestock and livestock products, engagement in various off-farm activities, as well as sale of farm products, trees, and tree products collected from natural forests and plantation. In some cases, non-growers also marketed trees and tree products they had in their homestead with no significant land possession.

Table 3 also presents a statistically significant difference between the group in total income, off-farm income, as well as tree plant and tree product income. Tree growers, on average, obtained a total income of ETB 95,053.30, higher than non-tree growers ETB 32,465.13. The tree growers had significantly ($p < 0.01$) higher total income than non-tree growers. The income generated from tree plants and tree products accounted for 55% of the total household income for tree grower households that was higher than other income sources. Meanwhile, the non-tree grower household's income (72%) came from livestock. Income generated from trees and tree products accounted for 41% of total household income for the sample households. Similar findings were observed by Kebebew (2002) and Teshome (2004) from studies in their respective locations (revenue from tree sales contributed 50% of total household income).

Table 3. Summary of income and their monetary values of sample household in ETB

Income source	Grower (n = 90)		Non-grower (n = 60)		Overall (150)		T-test
	Mean	SD	Mean	SD	Mean	SD	
Livestock	27,508.56	20,190.35	23,389.98	12,097.06	25,861.12	17,479.71	1.657
Crops	8,480.81	4,657.08	5,620.98	3,716.49	7,336.88	4,516.65	0.492
Off-farm	6,832.78	10,434.58	3,202.83	3,926.15	5,380.80	8,621.10	11.095***
Tree and tree products	51,952.06	119,101.80	251.33	488.05	31,271.77	95,493.32	11.851***
Total income	95,053.30	120,351.29	32,465.13	14,554.44	70,018.03	98,397.72	14.601***

Note: *** refers to statistically significant at 1%, 5% and 10%, respectively

The average income obtained from tree plants and tree products of tree growers (ETB 51,952.06) was higher than that of non-tree grower households (ETB 251.33). Similarly, a socio-economic analysis of growing Eucalyptus in Kenya found that the sale of wood products from smallholder plantings provided at least 20% of total household income (Gustavsson and Kimeu, 1992). Studies carried out by Teshome (2004) and Mekonnen et al. (2007) in northern, central and southern highlands of Ethiopia respectively showed the contribution of incomes generated from the transaction of trees and tree products owned as woodlots rising to 25 % of household cash income.

Results depicted that the total income of tree growers from planting trees was much higher than that of non-tree growers. This implies that tree grower households have a higher level of livelihood security, change their livelihood strategies and cope with livelihood shocks as compared to non-tree growers. The tree growers had significantly ($p < 0.01$) higher income from tree and tree products than non-tree growers. The average tree grower households' income gained from off-farm activities (ETB 6,832.78) was greater than that of the non-tree grower households (ETB 3,202.83). The tree growers had significantly ($p < 0.01$) higher off-farm income than non-tree growers. This indicates that income variation between growers and non-growers was found in total average household income as a result of grower households' decision to incorporate tree planting activities in their livelihood.

The major tree products growers extracted from their tree plantation and supplied to the market were standing trees (construction poles), firewood, charcoal and split woods. The proportion of sold quantities and income obtained from these products varied, depending on local and regional market demands by product types. Construction poles had brought the highest return (79%), followed by split wood (9%), firewood (6%) and charcoal (5%), as presented in Figure 2. Furthermore, the sale of tree poles and products had the potential to increase farm income, decrease poverty, improve food security and diversify smallholder farming systems in underserved areas (Mekonnen et al., 2007; Kebebew, 2010; Lemenih, 2010).

Figure 2. The proportion of revenues obtained from tree products

Determinants of smallholders' tree plantation

The maximum likelihood method was employed to influence the smallholder plantation and statistically significant variables are identified in Table 4. The overall likelihood test ratio statistics indicated by the Chi-square statistics significantly influenced the probability to grow trees, suggesting the strong explanatory power of the model. Pseudo R^2 values indicated that the independent variables included in the regression explained 22% variations in the likelihood of smallholder plantation. The result of logit estimation showed that the likelihood of household smallholder plantation as a grower was significantly determined by household age, household size, livestock holding, distance, income from trees and total income. However, the education level of household heads and farm size had no significant effect.

The households' decision to plant trees was positive and significantly influenced by the family size. This result is in line with family size, indicating a significant and positive influence on tree plantings (Holden et al., 2003; Duguma and Hager, 2010). This finding, on the other hand, contradicts the outcomes of several other studies, where family size was found to have no significant effect on tree planting; in other words, (Gebreegziabher et al., 2010; Jenbere et al., 2012) it had a negative significant effect tree planting (Ashraf et al., 2014). The farm size of the household had no significant influence on the decision to plant or not to plant trees. This finding contradicts the results of several studies (Gebreegziabher et al., 2010; Jenbere et al., 2012; Etongo et al., 2015; Shifa et al., 2015).

The age of the household head was positively associated and significantly influenced the decision to plant trees. Older household heads did not have equal ability to harvest crops and vegetables, in its place, like a better to grow tree. The younger household heads were much excited to take up new technologies rather than to grow trees. However, the findings of this study are in line with the common assertion that the age of the household and tree plantings were positively related (Abebaw and Dea, 2016). Tree planting decreased with the increase in the age of the heads of households because younger people had a longer planning prospect and were more willing to take risks than the older ones (Ashraf et al., 2014). This is in agreement with the results of several studies (Gebreegziabher et al., 2010; Abiyu et al., 2012; Etongo et al., 2015). However, studies contradicted by Jenbere et al. (2012) indicate that the respondent's age had no significant effect. The number of livestock holdings was negatively influenced the smallholder tree grower households. This means that the households with higher livestock holding would not be probability in tree plantation to diversify their livelihoods to meet the needs. The finding is in line with the findings of previous studies (Berhanu et al., 2007; Gebreegziabher et al., 2010; Tesfaye et al., 2011). Distance to the nearby market gave a significant and negative influence on the households' decision either to plant or not to plant trees.

The income from trees and tree products was positively associated and significantly affected the households' decision to plant or not to plant trees. This study is in line with the previous studies (Mekonnen et al., 2007; Gebreegziabher et al., 2010; Kebebew, 2010; Dessie et al., 2019). The total income of household heads was positively associated and significantly influenced the households' decision to plant trees. Consistent with this observation, various studies concluded that, though to a varying degree, incorporating trees in smallholder farming system could bring positive changes in total household income (Lemenih and Bonger, 2011; Abebe and Tadesse, 2014; Endale et al., 2017).

Table 4. Factors affecting smallholder plantation-binary logistic regression model results

Variables	Coef.	Std. Err	Z	P > Z
Family_size	0.7376135	0.4216491	1.75	0.080*
Age	0.1504486	0.0537985	2.80	0.005***
Education	-0.2062521	0.7652417	-0.27	0.788
Livestock	-3.2040510	1.09832	-2.92	0.004***
Distance	-0.6182717	0.2519123	-2.45	0.014**
Farm_size	-0.2318304	0.1458065	-1.59	0.112
Tree_inc	0.0019833	0.0007258	2.73	0.006***
Total_inc	0.0002075	0.0000774	2.68	0.007***
_cons	-10.09449	3.493022	-2.89	0.004***

Note: ***, **, * refer to statistically significant at 1%, 5% and 10%

CONCLUSIONS

The magnitude of the benefits of smallholder tree planting is influenced by various factors at different levels. The results of this study show that being tree growers has a positive effect on households' total income and livelihood. The model signifies that family size, age, tree income and total annual income have positive and significant influences on the households' decision to plant trees. Livestock holding and distance to the market; however, have negative and significant influences on the smallholders' tree plantation. Therefore, actors and other policymakers should devise mechanisms and policy formulations to avert the factors contributing to the farmers' decision. This will further support farmers to improve their income and livelihoods through sustainable agricultural production.

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