

Impact of Woodlot Production on the Income of Farmers in Ghana

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Abstract

Woodlot production can reduce deforestation and the rate of climate change. Additionally, it can reduce poverty and provide an alternative source of income for farmers. The objective of the study was to assess the impact of woodlot production on the income of farmers. The study was conducted in the Ashanti, Bono-East and Western regions of Ghana. The sample size for the study was 386 respondents. The propensity score matching was used to measure the impact of woodlot production on the income of farmers. From the findings, those who are into woodlot production make GHS 586.917 less than those who are not into woodlot production. Hence, woodlot producers should be supported financially to motivate investors to venture into woodlot production.

Key words: Ghana, Income, Propensity score matching, Woodlot producers

Résumé

La production de bois peut réduire la déforestation et le taux de changement climatique. De plus, elle peut diminuer la pauvreté et fournir une source de revenu alternative pour les agriculteurs. L'objectif de cette étude était d'évaluer l'impact de la production de bois sur le revenu des agriculteurs. L'étude a été menée dans les régions d'Ashanti, de Bono-East et de l'Ouest du Ghana. La taille de l'échantillon de l'étude était de 386 répondants. Le score de propension a été utilisé pour mesurer l'impact de la production de bois sur le revenu des agriculteurs. D'après les résultats, ceux qui pratiquent la production de bois gagnent 586,917 GHS de moins que ceux qui ne le font pas. Par conséquent, les producteurs de bois devraient être soutenus financièrement pour motiver les investisseurs à se lancer dans la production de bois.

Mots-clés : Ghana, Revenu, Score de propension, Producteurs de bois

Introduction

Farmers in Ghana who have credit constraints are more likely to participate in off-farm work (Issahaku and Abdul-Rahaman, 2019). This is because off-farm work provides an alternative source of income for farmers. Off-farm work reduces the poverty of farmers by 13% (Issahaku and Abdul-Rahaman, 2019). The income of farmers is generally low in Ghana. Anang *et al.* (2020) mention that off-farm income can increase the income of farmers in Ghana since their source of income is diversified. The type of off-farm work farmers should venture into is not however investigated.

Woodlot production is an alternative source of livelihood for farmers since it provides jobs for people, increases income and reduces deforestation. Addressing deforestation makes business sense; the woodlot production concept shifts from forest conservation (Weber and Partzsch, 2018). It looks at the forest as a new business opportunity. Woodlot production looks at sustainable and productive forest management where revenue is generated sustainably (Ehiagbonare, 2018).

This concept is expected to provide green jobs and thus reduce poverty. Woodlot production in Ghana is in three forms. One is the taungya system where the Forest Commission gives a portion of land to a farmer for a maximum of three years. The farmer plants trees as he/she cultivates his crops. After three years the farmer leaves the farm as trees might have formed canopies. The Forest Commission gives 40% of the revenue from trees to the farmer when trees are harvested (Acheampong *et al.*, 2016). The second type of woodlot production is the communal type where a group of people acquire a piece of land from the chief and use it for woodlot production. After a period of 20 years when trees mature, they can be harvested and/or processed and sold. The third and fourth type is where a private landowner decides to go into woodlot production. He/she may or may not be supported by forestry companies or/and the government. This study compared the income of farmers who are woodlot producers and farmers who are not woodlot producers. The objective of the study was to assess the impact of woodlot production on the income of farmers.

This study is significant in three ways. Firstly, payment for carbon due to tree plantation under programmes like the REDD+ programmes has been recommended to transcend to communities and individual investors in order to improve their income and encourage reforestation (Asare, 2013). Even with the plantation of staple and cash crop, payment of carbon to communities and individuals has been suggested (Mohammed *et al.*, 2016; Ashiagbor *et al.*, 2022). There is therefore the need to determine the income of both woodlot and crop farming investor in order to make informed decision that would enhance food production and reduced deforestation at the same time. This study determined the income of both woodlot and crop investors in order to suggest on who carbon payments should be paid to where possible. Secondly, all the four different types of woodlot producers face challenges.

Farmers' inability to make a living until the trees are harvested was mentioned by Acheampong *et al.* (2016) as a challenge in woodlot production especially for MTS. Based on the results of this study, recommendations would be made to help reduce the MTS's problems. Also, the income of investors should be assessed against crop farming in order to make recommendations on improving the income and mitigating the challenges of woodlot investors. Lastly, the purpose of this study was to compare the income of investors who produce woodlots and those who do not produce woodlots. Also, the purpose of the study was to determine how the production of woodlots affects farmers' income. This study will hopefully contribute to reducing Ghana's loss of forestland. Using woodlot production as an alternative livelihood activity would also earn farmers money, as it will generate income.

Deforestation reduction because of improved income of farmers. Woodlot production both reduces deforestation and improves the income of investors. Income has generally increased among farmers and investors who incorporated woodlot in farming. In Tanzania, Ramadhani *et al.* (2002) noted that woodlot production increased the income of farmers. In their study they mentioned that farmers engagement in woodlot production fulfilled two goals; increase income and reduce deforestation. Similarly, Dessie *et al.* (2019) mentioned that eucalyptus production provides income for investors and reduces deforestation in Ethiopia. The main reason why investors go into eucalyptus production is because of the income generated from the activity. Ferede *et al.* (2019) supported this by saying that woodlot producers earn more than for example crop farmers.

Arjumand *et al.* (2022) noted that woodlot production is a third source of income diversification for households in Kashmir Himalaya. If this finding is verified in Ghana, then Ghana's problems of deforestation would be reduced as farmers would get an alternate to other farming practices as this would generate income for them.

Farmers in Ghana have other options of generating income off the farm aside from agricultural production. Anang *et al.* (2020) found that farmers in Ghana have a variety of sources of income, which can enhance their income to a great extent through off-farm income. Off-farm income is perceived to increase the income of household by as much as 19% (Danso-Abbeam *et al.*, 2020). The income of farmers who engage in woodlot production and those who do not engage in woodlot production may create the picture of the impact of woodlot on farmers' income. In Ghana, Mensah (2001) mentioned that farmers get the same amount of money in cocoa production in addition to money from woodlot production if they decide to plant woodlot on their farm. Woodlot production may increase the income of farmers who earn a low wage in Ghana. If farmers can get at least GHS 1702 (income from off farm work as mentioned by Anang *et al.* (2020) as income in woodlot production, it would be an incentive to farmers to consider going into woodlot production.

There has been advocacy for the conservation of the forests (Ometto *et al.*, 2011, Sartoretto *et al.*, 2017). Other schools of thought have suggested forest economy (woodlot production) as the panacea to reduce deforestation (Ehiagbonare, 2018; Weber and Partzsch, 2018). There would be decrease in the use of forestland for agriculture if the rational investor increases his/her income by planting timber trees. There is need to examine the incomes of farmers engaged vis-a-vis in woodlot production.

Methodology

Data collection and analysis. Propensity score matching (PSM) has been used in many impact studies (Ogutu *et al.*, 2014; Issahaku *et al.*, 2017). In this study, the treated are woodlot producers/managers and the control are the non-woodlot producers/managers. There is a dichotomous answer to whether a person is a woodlot producer or not. In economic parlance, a person is into woodlot production/management if the expected utility of woodlot production is greater than not going into woodlot production. The hypothesis is that a person embarking in woodlot production will increase his/her income. Income is conceptualized as money gained by the person both on-farm and off-farm. To model the impact of woodlot production on the income of a person, the model below is specified in Equation (Eq.) 1

$$I_{ij} = f(X_{ij}, D_{ij}) \quad \text{Eq. (1)}$$

Where I= income, subscript i represents a person, j (j = 1, 2) represents the treatments,

D is a dummy, equal to 1 if a person has or manages a woodlot and 0 otherwise. X is a vector of independent variables hypothesized to influence income as specified in Table 1. Equation 1 can be modeled with the conventional ordinary squares (OLS) model, where the estimate of the coefficient of D indicates the impact of woodlot production/management on the income of a person. However, this approach would potentially yield biased and inconsistent estimates because the decision to go into woodlot is not random and, thus, selectivity is introduced, thereby violating one of the assumptions of OLS. In other words, the covariance of D and the error term in equation (1) was non-zero if certain characteristics influence the decision to go into woodlot production. In this case, an appropriate econometric procedure should consider selectivity bias emanating from such characteristics.

Literature suggests several alternatives such as the Heckman selection, the double-difference, and the instrumental variable (IV) models. However, the use of an OLS in the second stage of the Heckman model imposes a limiting assumption of normally distributed errors which will likely suffer the problem of a conventional OLS.

Also, Ogutu *et al.* (2014) noted that the double-difference method has a limiting assumption of time-invariant selection bias which is difficult to verify. The IV approach is often applied with caution because of the difficulty in finding a suitable instrument. One empirical framework for analyzing equation (1) in a manner that avoids the weaknesses of the above models is the widely used Propensity Score Matching (PSM). The advantage of the PSM over the parametric approaches enumerated above is that it does not rely on any functional assumption about the relationship between the outcome (i.e. profitability) and its determinants (Issahaku, Abu and Nkegbe, 2017). Further, the PSM can account for selectivity bias (Issahaku *et al.*, 2017).

The PSM addresses selection bias by assuming, among other things, conditional independence, which states that assignment to managed forest and profitability are independent. The fundamental objective of the PSM is the estimation of the average treatment effect on the treated (ATT), which is the difference between the profitability of farmers who manage the forest and the profitability of farmers who do not manage the forest.

Estimation of the average treatment effect on the treated (ATT), which is the difference between the income of woodlot producers/managers and what would have been their income if they were not in woodlot production/management is specified as:

$$ATT_{ij} = E(I_{1ij}|D_{ij} = 1) - E(I_{0ij}|D_{ij} = 1) \quad \text{Eq. (2)}$$

Where I_{1ij} is income of the i^{th} person who is into woodlot and I_{0ij} is what the income of the i^{th} person who would have woodlot been if he/she does not have woodlots. The parameter $E(I_{0i}|D_i = 1)$ referred to as the counterfactual, cannot be measured, but the income of a farmer who does not go into woodlot $E(I_{0i}|D_i = 0)$ can be measured and used in place of the counterfactual. However, this would lead to biased estimates, since there is a possibility of pre-treatment differences between people who are in woodlots and those who are not. The PSM proceeds with this counterfactual problem by summarizing the effect of observed predictors (X) into a single estimate, referred to as the propensity score and specified as:

$$p(X_{ij}) = Pr[D_{ij} = 1|X_{ij}] = E[D_{ij}|X_{ij}] \quad \text{Eq. (3)}$$

Since the treatment is binary (go into woodlot production/management), either logit or probit would be used in estimating the propensity scores. The use of probit or logit was used based on the feedback from the field. If the majority of respondents are into woodlot, the logit was used. Probit was used if a few respondents go into woodlot. After the estimation of the propensity scores, the next step is the selection of a matching algorithm that will use the scores to match a person who manage the forest and those who do not for minimizing the level of bias between the two groups. The popular algorithms are nearest neighbor matching (NNM), radius matching (RM) and kernel matching (KM).

The most straightforward matching estimator is the nearest neighbor (NN) matching. The individual from the comparison group is chosen as a matching partner for a treated individual that is closest in terms of the propensity score. Several variants of NN matching are proposed, e.g. NN matching 'with replacement' and 'without

replacement'. In the former case, an untreated individual can be used more than once as a match, whereas in the latter case it is considered only once. Matching with replacement involves a trade-off between bias and variance. If we allow replacement, the average quality of matching will increase and the bias will decrease.

Matching faces the risk of bad matches if the closest neighbor is far away. This can be avoided by imposing a tolerance level on the maximum propensity score distance (caliper). Imposing a caliper works in the same direction as allowing for replacement. Bad matches are avoided and hence the matching quality rises. However, if fewer matches can be performed, the variance of the estimates increases.”

Kernel is a non-parametric matching estimator that uses weighted averages of all individuals in the control group to construct the counterfactual outcome. Thus, one major advantage of this approach is the lower variance, which is achieved because more information is used. A drawback of this method is that possibly observations are used that are bad matches.”

There is no clear rule for determining which algorithm is more appropriate. The nearest neighbor and the kernel method are often used. The third step is the estimation of the impact of woodlot production/management on the income of a person. The following effects was estimated:

$$ATT_{ij} = E\{E\{P_{1ij}|D_{ij} = 1, p(X_{ij})\} - E\{P_{0ij}|D_{ij} = 0, p(X_{ij})\}|D_{ij} = 1\} \quad \text{Eq. (4)}$$

$$ATE_{ij} = E\{E\{P_{1ij}|D_{ij} = 1, p(X_{ij})\} - E\{P_{0ij}|D_{ij} = 0, p(X_{ij})\}\} \quad \text{Eq. (5)}$$

Where ATT is the average treatment effect on the treated, (which measures the effect of woodlot production/management on the income of farmers) and ATE is the average treatment effect (which measures the effect of woodlot production/management on the income of both woodlot producers/ managers and non-woodlot producers/ managers). Apart from the PSM based algorithms, we also estimate equation (3.13) using the teffects (psmatch version) and the treatment reweighting (treatrew) methods as a way of checking the robustness of results.

Sensitivity analysis is conducted on the PSM based estimates to determine the impact of hidden biases using the Rosenbaum bounds (rbounds) test. Hidden biases occur when some unobserved variables or characteristics simultaneously influence woodlot and income. The rbounds does not conclude on whether or not hidden biases exist, as well as the magnitude of the biases, but asks whether the treatment effects may be altered by factors not observed in the dataset.

The Heckman Selection Model is employed as a parametric model to provide for robustness checks and to further assess the reliability of the PSM estimates, given that the PSM is not a parametric model. The Heckman Selection Model addresses sample selection bias and endogeneity problems.

Description of variables- Linear regression was used to estimate unknown parameters. Based on the theoretical discussion on the economic feasibility of farming or woodlot production, the logit model as specified in Equation 6 and 7 was used. The logit model was used to show the factors that influence the use of the managed forest (See explanation in Table 1)

$$\begin{aligned}
 \text{Use of managed forest land} &= F(\text{con, Typ, Sca, For, Vis, Awa, Law, rel, Vis, Edu,} \\
 &\text{Pro, Amt, kno, accl, par, accc, oth, awaf})
 \end{aligned}
 \tag{6}$$

Eq. (6)

Eq. (7)

Where ;U is the dependent variable

$X_1 \dots X_{18}$ are the independent variables

β_0 is a constant term

$\beta_1 \dots \beta_{12}$ are the coefficients of the independent variables

ε_i is the error term

Data collection. Woodlot producers were categorized under woodlot managers and woodlot owners. Woodlot managers fall under the taungya system and the communal system. Woodlot owners fall under woodlot producer off reserve and woodlot producer on contractual relationship with other firms. The study selected districts with forest reserves since these districts have the climatic conditions for forest management to thrive. The study used a multi-stage sampling methodology. In the first stage, one area with a forest reserve was randomly selected from each agro-ecological zone (Permadi, 2018). The forest reserves were considered because deforestation is driven by farming in the forest reserves (Acheampong *et al.*, 2019). Three regions namely Ashanti, Bono-East and Western Regions were selected (Table 2). This is because these three regions in addition to having a forest reserve had the highest rate of deforestation between 2001 and 2020 (Mongabay, Deforestation Statistics for Ghana, unpublished data). In the second stage, districts in the regions were possessively selected from each of the three regions. In Western Region, Wassa East was selected because it has the largest most diverse forest reserve (Subri Forest Reserve) with deforestation (Tsai, 2019). Wassa East and Tarkwa Nsuaem have farmers who were into taungya farming. Taungya farming is a collaboration between farmers and the Forest Commission where the land on reserve is given to farmers to farm on for at most three years (after which trees form canopies thus preventing farming). Farmers plant timber trees whilst farming on land. Atebubu was selected because it has one of the largest associations of woodlot producers. On the other hand, Mampong was selected because it had a forest company that has been given consignment to plant trees.

For communities, a change detection yielded a hotspot of deforestation in the various districts selected. Communities were selected based on nearness to reserves and biodiversity. After the selection of hotspots, stakeholders did a ranking of communities. The Forest Commission and the Ministry of Food and Agriculture gave a list of investors in the various communities. Respondents were randomly selected from the list of investors given.

Table 1. Measurement of variables

Variable	Variable description	Measurement	Expected sign
Dependent variable			
D	Use of forestland for woodlot or farming	Woodlot =1 Farming =0	
Independent variables			
General			
X ₁ =Association	Whether he is part of an association or not	1= Yes 0= No	+
X ₂ =Type of crop	Type of crop grown	1= cash crop 0= staple or crop	+
X ₃ =Total land size	Total land size in hectares	Number of hectares	+/-
X ₄ =Forest land	Perception of quality of forest land	1= good 0= bad	+/-
Institutional policy			
X ₅ = Visitation by representatives from Forestry Commission	The number of visits from a representative from the Forestry Commission	Number of visitations	+
X ₆ = Awareness of law forbidden managed forest	Whether they are aware of laws forbidden management of forest lands	A dummy variable (1=Yes, 0=No)	-
X ₇ =Law forbidden farming	Whether they are aware of laws forbidden farming in forest	A dummy variable (1=Yes, 0=No)	-
X ₈ = Relaxed policies of forest protection	Perception of policies of forest protection	1= very relaxed 0= not relaxed	+
Forest management			
X ₉ = Vision for forest management	Whether he wants forest to be managed for revenue in the near future or not	A dummy variable (1=Yes, 0=No)	+
X ₁₀ = Education on the importance of forest	Exposure to education on the importance of forest	Very frequent=1 Not Frequent=0	+
X ₁₁ = Profitability of woodlot	Net Present Value of investors	NPV	+
Farm characteristics			
X ₁₂ = Amount of money gained in farming	Whether he knows the amount of money gained in farming	A dummy variable (1=Yes, 0=No)	-
X ₁₃ = Knowledge in benefit of farming	Exposure to knowledge on the benefit of farming	Very frequent=1 Not Frequent=0	-
X ₁₄ =Access to land	Access to land	A dummy variable (1=Yes, 0=No)	+
X ₁₅ = Participation in forums	Whether he participates in forums or not	A dummy variable (1=Yes, 0=No)	+/-
X ₁₆ = Access to credit	Whether he has access to credit or not	A dummy variable (1=Yes, 0=No)	+
X ₁₇ = Other income apart from farming	Whether he has other income source apart from farming	A dummy variable (1=Yes, 0=No)	+
X ₁₈ = Awareness of forest laws	Whether he is aware of forest laws or not	A dummy variable (1=Yes, 0=No)	+/-

Table 2. Study areas

Agro-ecological zone	Region	District	Communities
Forest	Ashanti Region	Mampong	Mampong
		Sekyere Afram Plains	Drobonso
Transitional	Bono-East Region	Kintampo South	Adamsanu, Adum Anafoɔ
		Atebubu	Beposo, Kwame Danso
Coastal	Western Region	Wassa East	Sekyere Krobo, Kakoase, Essamang, Nsuta, Sekyere Aboaboso
		Tarkwa Nsuaem	Agona, Kakoase

Primary data were used. The study used questionnaires that had closed-ended and open-ended questions and they were administered with the assistance of well-trained local enumerators to ensure good communication with the respondents' hence proper understanding of the rationale for the study and also to enable a clear conceptualization of the questions being asked. This led to a 100% return of the questionnaires. For the purpose of the study, primary data were collected from woodlot producers and farming households both under the off reserves and the taungya system in the on reserves and with the respondents from each household being primary male (male of 18 years who is the primary decision taker in the household) and primary female (women of above 18 years who is the primary decision taker in the household) regardless of their relationship.

The population of the study were people who use forestland for either woodlots or farming. The sample size was calculated using Wang *et al.* (2012) formula for the unknown population. About 386 respondents were selected from the communities sampled.

Sample size = $(Z\text{-score})^2 * \text{StdDev} * (1 - \text{StdDev}) / (\text{margin of error})^2$, where Z= confidence level and StdDev= Standard deviation (Wang *et al.* 2012).

The researcher chose a 95% confidence level (1.96), a 0.5 standard deviation, and a margin of error (confidence interval) of +/- 5%.

$$(1.96)^2 * 0.5 * (1 - 0.5) / (0.05)^2 = 385$$

The sample size was distributed among agro-ecological zones and districts as shown in Table 3. Two districts were selected from each agro-ecological zone.

Table 3. Distribution of sample size among regions and districts

Agro-Ecological zones	Districts	Woodlot producers	Farmers	Frequency	Percent
Forest	Mampong, Sekyere Afram Plains	36	88	124	32.12
Transitional	Kintampo South, Atebubu	50	86	136	35.23
Coastal	Wassa East, Tarkwa Nsuaem	42	84	126	32.64
Total		128	258	386	100

Mampong, Wassa East and Tarkwa Nsuaem had woodlot producers who were with the Forestry Commission operation on the on reserve taungya system. This resulted in the high number of respondents (75) selected. The Forestry Commission gives timber tree species like the Odum, Emire and Cassia to be planted. Community woodlot producers were found in the Atebubu Amantin district. They formed a group to plant timber trees like Acacia and Cassia. About 15 community woodlot producers were interviewed. A total of 128 woodlot producers were interviewed. The number of farmers were selected based on the availability of woodlot investors in the district. This was because there were many farmers as compared to woodlot producers in the districts. An investor who is both a farmer and a woodlot producer was interviewed on woodlot production since those into woodlot production were few as compared to those who were into farming.

Study area. The study was conducted in three regions of Ghana that is the Ashanti, Bono East and Western Region. Ashanti region is in the Forest zone while the Bono East region is in the transitional zone. The Western region is in the coastal zone. Mampong Manicapaity and Sekyere Afram plains were chosen for Ashanti Region (Figure 1). Wassa East and Tarkwas Nsuaem was chosen for Western Region (Figure 1). Atebubu and Kintampo South was chosen for Bono East Region (Figure 1).

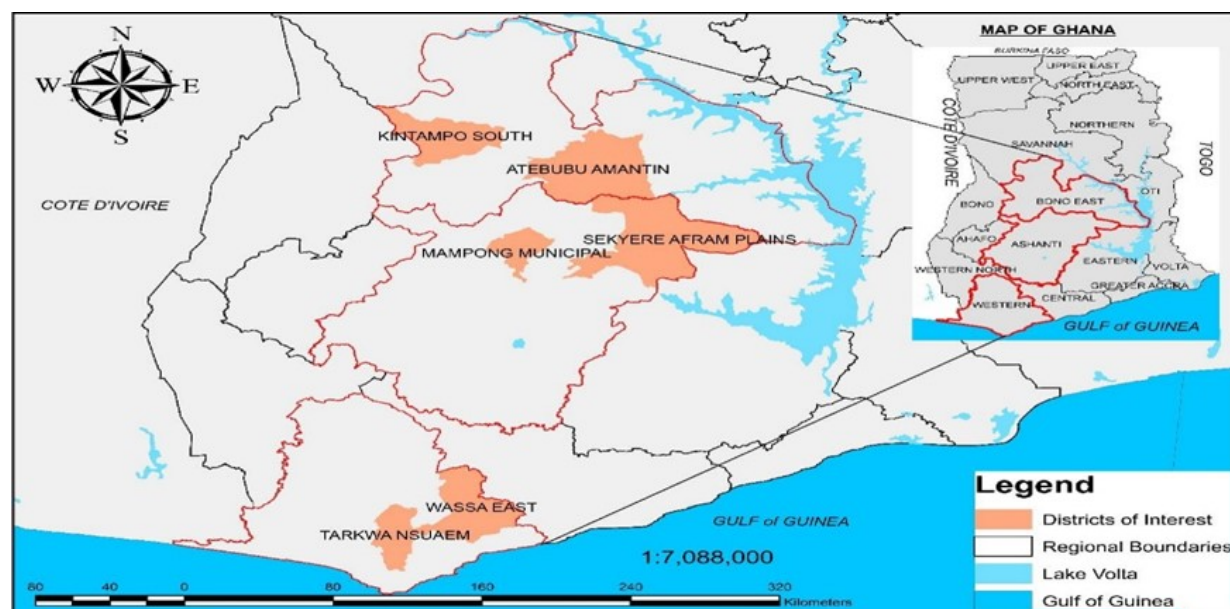


Figure 1. Study Area

Results and Discussion

Demographic characteristics of respondents. Males were dominant in both crop farming activities and woodlot production as 170 males are in crop farming and 107 males were in woodlot production .

This might be because both crop farming and woodlot production require energy hence men predominate. Also, men have access to resources like land as compared to females (Buyinza *et al.*, 2008; Donkoh *et al.*, 2019).

This enables mento invest in production of crops and woodlots. This finding agrees with the findings of Masamha *et al.* (2017) that men are dominant in production value chains and are involved in commercial production. Males in the forestry Industry were proportionally higher than males in the agriculture industry. This agrees with findings that males are proportionally more in the forestry industry than other industries.

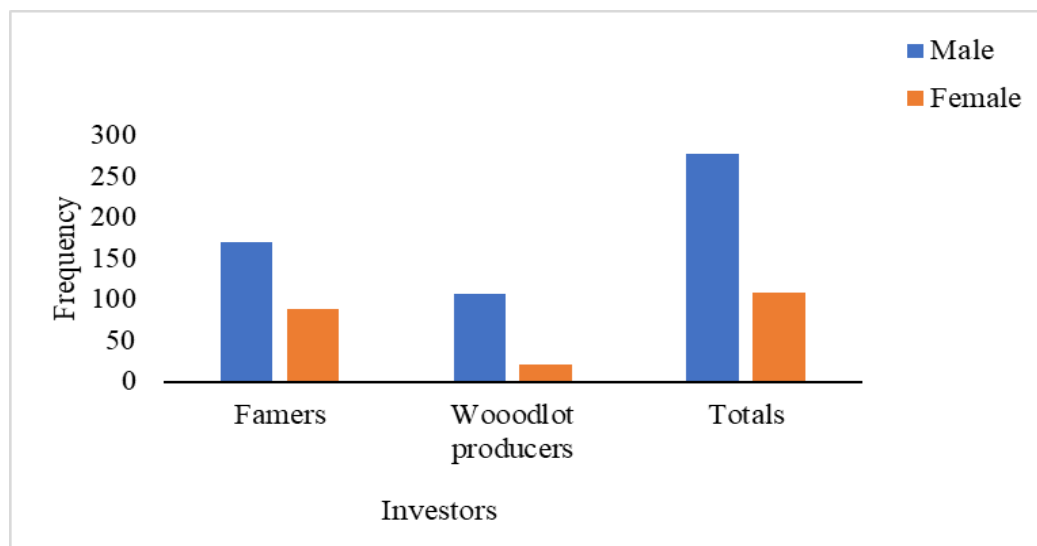


Figure 2. Type of respondents in relation to the type to venture

Fewer females (21%) were involved in woodlot production as compared to crop farming. Findings however shows that gender was not significant in relation to an investor going into woodlot production or crop farming (Table 4a)

Table 4a. Demographic characteristics of respondents

Characteristic	Description	Farmers	Woodlot producers	T-statistic	Totals
		Mean or frequency	Mean or frequency		
Sex	Male	170	107	0.20	277
	Female	88	21		
Age of the respondent in years		46.33	45.63	0.08	109
Marital status	Married	174	113	0.66	287
	Not married	84	15		
Religious status	Christian	244	117	0.19	361
	Non-christian	14	11		
Years of education of the respondent		6.14	6.91	0.91	25
Number of people in the household		5.11	7.05	0.08	
Other source of income aside crop farming	Yes	116	78	0.02	194
	No	142	50		
Land sizes owned		3.22	8.30	0.04	192
Participation on fora	Yes	116	78	0.86	194
	No	142	50		

The average age of farmers was 46.33 years while that of woodlot producers was 45.63 years (Table 4a). Averagely investors in woodlot production and farming were of more than 45 years in age. This implies that the young were less engaged in crop farming or woodlot production. The findings however show that age was not significant (0.08 significance level) in relation to an investors going into woodlot production or crop farming (Table 4b). This agrees with the findings by Muthoni (2012) that age had no significant relationship with the effective management of the forest.

Table 4b. Demographic characteristics of respondents

Characteristic	Description	Farmers	Woodlot producers	T-statistic	Totals
Type of venture	Staple crop	258	128		
	Cash crop	104			
	PWP who are not in contractual relationship		28		
	PWP who are in contractual relationship		10		
	On reserve Taungya		75		
	Community woodlot producers		15		
	Cassava	2997.5			
	Maize	2000			
Gross Margin for one season	Plantain	4158			
	Cocoa	6852.5			
	Cashew	3993.275			
	Other crops	2665.325			
	Teak		1690		
	Emire		13040		
	Acacia		10494.6		
	Cedrella		30640.5		
	Other timber trees		6983.138		

A total of 174 farmers were married as compared to 84 farmers who were not married (Figure 3). In terms of woodlot production 113 woodlot producers were married while 15 respondents were not married. More than three fourth of respondents in both crop farming and woodlot production were married. This finding agrees with the findings of Oluwayemisi *et al.* (2017) that people who are married have adequate labour for production. This explains while household size is averagely more than 5 in crop farming and woodlot production. The findings however shows that marital status is not significant (0.66) in relation to an investor going into woodlot production or crop farming (Table 4a).

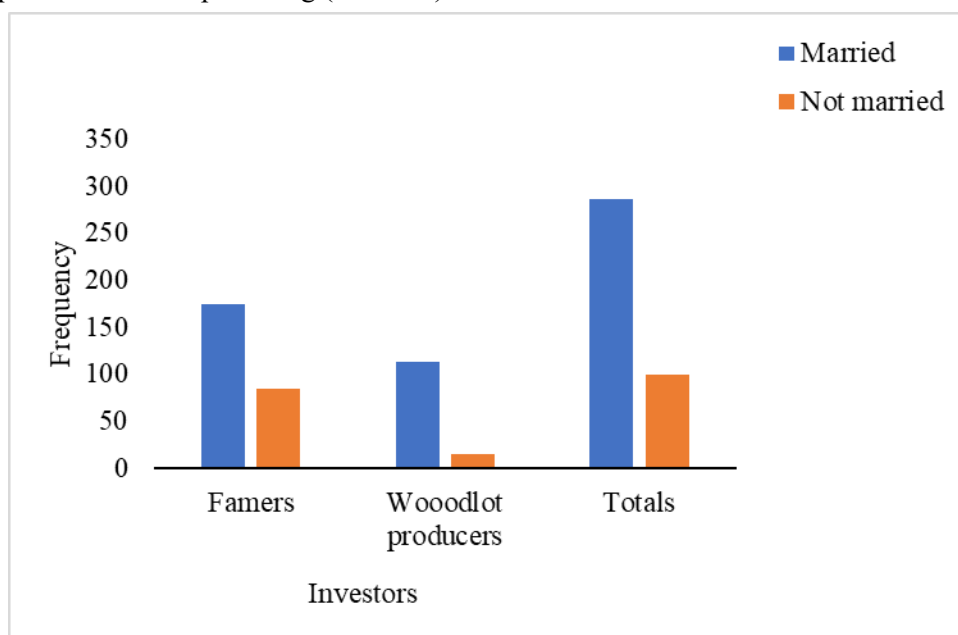


Figure 3. Marital status of respondents in relation to the type of venture

Most of the investors/managers were Christians (244 for crop farmers and 117 for woodlot producers) (Table 4a). Almost all (more than 88%) of the respondents were Christians. The findings however show that Christianity was not significant factor (0.19) in relation to an investor going into woodlot production or crop farming (Table 4a).

The average years of education of farmers was 6.14 while that of woodlot producers was 6.91. The years of education of farmers were slightly lower (6.14 as compared to 6.91) than that of woodlot producers (Table 4a). Woodlot producers were more educated than farmers averagely. This confirms findings of Oluwayemisi *et al.* (2017) and Donkoh *et al.* (2019) that education increase the likelihood of adoption by farmers. In a situation, however, where the educated doubt a concept, their likelihood of adoption is minimized (Lemchi *et al.*, 2005). The findings however shows that the years of education was not significant (0.91) in relation to an investor going into woodlot production or crop farming (Table 4). Land size had a negative relationship with the adoption of woodlot (Buyinza *et al.*, 2008; Muthoni, 2012)

The household size of woodlot producers was slightly higher (7.05 as compared to 5.11) than for farmers (Table 4b). This result agrees with the findings by Oluwayemisi *et al.* (2017) that large household size increases the likelihood of adoption of a technology as adequate labour can be provided for the adoption of the intervention. Also, the average household size of 5.11 agrees with the census figures of the study area. The higher household size of 7.05 for farmers in woodlot production may explain why farmers enter the MTS scheme thus providing enough food for their families. The findings however show that the household size was not significant (0.08) in relation to an investor going into woodlot production or crop farming (Table 4b).

Of the respondents, 116 farmers had other sources of income while 78 woodlot producers had also other sources of income apart from crop farming. Other sources of income here exclude woodlot production. From the findings, more than half of farmers and woodlot producers had other sources of income. This finding agrees with that of Anang *et al.* (2020) that farmers in Ghana have a variety of sources of income especially through off-farm activities. The findings shows that other sources of income aside from crop farming was significant (0.02) in relation to an investor going into woodlot production or crop farming (Table 4). This indicates that woodlot producers had other sources of income aside from crop farming as compared to farmers. Sources of income of woodlot producers included private and government industry employment.

On average woodlot producers had 8.30 hectares of land while farmers had 3.22 hectares of land. The large size of land may entice people to go into woodlot production. Hence the findings show that land size owned was a significant factor (0.04) in relation to an investor going into woodlot production or crop farming (Table 4b). This explains why farmers who have a large piece of land usually go into woodlot production. Farmers who do not have a large piece of land or/and work as a tenant on other people's land are not able to grow trees. This agrees with MLNR (2016) findings that tenants cannot grow trees for commercial purposes. Inadequate access to land restricts woodlot production (Boakye and Baffoe, 2006). Also, 116 farmers participate in fora while 78 woodlot producers participate in fora. The findings shows that participation in fora was not significant (0.86) in relation to an investor going into woodlot production or crop farming (Table 4b).

All woodlot producers were also cultivating staple crops. Farmers however chose between venturing into cash crop or woodlot production. Of the respondents 104 farmers were into cash crop production in addition to the cultivated staple crops. With woodlot production, private woodlot producers who were not in contractual relationship (PWPNC) were 28. These woodlot producers usually cultivated teak plantations and sold to the open market. Teak producers were mostly located in the Kintampo South district. Also, 10 private woodlot producers were in contractual relationships. These contractual relationships were between private forestry companies. This was common in Sekyere Afram Plains District. Contractors dictated the type of timber trees to grow under PWP. Exotic timber trees like *Cedrella* were mostly planted.

For staple crops, cassava and plantain take about a year to mature. Maize however can be grown twice in a year. Farmers also intercropped maize, cassava, and plantain on the same field. In terms of the cost of production, cassava and plantain had the least cost of production. This is because there are no pesticides used for production. This may account for the reason why gross profit of cassava and plantain was higher than that of maize. The gross profit for cassava was GHS 2997.50 (Table 4a). This gross profit is higher than that reported by Okyere and Baidoo (2020) gross profit of 331.01. This reason for the great disparity was that only 45% of cassava was sold as cassava was used for consumption and gift.

Maize was commonly infested by fall armyworm which increased the cost of production. This may explain why maize had a lower gross margin (GHS2000) as compared to cassava and plantain (Table 4b). MoFA (2021) mentioned that the potential gain in maize production was GHS 3 045 per hectare. This figure did not account for potential loss of production. Also, cost of pesticide control was very low (GHS 75) in MoFA (2021) study. The gross profit of cocoa production is GHS 6852.5. This agrees with findings of Mensah (2002) that cocoa production is profitable. In both staple and cash crop production, cocoa production gave the highest gross profit. Also, the gross profit of cashew production was GHS 3993.275. This is similar to the findings of Yeboah *et al.* (2023) that cash crops generate more income for farmers. According to them the annual income of cashew farmers in Ghana ranged between GHS 5000 and 10000 (Yeboah *et al.* 2023).

Impact of Woodlot Production on the Profitability of Farmers. In all, 386 investors were interviewed. About 67% of respondents were woodlot producers and 33% were farmers (Figure 4). Under woodlot production, both private woodlot producers who were in contractual relationship and those who were not in contractual relationship were selected. Also, woodlot producers who were in association were selected. This ensured that all types of woodlot producers were included in the study.

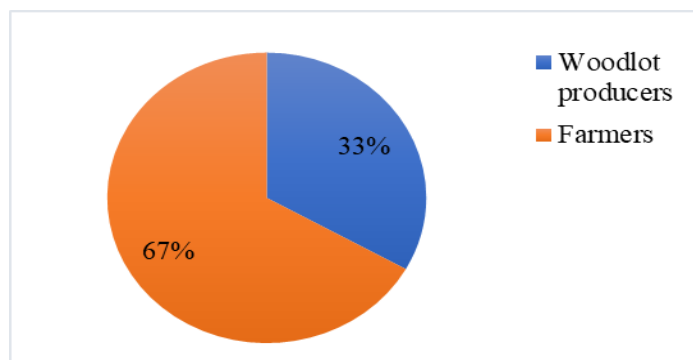


Figure 4. Percentage distribution of woodlot producers and farmers

The propensity score distribution and common support for propensity score estimation is shown in Figure 5. When matching the respondents, those who used forestland for woodlot production were similar to those who did not use forestland for woodlot production (Figure 5).

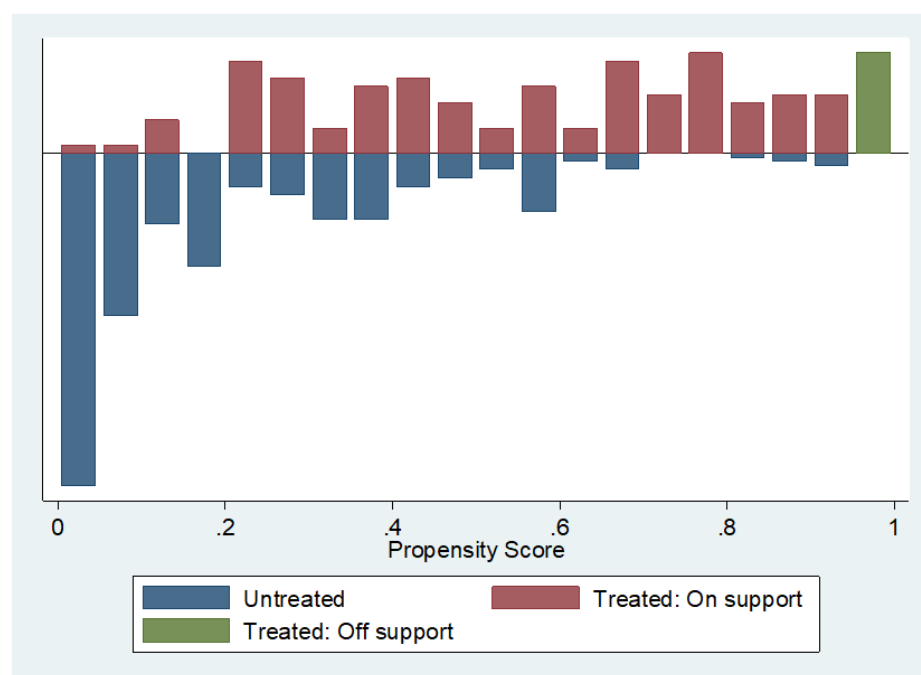


Figure 5. Matching of woodlot producers/manager and farmers

Table 5. Description of variables of factors that affect use of land for woodlot production

Variable	Observation	Mean	Std. Dev.	Min	Max
Association	386	0.591	0.492	0	1
Types of crops	386	0.878	0.392	0	3
Sex	386	0.718	0.451	0	1
Age	386	46.096	14.656	20	84
Marital status	386	0.744	0.437	0	1
Years of education	386	6.396	4.570	0	16
Household size	386	5.754	3.179	0	15
Ownership of land	386	0.557	0.497	0	1
Total land size	385	12.275	23.115	1	200
Access to credit	386	0.360	0.481	0	1
Perception on quality of forestland	386	0.948	0.222	0	1
Number of visitation by Forest Commission	386	7.842	11.503	0	50
Exposure to education on the importance of forest	386	0.642	0.480	0	1
Knowledge on the amount of money gained in woodlot production	386	0.145	0.353	0	1
Income	386	0.503	0.501	0	1
Awareness of forest laws	386	0.606	0.489	0	1
Willingness to engage in woodlot	386	0.611	0.488	0	1
Do you do sharecropping	386	0.425	0.495	0	1
Type of reserve	386	0.207	0.406	0	1
Association	386	0.591	0.492	0	1

The number of respondents was 386. The maximum and minimum response was 1 and 0, respectively for association, sex, marital status, ownership of land, access to credit, perception on quality of forestland, exposure to education on the importance of forest, Knowledge on the amount of money gained in woodlot production, Income, awareness of forest laws, willingness to engage in woodlot, sharecropping and type of reserve variables (Table 5).

The probit results shows that those who were into woodlot production did have other sources of finance apart from the venture capital (Table 6). Use of land for woodlot production was not significant with engagement in an association. Use of land for woodlot production was not significant with sex. Use of land for woodlot production was not significantly associated with total land size. Use of land for woodlot production was not significantly associated with number of visitations by the Forestry Commission. Use of land for woodlot production is not significant with exposure to education on the importance of forest.

Table 6. Probit Results of factors that affect the use of land for woodlot production

Variable	Coef.	Std. Err.	z	P>z [95% Conf. Interval]
Association	0.156	0.253	0.620	0.536
Types of crops	0.529***	0.209	2.530	0.011
Sex	-0.009	0.007	-1.330	0.183
Age	0.600***	0.237	2.530	0.011
Marital status	-0.045***	0.022	-2.010	0.044
Years of education	0.118***	0.030	3.940	0.000
Household size	0.997***	0.227	4.400	0.000
Ownership of land	0.011***	0.005	2.340	0.019
Total land size	-0.008	0.177	-0.050	0.962
Access to credit	-0.701	0.480	-1.460	0.144
Perception on quality of forestland	0.035***	0.008	4.600	0.000
Number of visitation by Forest Commission	-0.721	0.495	-1.460	0.145
Exposure to education on the importance of forest	0.376	0.256	1.470	0.141
Knowledge on the amount of money gained in woodlot production	0.189	0.178	1.060	0.289
Income	1.015***	0.495	2.050	0.040
Awareness of forest laws	-0.454***	0.184	-2.460	0.014
Willingness to engage in woodlot	-0.129	0.209	-0.620	0.537
Do you do sharecropping	-0.809***	0.220	-3.680	0.000
Type of reserve	-1.748	0.680	-2.570	0.010
_cons	0.070	0.199	0.350	0.725

*** denotes $p < 0.01$, ** denotes $p < 0.05$, * denotes $p < 0.10$

Number of obs = 385, Prob > F = 0.0000, $R^2 = 0.632$, Pseudo $R^2 = 0.612$

Positive perception of quality of forestland appeared to lead to the use of forestland for woodlot production. This is in line with the findings by Tham *et al.* (2020) who mentioned that rocky land in Vietnam was suitable for production of acacia woodlot leading to the use of land for acacia woodlot production. Generally, those who were into woodlot production made less income as compared to those who are not into woodlot production. This agrees with findings from Jagger *et al.* (2005) that average annual net benefits for all types of woodlots were negative.

From Table 7, those who were into woodlot production made GHS 587.876 less than those who were not into woodlot. The reason for this might be because those who are not into woodlot production are into other off farm work which generates much more income as compared to woodlot production. Similarly, Arjumand *et al.* (2022) noted that in woodlot production a third source of income diversification for households in the Kashmir Himalaya. According to them, agriculture has the largest income share of rural people followed by business. Woodlot production is ranked third in terms of income. Since investors invest more in ventures that generate the highest income, it can be inferred that business (off farm work) was more profitable as compared to woodlot production. This finding is however in contrast with Tham *et al.* (2020) who mention that acacia production improves producers' household income by 33–56% and it is the major source of income in the area of their study. They found that woodlot production (acacia) gave the highest source of income followed by agriculture and lastly non-farm income. The reason for their findings may be that in Vietnam, prices of acacia woodlot was high as compared to that in Ghana leading to increase in sales and profitability accordingly. Also, the land in the study area in the Vietnam was rocky supporting acacia as compared to agriculture.

Table 7. Effects of woodlot production on income of investors

Income	Coef.	Std. Err.	P>t
Woodlot	-587.876***	42.813	0.000
_cons	2300.723	24.654	0.000

Number of observations = 386, Prob >F = 0.000, R-squared = 0.329, Adjusted R-squared = 0.328

The finding of the current study is however in contrast with that of Ramadhani *et al.* (2002) who mentioned that woodlot production increased the income of farmers. It can be inferred that when farmers venture into woodlot production they decrease their chances of getting income from other alternative ventures. Also, Ramadhani *et al.* (2002) used a shorter period (five years) in his analysis for maturity of timber trees. This short time may not give room to shock that may happen after five years.

Table 8. Matching methods used to measure impact

Type of method	Sample	Difference	Standard error	T-Statistics
Radius matching	ATT	-578.92	70.87	-8.17
	ATU	-597.71	65.68	-9.10
	ATE	-642.30	63.48	-10.12
Nearness neighbour	Unmatched	-586.92	42.87	-13.69
	ATT	-687.0334	89.52	-7.67
	ATU	-378.12		
Kernel method	ATE	-488.38		
	Unmatched	-586.92	42.87	-13.69
	ATT	-695.40	89.62	-10.13
	ATU	-581.60		
	ATE	-620.37		

The matching results are shown in Table 8.

The Average Treatment on the treated (ATT) on an investor drawn from the total population at random was GHS 578.921 less (Table 8). This implies that woodlot investors decreased their profit by GHS578.921. The difference however between those who use forestland for woodlot production and those who do not use forestland for woodlot was GHS586.917 (Table 8). This finding is in contrast with those by Dessie *et al.* (2019) who noted that woodlot production increased the income of investors. The reason for their findings may be because they did not compare income from timber production with income from other sources like agriculture and off farm income. They explain that the main motivation why people (over 82%) go into eucalyptus production was because of its income. This reason might imply that investors are likely to invest in crop farming as it generates more profit compared to woodlot production.

Conclusion and Recommendation

Those who use forestland for woodlot production earn between GHS 578 and GHS 648.502 less than those who do not use forestland for woodlot production (using different methods). In general, those involved in woodlot production earn less than those who are not involved in woodlot production. The Average Treatment on the treated (ATT) on an investor drawn from the total population at random was GHS 578.921 less. This implies that woodlot investors decreased their income by GHS578.921. The difference however between those who use forestland for woodlot production and those who do not use forestland for woodlot was GHS586.917. In summary, woodlot is a potential new market to reduce deforestation and generates income in a sustainable way, however, a potential investor in woodlot production would get less income as compared to an investor who does not engage in woodlot production. Also, woodlot production takes long time (more than five years) for one to get income.

To increase income of woodlot producers, investors in woodlot plantations should be considered under the REDD+ programme. This means that money should be paid to investors for invest in woodlot. This would increase the income of woodlot producers as suggested by Asare (2013) and Insaadoo *et al.* (2013) encourage people to go into woodlot production. Also, government and funding agencies should support woodlot producers to raise funds to pay for expenses in woodlot production in order to encourage investors to go into woodlot production. Any rational investor would choose crop farming instead of woodlot production because it takes a shorter time for one to get return from crop farming as compared to woodlot production. A conscious effort therefore must be made to attract investors to go into woodlot production.

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