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Original Paper

Assessing the impact of the adoption of agroforestry technology on food production and poverty reduction among farming households in Oyo State, Nigeria

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This study determines the impact of agroforestry practices on food production, income generation and poverty reduction among farming households in Oyo State, Nigeria. A multi-stage sampling technique was used to select the respondents. Both descriptive statistics such as frequencies and percentages as well as inferential statistics such as Propensity Score Matching (PSM) and Foster Greer Thorbecke (FGT) analysis were used in the study. It was discovered that the propensity score distribution and common support for propensity score estimation shows the results from the covariate balancing tests both before and after matching in which the treatment (adopters) and comparison (non-adopters) groups are said to be balanced. The result of the impact of the adoption of agroforestry practices on farmers' income from the PSM analysis shows that the adoption produces a positive and significant impact on the farmers' income, while the result of the impact of the adoption on farmers' output was found to be negative, though not significant. This could be attributed to improper adoption or practices of the technologies by the farmers. It was also discovered that about 27% of the adopters fell below the poverty line ($183.25) and were therefore regarded as poor while about 67% of the non-adopters fell below the poverty line ($102.21) and can therefore be described as poor. FGT poverty index was then used to show the extent of poverty among the farming households and it was found that the adopters of agroforestry technology were faring better than the non-adopters of agroforestry technology.

Keywords: agroforestry technology, food production, poverty reduction, Propensity Score Matching (PSM), Foster Greer Thorbecke (FGT)

1 Introduction

Poverty in Nigeria has been on the increase, notwithstanding several governmental and non-governmental interventions to reduce it through poverty alleviation/reduction programmes and projects (Adepoju and Okunmadewa, 2010). Estimate of poverty incidence from 2009–10 was 53.5% according to the international poverty line of $1.90 per person per day (2011 Purchasing Power Parity (PPP)). In 2016, it was projected to have fallen to 48.4%. But owing to slow growth, poverty has been on the rise (World Bank, 2018). The United Nations Human Development Report (2019) declares that Nigeria's Human Development Index (HDI) value for 2018 is 0.534 which puts the country in the low human development category, positioning it at 158 out of 189 countries and territories.

In Nigeria, poverty has persisted and many interventions have not yielded noticeable improvement in the country's Human Development Index. Plagued with the challenges of the effects of Covid-19, unemployment crises, climate change, conflict, fragility and violence, Nigeria (the most populous country in Africa) stands at a grave risk if poverty is not tackled (Danaan, 2018).

Therefore, reducing poverty is an important development policy issue because economic growth is obviously associated with poverty reduction (Osowole, 2011).

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Poverty, which has been defined as the deprivation of well-being related to lack of material income or consumption, low levels of education and health, vulnerability and exposure to risk, lack of agency, and powerlessness, has remained a threat and challenge to humanity in all ramification (World Bank, 2001; Maduka, 2007). In Africa, poverty remains an important topic and has been connected to climate change and its associated hazards and food insecurity (Beegle et al., 2016; Thornton et al., 2006; Charles, 2019). Therefore, reducing poverty by means of improvement in the environment, sustainable use of natural resources and sustainableland management practices, such as agroforestry, should be at the forefront of major global initiatives (Adams et al., 2004; Griggs et al., 2013).

Agroforestry has earned a distinct identity as an approach to sustainable landuse (Rahman et al., 2010). Garrity and Stapleton (2011) noted that agroforestry is one of mankind best hopes to create a climate-smart agriculture, increase food security, alleviate rural poverty and achieve a truly sustainable development. Meanwhile, Agroforestry has been defined as a land use system in which woody perennials are grown with food crops and/or livestock leading to many beneficial, ecological and economic interactions between trees and non-trees components (Idumah et al., 2018). The International Council for Research in Agroforestry (ICRAF) now World Agroforestry Centre also defined agroforestry as a "dynamic ecologically based natural resources management system that through interactions of trees on farm and in the agricultural landscape diversifies and sustains production, enhancing social, economic and environmental benefits for land users at all levels"(Idumah et al., 2018; Rahman et al., 2010; Mutua et al., 2014; Kennedy et al., 2016).

Agroforestry not only helps to increase food and fodder but also protects the existing forest where the unemployed and the poor earn their livelihoods. Agroforestry also helps to lift rural poor from poverty through market-driven, locally led tree cultivation systems that generate income and build assets; conserve biodiversity through integrated conservation-development solutions based on agroforestry technologies (Rahman et al., 2010; Kandji et al., 2006). Furthermore, it can protect forest through agroforestry-based solutions; assist the rural poor to better adapt to change and derive benefits from emerging carbon markets, through tree cultivation (Rahman et al., 2010; Ajayi and Catacutan, 2012; Maren and Carolyn, 2011).

Studies have shown that the adoption of agroforestry technology in some parts of Nigeria has proven to prevent some environmental problems like soil erosion, flooding and desert encroachment in addition to ensuring that several thousand hectares of marginal lands are salvaged and planted with economic trees as well as securing land for the farming population for food production (Adeola, 2015). Further studies have also revealed that agroforestry practices enhance farmers' income, food security and improve on poverty status of the farming households (Tiwari et al., 2017; Olajuyigbe, 2016; Kareem et al., 2017).

Despite these evidences that revealed the benefits of agroforestry technology's adoption, not many farmers have adopted these technologies. This may probably be due to several factors like inadequate knowledge of these technologies, non-availability of seed/seedlings, lack of appropriate skills, insecure land tenure/land ownership pattern, inability to understand agroforestry practices, decrease in crop yield, lack of access to credit facilities, inadequate source of information on the practice etc. (Akinwalere, 2016; Owombo and Idumah, 2017).

This study therefore, attempts to address the gaps in the previous studies by assessing the significant impact of the adoption of agroforestry technology on income generation, farmers' output and poverty reduction strategies as well as the factors militating against the adoption of agroforestry among farming households in Oyo State, Nigeria, under the following specific objectives:

1. To determine the impact of agroforestry practices on food production and income generation in the study area.
2. To determine the contribution of agroforestry practices to poverty reduction in the study area.
3. To identify factors militating against the adoption of agroforestry in the study area.

2 Material and methods

2.1 Study area

The study was carried out in Oyo State, Nigeria. Oyo State is located between latitude 20,381 and 40,351 east of the Greenwich meridian. Oyo State is located in the south-west zone of Nigeria. The state consists of thirty-three Local Government Areas (LGAs) and covers an area of 28,454 square kilometers. Agriculture is the main occupation of the people and small-scale traditional farming system predominates in the area. The bulk of the produce come from annually cultivated rain-fed farms. Oyo state has four Agricultural Development Programme (ADP) zones, namely; Ibadan/Ibarapa zone, Oyo zone, Saki zone and Ogbomoso zone (see Figure 1). Ibadan/Ibarapa zone has fourteen LGAs/Blocks, Oyo with only five, Saki zone with nine zones and Ogbomoso has only five LGAs/Blocks in their zones.

Figure 1 Map showing the Four ADP zones in Oyo State, Nigeria
Source: Cartographic Laboratory, IFSERAR, FUNAAB, 2016

2.2 Sampling procedure

A multi-stage sampling technique was used to select the respondents from the study area. The first stage was the random selection of two Agricultural Development Project (ADP) zones out of the four agro-ecological or ADP zones in Oyo state since they all have a dominance of rural farmers. The selected zones were Ibadan/Ibarapa and Saki zones. The second stage was the random selection of Local Government Areas also known as ADP Blocks from the selected zones. Six Local Government Areas (LGAs) were selected from Ibadan/Ibarapa zone while four LGAs were chosen from Saki Zone. The selection was done based on the proportion of number of local government areas in each of the selected zones. The third stage was the random selection of two communities in each Local Government Area, making a total of twenty communities in all. The fourth stage was the random selection of twenty farmers in each Local Government Area making a total of two hundred copies of questionnaires. However, only 199 copies of the questionnaire were eventually utilized for the analysis due to non-recovery of a copy of the administered questionnaire.

2.3 Method of data analysis

2.3.1 Propensity score analysis

This is an important tool to identify imbalance in covariates with regard to treated and comparison groups. The objective of establishing a propensity score is for covariate balancing between individuals who did and did not receive a treatment, thereby ensuring easy isolation of the effect of a treatment.

A propensity score (π) for an individual (*i*) is defined in Rosenbaum and Rubin (1983) as the conditional probability (*P*) of assigning a participant to a particular treatment or comparison group (*T*) given a set of covariates (*X*), expressed as:

$$\pi_i = (T_i = 1|X_i) \qquad (1)$$

In theory, pertinent pre-treatment variables are used to obtain probabilities of group membership which are used to match participants in treatment and comparison groups in a way that both groups have equal means or likelihoods of receiving treatment. After matching, differences between groups should reflect real treatment effects in the population and similar to the interpretation of randomized designs.

As covariates are identified, probabilities of group membership or propensity scores are estimated for all participants. Logistic regression is the most commonly used estimation technique (Guo and Fraser, 2010; Thoemmes and Kim, 2011) and is relatively easy to interpret given that the predicted probabilities (*P*) of group membership (*T*) are the propensity scores (π) for a given set of covariates (X).

$$\pi_i(X_i) = (T_i = 1|X_i) = \frac{1}{1+e^{-xibi}} \qquad (2)$$

This study therefore adopted the use of Propensity Score Matching (PSM) model to analyze the impact of the adoption of agroforestry technology on income and food production of farmers in the study area. Propensity Score Matching simply means matching treated and untreated observations on the estimated probability of being treated (propensity score). The ideal comparison group is selected such that it matches the treatment group using a comprehensive baseline either survey or time invariant characteristics. The matches are selected based on of similarities in observed characteristics. This assumes no selection bias based on unobserved characteristics.

Therefore, let $P(X) = Pr(z = 1|x)$ represent the probability of adopting agroforestry technology, that is the propensity score. Propensity Score Matching will then construct a statistical comparison group by matching observations on the agroforestry adopters to non-adopters for similar values of propensity score. Rather than create a match for each adopter with exactly the same value of *X*, we can therefore match the probability of adoption.

Therefore, to evaluate the impact of Agroforestry technology adoption on income and food production (in terms of crop yield/year), a measure of the impact was used to compare the outcome of those who adopted agroforestry practices and those who did not adopt:

Let Y_1 = adopters of agroforestry technology,

Y_0 = non-adopters of agroforestry technology.

The impact of the adoption will therefore be the change in the mean outcome caused by adopting the technology.

$$\bar{Y} = Y_1 - Y_0 \tag{3}$$

Since it may not be possible to estimate individual treatment effects in equation 1 directly, the evaluation parameter, which is the Average impact of the treatment on the treated (ATT), was introduced

$$\begin{aligned} Y_{ATT} &= ATT(Y|X; Z = 1) = E(Y_1 - Y_0|, Z = 1) = \\ &= E(Y_1/Z = 1) - E(Y_0|, Z = 1) \end{aligned} \tag{4}$$

where: Z – an indicator variable, showing whether a respondent actually adopted agroforestry technology or not. It is equal to 1 if respondent adopted and 0 if otherwise. *X* denotes a vector of control variables. STATA 12 Version was used for this analysis

2.3.2 Foster Greer Thorbecke (FGT) analysis

To assess the impact of agroforestry technology adoption on poverty reduction in the study area, poverty line was first constructed. Poverty line is described as a borderline that distinguishes poor from non-poor households in terms of their level of welfare. Two approaches are commonly adopted to determine the poverty line namely: expenditure and income approach. To compare the level of poverty among the adopters and non-adopters of agroforestry technology, Foster Greer Thorbecke measure of poverty was adopted.

Following Foster, Greer and Thorbecke (1984), the model is expressed as:

$$P\alpha = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{Z - y}{Z}\right]^{\alpha} \tag{5}$$

where: Z – the poverty line defined as 2/3 of Mean annual per capita expenditure; y – the annual per capita expenditure – poverty indicator/welfare index per capita; q – the number of poor households in the population of size n; a – the degree of poverty aversion; $a = 0$ – is the Headcount index (P_0) measuring the incidence of poverty (proportion of the total population of a given group that is poor, based on poverty line); $a = 1$ – is the poverty gap index measuring the depth of poverty that is on average how far the poor is from the poverty line; $a = 2$ – is the squared poverty gap measuring the severity of poverty among households, that is the depth of poverty and inequality among the poor

3 Results and discussion

From Table 1, it was discovered that majority (about 65%) of the adopters of agroforestry technology were between 40 and 59 years of age while 68.61% of non-adopters were within the same age range. Majority (38.29%) of the adopters had secondary education while majority (35.23%) of non-adopters had tertiary education. Large proportion (95.74%) of the adopters was male while about 85% of the non-adopters were male, with female accounting for 4.26% and 15.24% of the adopters and non-adopters respectively. In addition, majority (72.68%) of the adopters had farm size of 8 ha and below while 83.81% of the non-adopters had equivalent land holdings. This is an indication that majority of the farm households in the study area are small scale farmers. This is because, according to Ozowa (2005), farm households with less than 10 ha of farmland are regarded as small-scale farmers. This is according to international standards measurement for farm sizes. It was also observed that the adopters of agroforestry technology had larger household size than the non-adopters with 73.4% of the adopters having household size from 6 to 15 while 64.76% of the non-adopters had same household range. This may not be unconnected to the fact that adopters with larger household sizes realized that they had more people to cater for, hence the need to add tree planting (especially multipurpose and fruit trees) to their farming activities so as to have additional sources of income to cater for family needs.

Figure 2 shows propensity score distribution and common support for propensity score estimation. The "treated" in the figure shows the observations in the adopters' group that have a suitable comparison. The balancing test was thereafter applied to find out if the differences in the covariates of the two categories in the matched sample have been eliminated, in which case, the matched comparison group can be considered a plausible counterfactual (Ali and Abdulai, 2010).

Table 2 shows the results from the covariate balancing tests both before and after matching. The standardized mean difference of 28% before matching has now decreased to about 8.4% after matching. Therefore, it can be concluded that the matching process decreased the total bias. In addition, the ratio of variances of the propensity score and covariates from the adopters and non-adopters are all near 1 except for household size where the unmatched was significant.

But after matching, the bias was significantly reduced by about 87% and the ratio of the variances after

Table 1 Socio-economic characteristics of respondents

Variable	Adopters (*N* = 94) frequency	Percentage	Non-adopters (*N* = 105) frequency	Percentage
Age (years)				
≤39	02	2.13	11	10.48
40–49	20	21.27	31	29.52
50–59	41	43.62	40	38.09
60–69	21	22.34	20	19.05
>70	10	10.64	03	2.86
Gender				
Male	90	95.74	89	84.76
Female	04	4.26	16	15.24
Educational status				
No formal	02	2.13	09	8.57
Primary	10	10.64	14	13.33
Secondary	36	38.29	33	31.43
Tertiary	31	32.97	37	35.23
Vocational	15	15.96	12	11.43
Farm size (Ha)				
≤2	20	21.27	24	22.86
2.1–5.0	34	36.17	54	51.43
5.1–8.0	16	15.24	10	9.52
≥8.1	24	25.53	17	16.19
Household size				
≤5	23	24.47	36	34.29
6-10	56	59.57	64	60.95
11-15	13	13.83	04	3.81
≥16	02	2.13	01	0.95
Farming experience years				
≤ 10	05	5.32	10	9.52
11–20	41	43.62	50	47.62
21–30	23	24.47	25	23.80
≥31	25	26.59	20	19.05

Source: Field Survey, 2019

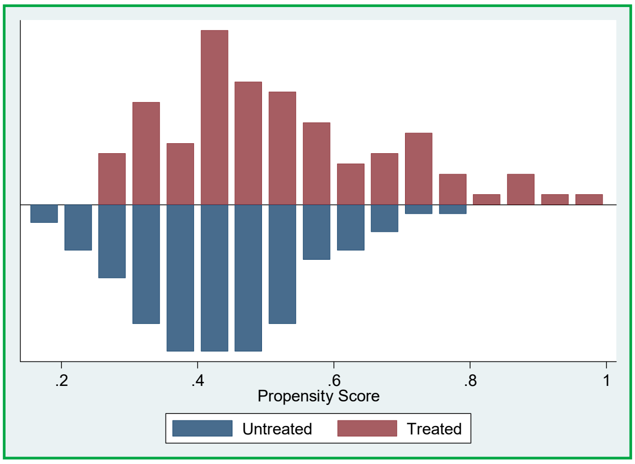

Figure 2 Graphical representation of propensity score match among adopters and non-adopters of agroforestry technology

matching is now not statistically different from 1, as shown in Table 3. Therefore, the treatment (adopters) and comparison (non-adopters) groups are said to be balanced. This is because, according to Rubin (2001), ratio of variances of propensity score and covariates from the treatment and comparison groups should be near one if the treatment and comparison groups are balanced.

Table 4 reveals the result of the impact of adoption of agroforestry practices on farmers' output in the study area. The result from the Propensity Score Matching Analysis shows that the adoption of agroforestry had a negative, though not significant, impact on the farmers' yields. The Average Treatment Effect (ATE) of the treatment on a farmer drawn from the total population at random is -119,316 Kg of food production per year. This implies that agroforestry technology decreased the farmers' farm output by 119,316 Kg and reduced the output of the sampled farmers who adopted the technology by 196,794 Kg per year. This, however, is in contradiction with *a priori* expectation in which adoption of agroforestry technology is expected to enhance farmers' output. This is at variance with study by Jama et al. (2006) where agroforestry technologies were said to have found enormous applications in many parts of Africa by lifting many out of poverty, by increasing crop production and yields on the farm by double or quadruple folds, especially in Kenya, Uganda, Tanzania, Zambia, Malawi, Mozambique and Zimbabwe that are now adapting the component technologies to their conditions. This was also corroborated by Sileshi et al. (2012) that in South Africa, agroforestry has helped to increase crop yields and stabilize crop production in times of drought and other extreme weather conditions. However, since the decrease in yield was not statistically significant and considering the importance of agroforestry practices globally, the reduction could be attributed to improper practices of agroforestry technology among the adopters. It might be that the adopters did not observe the recommended spacing for the planted agroforestry trees which after forming their canopy, the canopies

Table 2 Matching quality indicator (before and after matching)

Sample	Ps R2	LR chi2	*p* >chi2	Mean Bias	Med Bias	B	R	%Var
Unmatched	0.094	25.87	0.000	28.0	23.7	72.9*	1.45	17
Matched	0.014	3.58	0.733	8.4	8.8	27.4*	0.93	17

Source: STATA 12 Output

Table 3 Propensity score test (PSTEST) assessing balance in the matched samples

Variable	Unmatched matched	Mean treated	Mean control	% bias	% bias reduct	T	*p* >|*t*|	*V(T)/V(C)*
Age	U	56.479	51.752	49.6		3.49	0.001	0.91
	M	56.479	57.574	-11.5	76.8	-0.78	0.438	0.86
Education	U	2.5	2.2762	21.6		1.52	0.131	0.75
	M	2.5	2.5	0.0	100.0	0.00	1.000	0.81
Access to extension	U	.58511	.64762	-12.8		-0.90	0.367	1.06
	M	.58511	.60638	-4.4	66.0	-0.30	0.768	1.02
Farming experience	U	26.277	23.181	25.8		1.82	0.070	1.18
	M	26.277	27.011	-6.1	76.3	-0.39	0.694	0.91
Access to credit	U	.43617	.37143	13.2		0.93	0.355	1.05
	M	.43617	.37234	13.0	1.4	0.89	0.375	1.05
Household size	U	7.6277	6.4762	44.8		3.18	0.002	1.93*
	M	7.6277	7.2234	-5.8	87.1	-0.36	0.721	1.15

Source: STATA 12 Output

Table 4 Impact of the adoption of agroforestry technology on food production (crop yield) of rural farmers

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Farm output	unmatched	41,841.7872	98,131.6762	-56,289.889	67,424.7472	-0.83
	ATT	41,841.7872	238,636.106	-196,794.319	178,490.949	-1.10
	ATU	98,131.6762	48,176.3238	-49,955.3524		
	ATE			-119,316.472		

Source: STATA 12 Output

Table 5 Impact of the adoption of agroforestry technology on income of rural farmers

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Farm income	unmatched	621,010.638	355,057.143	265,953.495	77,952.2614	3.41*
	ATT	621,010.638	278,893.617	342,117.021	92,166.0362	3.71*
	ATU	355,057.143	502,247.619	147,190.476		
	ATE			239,266.332		

Source: STATA 12 Output

now cast too much shades on the arable crops, thereby preventing the arable crops from receiving the required amount of sunlight for improved yields.

Table 5 shows the result on the impact of the adoption of agroforestry practices on farmers' income in the study area. The result from the PSM analysis shows that the adoption produces a positive and significant impact on the farmers' income. The Average Treatment Effect on the treated (ATT) of the entire population of the adopters in the study area was $950.33 per year. This implies that the average annual income of the adopters increased by $950.33 per year. In addition, the average effect of the treatment (ATE) on the entire population in the study area is $664.63. That is if any adopter of agroforestry practices is picked at random in the study area, the average annual income will be $664.63. The implication of this is that if both adopters and non-adopters of agroforestry technology were considered, income due to adopters will increase by about $664.63 per year. Furthermore, for the impact on the non-adopters, the average treatment on the untreated (ATU) had a positive impact but not significant effect on income which will increase by $408.86 provided they were treated. Therefore, adoption of agroforestry technology will lead to an increase in farmers' income in the study area. This finding agrees with Idumah and Akintan (2014) and Idumah and Owombo (2019) who reported that agroforestry enhanced the income of agroforestry farmers in Edo state, Nigeria. Likewise, Sarvade and Singh (2014) posited that agroforestry helps to enhance nutrition, health and income of rural poor and described the system as the best one option for tackling food security problem. This could be attributed to multipurpose benefits derivable from the practice of agroforestry which in addition to enriching soil nutrients; it serves as source of income to farmers, as farmers can generate income from sales of timber for construction or sales of wood as poles. Agroforestry also enables farmers to generate income fruit trees planted on their farms. All these therefore accounted for the positive and significant impact of agroforestry on the income of the adopters in the study area.

Table 6 shows the value of income generated by the farming households in the study area as well as the value of the poverty line. The values of poverty line computed for the adopters and non-adopters of agroforestry technology were $183.25 per year and $102.21 per year respectively. The households that earn less than the value of poverty line was considered to be poor and those above the poverty line are regarded as non-poor. It was then discovered that about 27% of the adopters fell below the poverty line and were therefore regarded as poor while about 67% of the non-adopters fell below the poverty line and can therefore be described as poor.

Foster Greer Thorbecke (FGT) poverty index was used to show the extent of poverty among the farming households in the study area. The poverty aversion parameters used were P_0, P_1, and P_2 which translate to poverty incidence (headcount), poverty depth (gap) and poverty severity respectively. Table 7 revealed that the incidence of poverty (P_0) among the adopters was 0.2659 and 0.6667 for the non-adopters indicating that 26.6% of the adopters were poor and 66.67% of the non-adopters were poor, with reference to the poverty line. The value of the poverty depth (P_1) among the adopters was 0.4481 and 0.6982 for the non-adopters. This implies that an average poor adopter of agroforestry technology would require 44.8% of the poverty line to get out of poverty

Table 6 Annual income generated by farming households in the study area

Income	Adopters (N = 94) frequency	Percentage	Non-adopters (105) frequency	Percentage
≤N100,000	32	34.04	79	75.23
N100,001–N200,000	10	10.63	5	4.76
N200,001–N300,000	5	5.32	4	3.81
N300,001–N400,000	3	3.19	3	2.86
N400,001–N500,000	7	7.44	5	4.76
N500,001–N600,000	8	8.51	4	3.81
N600,001–N700,000	5	5.32	2	1.90
N700,001–N800,000	2	2.13	1	0.95
N800,001–N900,000	4	4.26	2	1.90
N900,001–N1,000,000	6	6.38	0	0
>N1,000,000	12	12.77	0	0
Poverty line	$183.25		$102.21	

Source: Field survey, 2019

N.B. – exchange rate of N360 to $1 was used

Table 7 Effect of Agroforestry Technology on Poverty Reduction among Rural Farmers

Variable	P_0	P_1	P_2	G	N
Adopters	0.2659	0.4481	0.2204	25	94
Non-adopters	0.6667	0.6982	0.4994	70	105

P_0 – poverty incidence; P_1 – poverty depth (gap); P_2 – poverty severity; G – no of poor households; N – total no of households

Table 8 Constraints to the Adoption of Agroforestry in the Study Area

Constraint	*Frequency	Percentage	Rank
Insufficient land for tree planting	99	49.75	3rd
Illegal felling of trees	77	38.69	7th
Long gestation period of trees	102	51.26	2nd
Lack of technical assistance	80	40.20	5th
Lack of planting materials	84	42.21	4th
Lack of knowledge and skills	118	59.30	1st
Competition among trees and arable crops on farmland	79	39.70	6th

Source: Field survey, 2019
*Multiple responses

while an average poor non-adopter would need 69.8% of the poverty line to get out of poverty. In addition, the value of poverty severity (P_2) among the adopters was 0.2204 and 0.4994 for the non-adopters. This therefore implies that the poverty severity among the adopters was 22.04% and 49.9% for the non-adopters. It was therefore discovered from the study that the adopters of agroforestry technology were faring better than the non-adopters of agroforestry technology, as they recorded lower poverty incidence and depth than the non-adopters of the technology. It could therefore be inferred that adoption of agroforestry technology plays significant role in poverty reduction in the study area.

There are many constraints militating against the adoption of agroforestry technologies by farmers in the study area. This study therefore highlighted some of the problems faced by farmers in the adoption of agroforestry in the study area. Some of the problems examined includes; insufficient land for tree planting, illegal felling of trees, long gestation period of trees, lack of technical assistance, lack of planting materials, lack of knowledge and skills as well as competition among trees and arable crops on farmland. It was discovered that 59.30% of the respondents (both adopters and non-adopters) stated that lack of knowledge and required skills on agroforestry was a constraint to their adoption of agroforestry and this ranked highest among the constraints, as shown in Table 8. This possibly explains why the adopters of agroforestry technology in the study area could not efficiently explore the potentials of agroforestry technology. This therefore accounted for the reduction in farm outputs of the adopters relative to the non-adopters. Furthermore, ranking second highest among the constraints militating against the adoption of agroforestry technology among the farmers in the study area is the gestation period of agroforestry trees as 51.26% of them described the long gestation period of agroforestry trees as a constraint. In addition, 49.75% of the respondents stated insufficient land as a constraint to the adoption of agroforestry. This is where expertise of the extension agents and some subject matter specialists are needed to train and enlighten the farmers on how to make effective use of their land to accommodate both their tree crops and arable crops. This work is therefore in line with the study by Amonum and Bada (2019) where lack of land, lack of tree seedlings as well as inadequate extension personnel were stated as some of the constraints affecting the adoption of agroforestry in Katsina State of Nigeria.

4 Conclusions

It can be inferred that the impact of the adoption of agroforestry practices on farmers' income in the study area produces a positive and significant impact on the farmers' income while the result of the impact of adoption of agroforestry practices on farmers' output in the study area produces a negative but not significant impact on the farmers' yields. This may not be unconnected to improper practices of the technologies among the farmers. It was discovered that about 27% of the adopters fell below the poverty line and were therefore regarded as poor while about 67% of the non-adopters fell below the poverty line and can therefore be described as poor. It was therefore concluded that the adopters of agroforestry technology were faring better than the non-adopters of agroforestry technology. Agroforestry practices can therefore be said to play prominent role in the enhancement of farmers' income, reduction of poverty and the overall improvement in livelihood within the study area.

It is therefore, recommended that efforts should be geared towards increasing adoption of agroforestry technology through awareness and sensitization of farmers so as to enjoy the benefits of agroforestry practices. There is the need for training and enlightenment of the farmers, by extension agents and specialists on agroforestry technology, on how to make effective use of their land to accommodate both their tree crops and arable crops for improved yield and productivity. Farmers should also be provided with necessary and early-maturing tree seedling by government through the appropriate research institute (such as Forestry Research Institute of Nigeria, FRIN) to encourage and motivate the farmers to adopt agroforestry technology.

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