RESEARCH ARTICLE

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Technical efficiency of agroforestry production technology among smallholder farmers in Kaduna State, Nigeria

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Abstract

This study evaluated technical efficiency of agroforestry production technology among smallholder farmers in Kaduna State, Nigeria. Multi-stage sampling technique was adopted. A total sample size of 120 smallholder agroforestry farmers was used. Primary data were collected with the aid of structured and well-designed questionnaire. Analytical tools used were: descriptive statistics, farm budgeting techniques, financial analysis, stochastic production frontier model, and principal component model. About 85% of agroforestry farmers were male, while 15% were female. Also, 87.50% of agroforestry farmers were less than 50 years of age. The mean age was 45 years. Furthermore, 85% of agroforestry farmers had formal education and were literate. The household sizes were large with mean value of 6 members per household. The agroforestry systems practiced include: alley farming, shelterbelts, wind breaks, home gardens, api-silviculture, aqua-forestry, retaining tree on farm land, taungya systems, farmed parkland, and silvo-pasture. The result of the farm budgetary technique show that agroforestry farming was profitable among the smallholder farmers in the study area. The result of the maximum likelihood estimates shows that the significant factors influencing output of agroforestry production technology were: seed input ($P<0.05$), farm size input ($P<0.01$), fertilizer input ($P<0.10$), labour input ($P<0.10$), and chemical input ($P<0.01$). The significant factors influencing technical inefficiency of agroforestry production technology were: gender ($P<0.10$), marital status ($P<0.01$), education level ($P<0.01$), experience in agroforestry production ($P<0.01$) and size of households ($P<0.10$). The average technical efficiency score obtained by the smallholder agroforestry farmers was 40.18%. The constraints facing agroforestry farmers include: lack of training and capacity building, inadequate extension officers, lack of improved seeds, lack of credit facilities, lack of fertilizers, and lack of agroforestry tree seedlings. The study recommends that agroforestry tree seedlings should be made available to farmers, credit facilities should be provided for easy access to agroforestry production technologies, extension officers should be employed, and improved seeds, fertilizers should be provided for increased productivity.

Keywords: Technical Efficiency, Agroforestry Production Technology, Kaduna State, Nigeria

INTRODUCTION

Agroforestry can be defined as the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/ or animal systems to benefit from the resulting ecological and economic interactions. The Food and Agriculture Organization, FAO (2015) defined agroforestry as a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms bamboos, etc) are deliberately used on the same land management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence. Agroforestry is a combination of forestry and agriculture, it is an intensive land management system that optimize the benefit from the biological interactions created when trees and or shrubs are combined deliberately with crop and/ or animals. The system is intentional, intensive, interactive, and integrated. Agroforestry, the integration of trees in agricultural activities has the capacity to increase soil fertility, reduce evaporation, increase nutrient recycling, reduce land degradation from erosion, and improvement of water quality. These benefits will have an impact and environmental benefits at the farm level, local and regional levels. Agroforestry helps to maintain the well-being of societies at all levels (Alemu, 2016). Agroforestry is a proven model of integrated sustainable land use system which can enhance agricultural productivity and production in a low input and in an ecological and economically feasible way in the effort of enhancing food security sustainably (Mbow, 2015). The growing of trees on the border of the crop land is a good source of income for smallholder farmers on one hand and on the other hand plays an important role in increasing soil fertility, enhances biodiversity and cleans water that ultimately reduces global warming by carbon sequestrations (Ingwe *et al*., 2009). Agroforestry systems are both stable and sustainable, it has greater diversity than do monoculture practices and can distribute production over a long period, thus provide income that is more regular with increased cash flow stability. Integrating of trees into agricultural systems may result in more efficient use of sunlight, moisture and plant nutrients than is generally possible by mono-cropping of either agricultural or forestry crops (Amunum *et al*., 2009). Agroforestry system contribute to the rural economy poverty alleviation, employment, and environmental protection at a local regional and national level (Alavalapati *et al*., 2004). Agroforestry production technology also have economic dimension since it helps maximize agricultural production by reducing soil erosion, water, and organic matter losses. The practice can increase microbial activities which can help nutrient recycling, thus increase the fertility of soil under agricultural production (Jose, 2009). Nitrogen fixing trees can also increase agricultural production and thereby reduced cost for agricultural inputs. Agroforestry practices are essential resources to combat climate because of their role in sequestering carbon and other greenhouse gases (AAC, 2014). Agroforestry production technologies are also known to increase the biodiversity resource potentials, since they provide shelter and food, they are known to support the existence of wildlife. The presence of woody perennials in agroforestry systems may affects several bio-chemical and bio-physical processes that determine the health of the soil substrate. The impacts of trees on soil include: surface litter cover and under story vegetation, amelioration of erosion, maintenance or increase of organic matter and diversity, nitrogen fixation, continuous degeneration of roots and decomposition of litter, enhancement of physical properties such as porosity, soil structure, and moisture retention due to the extensive root system and the canopy cover, and enhanced efficiency of nutrient use because the tree – root system can intercept, absorb, and recycle nutrients in the soil that would otherwise be lost through leaching. The choice of tree species is the most important factors to be considered in agroforestry systems. The choice of tree species be made after careful consideration of their benefit for rural populace and adaptability for growth. The farmers' preference of forest trees would definitely be due to their potentials and adaptability to the land area. Technical efficiency is the extent to which smallholder farmers use their resources to produce the maximum possible output.

Objectives of the Study

The broad objective evaluated technical efficiency of agroforestry production technology among smallholder farmers in Kaduna State, Nigeria. Specifically, the objectives are to:

(i) determine the socio-economic profiles of smallholder agroforestry farmers,
(ii) determine the types of crops grown, animal reared and trees under agroforestry production technologies among smallholder farmers,
(iii) analyze the profitability of agroforestry production technology,
(iv) evaluate factors influencing technical efficiency of agroforestry production technology among smallholder farmers,
(v) evaluate socio-economic factors influencing technical inefficiency of agroforestry production technology among smallholder farmers,
(vi) determine the technical efficiency scores of smallholder agroforestry farmers, and
(vii) determine the constraints faced by smallholder agroforestry farmers in the study area.

Methodology

This research study was conducted in Kaduna State, Nigeria. Kaduna State occupies between Longitudes $06^{\circ}\ 15^{|}$ and $08^{\circ}\ 50^{|}$ East and Latitudes $09^{\circ}\ 02^{|}$ and $09^{\circ}\ 02^{|}$North of the equator. The State has land area totaling 4.5 million hectares. The state vegetation is divided into two (2), the Southern guinea savanna and Northern guinea savanna. There are two (2) seasons in Kaduna State. The seasons are: wet and dry seasons, the dry season is between October to March, and the wet season starts from April to October, in between the wet and dry seasons is the brief harmattan period which span from

November to February. The mean or average rainfall is about 1,482mm, the temperature of Kaduna State ranges from 35°C to 36°C, which can be as low as 10°C to 23°C during the harmattan period. The population of Kaduna as at 2021 was 8.9 million people. They are involved in agricultural activities. The people are involved in agroforestry production technology. Crops grown include: okra, pepper, maize, ginger, sorghum, rice, yam, cassava, millet, and tomatoes. Animal reared include: cattle, goats, sheep, rabbit, and poultry.

Research Design

A descriptive cross-sectional research design was employed in this study with the aim of describing the socio-economic profiles of characteristics of smallholder agroforestry farmers, determine the various types of crops grown, animal reared and trees under agroforestry production technologies among smallholder farmers, and to evaluate socio-economic factors influencing technical inefficiency of agroforestry production technology among smallholder farmers in the study area.

Sampling Techniques and Sample Size

A multi-stage sampling technique was adopted for this study. In the first stage, purposive sampling procedure was used to select Kaduna State based of the numerous numbers and concentration of smallholder agroforestry farmers in the area. The second stage involved random selection of four (4) area councils using ballot box method. In the third stage, three (3) villages were selected randomly from each area council based on the intensity of smallholder agroforestry farmers. In the fourth stage, from sampling frame of 171 smallholder agroforestry farmers, proportionate and simple random sampling technique was used in each village to select the desired sample size of 120 smallholder agroforestry farmers. This study employed the formula advanced by Yamane (1967) in the determination or estimation of the sample size. The formula is stated thus:

$$n = \frac{N}{1+N(e^2)} = 120 \qquad (1)$$

Where,

n = Desired Sample Size

N = Finite Size of the Population

e =Maximum Acceptable Margin of Error as Determined by the Researcher

Methods of Data Collection

The data for this study was collected through the use of well-designed structured questionnaire. The data collected were cross sectional data from primary source, the data collected from smallholder agroforestry farmers were socio-economic profiles of the farmers, prices of production inputs, quantity of inputs used and constraints faced by farmers in the course of agroforestry production technology in the study area. Data were analyze using the following descriptive and inferential tools:

Descriptive Statistics

Data collected from field survey on smallholder agroforestry farmers were summarized through the use of mean, frequency distributions, and percentages. Descriptive statistics was used to summarize the socio-economic profiles of smallholder agroforestry farmers as stated in specific objective one (i), and determine the types of crop grown, animal reared, and trees under agroforestry production technology among smallholder farmers as stated in specific objective two (ii).

Farm Budgetary Technique

Gross margin and net farm income analysis of agroforestry production technology was estimated using the following models:

$$GM = TR - TVC \qquad (2)$$

$$GM = \sum_{i=1}^{n} P_i Q_i - \sum_{j=1}^{m} P_j X_j \qquad (3)$$

$$NFI = TR - TC \qquad (4)$$

$$NFI = \sum_{i=1}^{n} P_i Q_i - \left[\sum_{j=1}^{m} P_j X_j + \sum_{k=1}^{k} GK \right] \qquad (5)$$

Where

P_i = Price of Agroforestry Produce ($\frac{₦}{Kg}$),

Q_i = Quantity of Agroforestry Produce (Kg),

P_j = Price of Variable Inputs ($\frac{₦}{Unit}$),

X_j = Quantity of Variable Inputs (Units),

TR = Total Revenue obtained from Sales from Agroforestry Production Technology (₦),

TVC = Total Variable Cost (₦),

GK = Cost of all Fixed Inputs (Naira)

NFI = Net Farm Income (Naira)

The farm budgetary technique was used to analyze the profitability of agroforestry production technology as stated in specific objective three (iii).

Financial Analysis

According to Alabi *et al.* (2020), gross margin ratio is defined as:

$$Gross\ Margin\ Ratio = \frac{Gross\ Margin}{Total\ Tevenue} \quad (6)$$

According to Olukosi and Erhabor (2015), Ben-Chendo *et al.* (2015) operating ratio (OR) is defined as:

$$Operating\ Ratio = \frac{TVC}{GI} \quad (7)$$

Where,

TVC = Total Variable Cost (Naira),

GI = Gross Income (Naira),

The financial analysis was used to analyze the profitability of agroforestry production technology as stated in specific objective three (iii).

Stochastic Production Frontier Model

According to Alabi *et al.* (2022), the stochastic production frontier model is stated thus:

$$Y_i = f(X_i, \beta_i)e^{v_i - u_i} \quad (8)$$

$$l_nY = \beta_0 + \beta_1 l_nX_1 + \beta_2 l_nX_2 + \beta_3 l_nX_3 +$$

$$\beta_4 l_nX_4 + \beta_5 l_nX_5 + V_i - U_i \quad (9)$$

where,

Y_i = Output of Agroforestry Practices (kg)

X_i = Vectors of Factor Inputs

β_i = Vectors of Parameters

V_i = Random Variations in Agroforestry Technology

U_i= Error Term due to Technical Inefficiency

X_1 = Seed Input in kg

X_2 = Farm Size (ha)

X_3 = Fertilizer-Input in kg

X_4 = Labour-Input in mandays

X_5 = Chemical-Input in litre

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \quad (10)$$

where,

Z_1 = Gender (Dummy; 1, male; 0, otherwise)

Z_2 = Age of Smallholder Agroforestry Farmers in years

Z_3 = Marital Status (Dummy; 1, married; 0, otherwise)

Z_4 = Educational Level Attained

(Likert; 0, non-formal; 1, primary; 2, secondary; 3, tertiary)

Z_5 = Experience in Agroforestry Production Technology (years)

Z_6 = Size of Household (number)

α_0 = Constant Term

$\alpha_1 - \alpha_6$ = Parameters to be Estimated

U_i= Error Term due to Technical Inefficiency

Cost Saving Formula

The cost saving formula for average technical efficient (ATE) smallholder agroforestry farmers and least technical efficient (LTE) smallholder agroforestry farmers is stated as:

$$\text{Cost Savings} = \left[\left[1 - \frac{\text{ATES or LTES}}{\text{MaxTES}}\right] \times 100\right] \quad (11)$$

Where,

ATES = Average Technical Efficiency Score (Units)

LTES = Least Technical Efficiency Score (Units)

MaxTES = Maximum Technical Efficiency Score (Units)

This was used specifically to achieve objective four (iv), which is to evaluate factors influencing technical efficiency of agroforestry production technology, objective five (v), which is to evaluate socio-economic factors influencing technical inefficiency of agroforestry production technology by smallholder farmers in the study area, and objective six (vi) which is to determine the technical efficiency scores of smallholder agroforestry farmers in the study area.

Principal Component Analysis

The constraints facing smallholder farmers and militating against practice of agroforestry production technology were subjected to principal component analysis. This was used to achieve specific objective seven (vii).

RESULTS AND DISCUSSION

Socio-Economic Profiles of Smallholder Agroforestry Farmers

The socio-economic characteristics of smallholder agroforestry farmers was presented in Table 1. The socio-economic profiles under considerations were: sex, marital status, age, level of education, household size, farming experience, extension contact, membership of cooperatives, and farm size. The sex distributions of agroforestry farmers show that 85% were male, while 15% were female. The distributions of marital status categorized agroforestry farmers into single (39.16%), divorced (17.50%), and married (43.33%). About 87.50% of agroforestry farmers were less than 50 years of age. The mean age was 45 years. This means that agroforestry farmers were active, young, and energetic in their youthful age. This is in line with Luqman *et al*. (2018) who reported that majority of people in the research area were young, active age respondents and are more likely to adopt new technologies and they also have larger capacity to cultivate larger fields. About 85% of agroforestry farmers had formal education and were literate this include: tertiary (14,17%), secondary (35.83%), and primary (35%). Also, 15% of agroforestry farmers had no formal education. Farmers who have some level of education respond readily to improved technology thus increasing their productivity. According to Amaza and Tashikalma (2003), the literacy level of farmers is important as it determines the rate of adoption of improved technology for increased productivity. Also, Adekunle (2009) observed that the level of education of farmers will directly affects their ability to adapt to change and accept new ideas. Farmers who acquire some level of education are more likely to perceive new technologies than the ones who have no any form of education. Furthermore, 75% of agroforestry farmers had between 1 – 10 members as household size. The mean household size was 6 members per household. This signifies that more quality labour would be available for carrying out agroforestry production technologies. This is in line with findings of Villano and Fleming (2004). Averagely, farmers had 8 years' experience in agroforestry production technology. Agroforestry farmers with more years of farming experiences tend to be more efficient in production. Also, 73.33% of agroforestry farmers had extension contact, while 26.67% of agroforestry farmers do not have extension contact. In addition, 71.66% of agroforestry farmers were members of cooperative organizations, while 28.34% of agroforestry farmers do not belong to any members of cooperative organization. About 55.83% of agroforestry farmers had less than one hectare of farm land. The mean size of farm land was 1.25 hectares, this means that they are smallholder farmers.

Types of Crops Grown, Animal Reared and Trees under Agroforestry Production System among Smallholder Farmers

Table 2 presented the types of trees identified under the agroforestry systems, about eighteen (18) agroforestry trees were identified with various economic benefits. This include: *Parkia biglobosa, Musa species* and *Eucalyptus camadulensis* ranked first with the highest frequency (49) having 7.19% each respectively, followed by *Carica papaya* with 7.04%. This is in line with findings of Jamala *et al*. (2013). Table 3 shows the type of crops grown either as sole or in mixtures in agroforestry system. Maize ranked first with the highest frequency (58) having 11.08%, followed by rice with frequency of (56) having 10.70%, yam ranked third having frequency of (51) with 09.75%. The various types of animal reared under agroforestry system include: cattle (19.06%), sheep (15.71%), goats (16.05%), poultry (17.39%), fish (16.05%) and rabbits (15.71%) (Table 4). The various agroforestry systems practiced in the area include: alley farming, shelter belts, wind breaks, retaining tree on farm land, taungwa system, home garden, aqua-forestry, api-silviculture, silvo-pasture, farmed parkland etc.

Profitability Analysis of Agroforestry Production Technology per Cycle

Table 5 presents the results of the profitability of agroforestry production technology per cycle in the study area. The results show that the cost of seed inputs incurred by the agroforestry farmers is ₦25,500.00 carrying 10.49% of the total cost of production, the cost of fertilizer incurred was ₦51,000 and it carries 22.78% proportion of the total cost, while about 13% was incurred as the cost of purchasing chemical inputs. The total cost of labour incurred by the agroforestry farmers was ₦90,301.06 which carries 40.33% of the total cost, this carries the highest share of the total cost involved in the agroforestry production among the smallholder farmers in the study area. The total variable cost incurred by the agroforestry farmers was ₦193, 902.07 which is 86.6% of the total cost. The total fixed cost which comprises of depreciation on farm tools and rent on land was ₦30,221.62 which carries 13.49% of the total cost of production. The total revenue realized was ₦875,645.47, while the total cost of production incurred was ₦223, 888.13. The gross margin obtained was ₦651,757.34 which indicated that agroforestry farming was profitable among the smallholder farmers in the study area. The gross margin ratio obtained was 0.744, this implies that for every one (1) Naira invested in agroforestry production per hectare, 744 kobo covered interest, profits, taxes, depreciation, and expenses, while the net income was ₦624,771.78 with operation ratio of 0.221 implying that agroforestry is a profitable venture. Lower operating ratio is much preferable, the operating ratio of 0.221 signifies that the smallholder agroforestry farmers were cost effective in their handlings. This implied that

Table 1. Socio-Economic Profiles of Smallholder Agroforestry Farmers

Variables	Frequency	Percentage	Mean
Sex			
Male	102	85.00	
Female	18	15.00	
Marital Status			
Single	47	39.16	
Divorced	21	17.50	
Married	52	43.33	
Age (Years)			
31 – 40	18	15.00	
41 – 50	87	72.50	**45.0**
51 – 60	15	12.50	
Level of Education			
Non-Formal	18	15.00	
Tertiary	17	14.17	
Secondary	43	35.83	
Primary	42	35.00	
Household Size (Units)			
1 – 5	37	30.83	
6 – 10	78	65.00	**6.0**
11 – 15	05	04.17	
Farming Experience (Years)			
1 – 5	49	40.84	
6 – 10	41	34.16	**8.10**
11 – 15	21	17.50	
16 – 20	09	07.50	
Extension Contact			
Yes	88	73.33	
No	32	26.67	
Memberships of Cooperative			
Yes	86	71.66	
No	34	28.34	
Farm Size (Hectares)			
Less than 1.0	67	55.83	
i.1 - 2.0	28	23.33	**1.25**
2.1 – 3.0	15	12.50	
3.1 – 4.0	10	08.34	
Total	**120.00**	**100.00**	

Source: Field Survey (2022)

22.1% of returns from agroforestry production produce was used to cover cost of output sold and other operating expenses. This is in line with Alabi *et al.* (2023)

Table 5: Profitability Analysis of Agroforestry Production Technology per Cycle

Factors Influencing Technical Efficiency of Agroforestry Production Technology

Table 6 presents the results of the stochastic production frontier estimated through maximum likelihood method of estimation. The first stage of the stochastic frontier analysis show all the variables included in the model were statistically significant, the significant variables were: seed input, farm size, fertilizer input, labour input, and chemical input The coefficient of seed input influence the total output of the agroforestry production positively and it was significant at (P<0.05) probability level. The magnitude of the coefficient of seed input (0.3089) implies that percentage change in the seed input as a result of more usage will results in 30.9% increase in the total output of agroforestry production. This is in line with Idumah *et al*. (2015) who reported that seed contribute to the increase in total output which could lead to increase in the income of agroforestry farmers. Farm size influence the total output of agroforestry positively and it was statistically significant at (P<0.01). The elasticity of farm size 0.6701 implies that percentage change in the farm size will lead to 67.01 % increase in the total output of agroforestry production in the study area. This conforms with the findings of Amaza and Olayemi (2000) who reported that increase in farm output in

Table 2. Types of Trees under Agroforestry System in the Study Area

Trees under Agroforestry System	*Frequency	Percentage
Parkia biglobosa	49	07.19
Tamarindus indica	37	05.43
Mangifera indica	34	04.99
Azadiracta indica	46	06.75
Moringa oleifera	31	04.55
Adansonia digitata	37	05.43
Vitellaria paradoxa	43	06.31
Acacia Senegal	38	05.58
Jatropha curcas	46	06.75
Eucalyptus camadulensis	49	07.19
Tectonia grandis	29	04.25
Gwelina arborea	21	03.08
Cocus nucifera	42	06.16
Carica papaya	48	07.04
Musa species	49	07.19
Phoenix dactylifera	34	04.99
Terminalia ivorensis	27	03.96
Khaya ivorensis	21	03.08
Total	***681**	**100.00**

Source: Field Survey (2022) *Multiple Choices

Table 3. Types of Crops Grown as Sole or Mixtures in Agroforestry System

Types of Crops Grown in Agroforestry	*Frequency	Percentage
Okra	28	05.35
Pepper	34	06.50
Maize	58	11.08
Millet	39	07.45
Sorghum	48	09.17
Rice	56	10.70
Yam	51	09.75
Cassava	48	09.17
Onion	39	07.45
Tomatoes	38	07.26
Ginger	41	07.83
Vegetables	43	08.22
Total	***523**	**100.00**

Source: Field Survey (2022) *Multiple Choices

Table 4. Types of Livestock Reared in Agroforestry System

Livestock Reared in Agroforestry	*Frequency	Percentage
Cattle	57	19.06
Sheep	47	15.71
Goats	48	16.05
Poultry	52	17.39
Fish	48	16.05
Rabbits	47	15.71
Total	*** 299**	**100.00**

Source: Field Survey (2022) *Multiple Choices

the developing world is usually a function of farm size. Fertilizer input had a positive influence on the total output of agroforestry production, it was statistically significant at (P<0.10). The coefficient of the fertilizer input was 0.09120, this signifies that percentage change in the quantity of fertilizer applied as a result of more usage will result in 9.1% increase in the output of agroforestry production in the study area. Labour input and chemical input influence agroforestry production positively and were significant at (P<0.10) probability level respectively. The coefficient of labour and chemical input were 0.2321 and 2302 respectively, which implies that a percentage change in these inputs will results in the increase in the total output of agroforestry by 23.2% respectively in

Table 5. Profitability Analysis of Agroforestry Production Technology per Cycle

Items	Amount (Naira)	% of Total Cost
Total Revenue	**875,645.47**	
Gross Income	**875,645.47**	
Variable Cost		
Seed Input	23,500.00	10.49
Fertilizer Input	51,000.00	22.78
Insecticides	15,650.56	06.99
Herbicides	13,450.45	06.01
Labour Cost:		
(i) Land Clearing and Preparation		
(ii) Planting	11,650.56	
(iii) Weeding	23,800.00	
(iv) Fertilizer Application	7,500.00	
(v) Chemical Application	15,000.00	
(vi) Harvesting	24,600.00	
(vii) Transportation	5,400.50	
(viii) Loading and Offloading	2,350.00	
Total Labour Cost	90,301.06	40.33
Total Variable Cost	193,902.07	**86.61**
Fixed Cost		
Estimated Depreciation Value on Tools (Hoes, Machetes)	3,235.56	1.45
Rent on Land	26,750.50	11.95
Total Fixed Cost	30,221.62	**13.49**
Total Cost	223,888.13	**100.00**
Gross Margin	651,757.34	
Gross Margin Ratio (GMR)	0.744	
Net Farm Income (NFI)	624,771.28	
Operating Ratio (OR)	0.221	

Source: Field Survey (2022) USD = 760 Naira

the study area. This is in line with the findings of Yusuf and Abdulrahman (2018) who reported that labour is an important variable in agricultural production and also reported that agrochemical was positive and statistically different from zero. This implies that an increase in agrochemical to a certain level will decrease technical inefficiency because it reduces drudgery and controls weeds. The return to scale of the agroforestry farmers is 1.3236 which indicates increasing return to scale this implies that as the use of input increases, it will result in more than proportionate increase in the total output of the agroforestry farmers.

Socio-Economic Factors Influencing Technical Inefficiency of Agroforestry Production Technology

The technical inefficiency component revealed that the socio-economic factors influencing technical inefficiency were: gender, age, education level, experience in agroforestry, and size of household (Table 6). The negative sign of the coefficients implies decrease in technical inefficiency but increases technical efficiency, while the positive sign signifies increase in technical inefficiency and decrease in technical inefficiency in agroforestry production in the study area. Gender of smallholder agroforestry farmers influence technical inefficiency in agroforestry production negatively, the gender was measured as dummy such as 1, male, 0 otherwise, the coefficient of gender is -0.1714 and was statistically significant at (P<0.10), this implies that a unit change in gender being a male will result in the decrease in technical inefficiency or increase in technical efficiency in agroforestry production by 17.1% among the smallholder farmers, if a farmer is male will lead to increase in technical efficiency because male farmers are more energetic to carry out some task than their female counterpart would not be able to do. Marital status of smallholder farmer was significant at (P<0.01), the magnitude of the coefficient of marital status is -0.0365 which implies that a unit change in the marital status will result in 3.7% increase in the technical efficiency or decrease in technical inefficiency among smallholder agroforestry farmers in the study area. Education level of smallholder agroforestry farmer influence technical inefficiency negatively and it was statistically significant at (P<0.01). The coefficient of education level 0.2321 implying that a unit change in the education level of agroforestry farmers will result in 23.2% decrease in technical inefficiency among smallholder agroforestry farmers. Farmers with higher education level stand a chance of exploring more information of agroforestry

Table 6. Maximum Likelihood Results of the Stochastic Frontier Production Model

Variables	Parameters	Coefficient	Standard Error	t-Value
Constant	β_0	2.1396***	0.2565	8.34
Seed Input	β_1	0.3089**	0.0933	3.31
Farm Size	β_2	0.6701***	0.1175	5.70
Fertilizer Input	β_3	0.0912*	0.0453	2.02
Labour Input	β_4	0.2321*	0.099	2.34
Chemical Input	β_5	0.2302***	0.0142	16.21
Return to Scale (RTS)		**1.3236**		
Inefficiency Component				
Constant	α_0	2.6436***	0.4509	5.86
Gender	α_1	-0.1714*	0.0760	-2.25
Age	α_2	0.0021	0.0029	0.74
Marital Status	α_3	-0.0365***	0.0090	-4.05
Educational Level	α_4	-0.0231***	0.0062	-3.71
Experience in Agroforestry	α_5	-0.0358***	0.0087	-4.14
Size of Households	α_6	-0.0111*	0.0230	-1.79
Diagnostic Statistics				
Total Variance	σ^2	1.9011***		
Variance Ratio	γ	0.7221		
Log-Likelihood		-307.12		
Likelihood Ratio Test		318.31		

Source: Data Analysis (2022)

*Significant at ., **Significant at .***Significant at .

Table 7. Summary Statistics of Technical Efficiency Scores

Efficiency Score	Frequency	Percentage
0.00 – 0.20	10	08.30
0.21 – 0.40	23	19.20
0.41 – 0.60	50	41.70
0.61 – 0.80	22	18.30
0.81 – 1.00	15	12.50
Mean	40.18	
Standard Deviation	23.50	
Minimum	0.110	
Maximum	0.810	

Source: Field Survey (2022)

Table 8. Principal Component Model of Constraints Encountered by Smallholder Agroforestry Farmers

Constraints	Eigen-Value	Difference	Proportion	Cumulative
Lack of Training and Capacity Building	3.1272	0.2260	0.1702	0.1702
Inadequate Extension Officers	2.9452	0.2087	0.1664	0.3366
Lack of Improved Seeds	2.8325	0.1994	0.1606	0.4972
Lack of Credit Facilities	2.7630	0.1987	0.1534	0.6506
Lack of Fertilizers	2.6601	0.1885	0.1392	0.7898
Lack of Agroforestry Tree Seedlings	2.5020	0.1806	0.1024	0.8922
Bartlett Test of Sphericity				
Chi Square	721.22***			
KMO	0.7901			
Rho	1.00000			

Source: Field Survey (2022)

and have more ability of adopting innovation and new technologies. This is in conformity with the findings of Ogundari and Ojo (2007) who reported coefficients of educational level to be negative, meaning that this factors increases technical efficiency and decreases technical inefficiency. Experience in agroforestry influence technical inefficiency of agroforestry production negatively and was statistically significant at

(P<0.01) probability level, the coefficient of experience in agroforestry was -0.0358 implying that a unit change in years of experience in agroforestry will lead to 3.6% decrease in the technical inefficiency in agroforestry production, experience could help farmers to acquire more knowledge about agroforestry which would lead to increase in the technical efficiency in agroforestry production. This is in conformity with the Nwahia *et al*. (2020) who reported that farmers with more experience tends to be technically efficient than those that has less farming experience. Size of households influence technical efficiency in agroforestry production negatively and it was statistically significant at (P<0.10). The coefficient of size of household is -0.011, this signifies that a unit change in the number of size households will results in the decrease in technical inefficiency by 11.1% among agroforestry farmers in the study area. This in line with the finding of Nwahia *et al*. (2020) who reported that farmers with larger family size enhances labour availability as majority of the members were involved in agroforestry activities.

Technical Efficiency Scores of Smallholder Agroforestry Farmers in the Study Area

Table 7 shows the summary statistics of technical efficiency scores of smallholder agroforestry farmers. Majority (60.9%) of agroforestry farmers were between 21 to 60 % efficiency levels, this implies that most farmers were average technically efficient. The mean technical efficiency was 40.18 % leaving a gap of 59.82 % for improvement. This is in line with Yusuf and Abdulrahman (2018) who reported 61% average technical efficiency among farmers in Kogi State, Nigeria. In addition, the least technical efficiency score was 11.0 %, while the best performing smallholder agroforestry farms had the maximum technical efficiency of 81.0%. If the average smallholder agroforestry farmers were to achieve the level of technical efficiency like most of its efficient counterparts, then the average smallholder agroforestry farmers could make 50.39 % cost savings calculated as . The calculated value for the most technically inefficient smallholder agroforestry farmers reveal a cost savings of 86.42 % calculated as . This is contrary with the findings of Ogundari and Ojo (2007) who found an average technical efficiency of 81% among agroforestry farmers in South-Western Nigeria.

Constraints Encountered by the Smallholder Agroforestry Farmers in the Study Area

Table 8 presented the results of the Principal component analysis to identify the constraints encountered by agroforestry farmers in the study area, the Principal component analysis (PCA) is one of the important statistical tools which is likely related with the principles of factor analysis procedure which has the ability to transform the variables that interrelated in survey data that comprises of so many variables into nearest minimum or few number of variables that are uncorrelated. The output result of the number of principal components retained using the Kaiser Meyer criterion were six (6) based on the Eigen values that are greater than 1. The components that were retained explained about (0.8922) 89.22% of the variation in the component included in the model. The Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) for cowpea farmers were 0.7901 and the Bartlett test of Sphericity of 721.22 and was statistically significant at 1 % probability level this justified the subjection of the data set for principal component analysis. Lack of training and capacity building had an Eigen value of 3.272 and it was ranked 1st in the order of importance based on perception of the agroforestry farmers while inadequate extension officers, lack of improved seeds had an Eigen values of 2.9452 and 2.8325 respectively was ranked 2nd, 3rd respectively, while lack of credit facilities and lack of fertilizers with Eigen values of 2.7630 and 2.6601 respectively were ranked 4th and 5th respectively also in the order of its occurrence measured based on the perceptions of the agroforestry farmers. This result is in line with the findings of Alabi, *et al.* (2020) who use similar approach to identify the constraints encountered by farmers in crop production. The results are also consistent with Cooker *et al.* (2018)

Conclusion and Recommendations

Based on the findings emanating from this research work concluded that agroforestry farmers were young, active, resourceful, and energetic. The agroforestry systems practiced in the area include: alley farming, retaining tree on farm land, shelter belt, wind break, home gardens, api-silviculture, aqua-culture, silvo-pastures, farmed parkland, and taungya system etc. Agroforestry systems was profitable and worthwhile. The significant factors influencing output of agroforestry production were: seed input (P<0.01), farm size input (P<0.01), fertilizer input (P<0.05), labour input (P<0.05), and chemical input (P<0.01). The significant factors influencing technical inefficiency of agroforestry production technology were: gender (P<0.05), marital status (P<0.01), education level (P<0.01), experience in agroforestry production (P<0.01) and size of households (P<0.10). The average technical efficiency score obtained by the smallholder agroforestry farmers was 40.18%. The constraints facing agroforestry farmers include: lack of training and capacity buildings inadequate extension officers, lack of improved seeds, lack of credit facilities, lack of fertilizers, and lack of agroforestry tree seedlings. Based on the findings the following recommendations were made:

(i) Agroforestry tree seedlings should be made available free to smallholder farmers

(ii) Credit facilities should be provided for smallholder farmers to access new production technologies

(iii) Improved seeds and fertilizers should be made available for smallholder farmers for increased productivity.

(iv) Extension officers should be employed to disseminate research findings and new agroforestry production technology to smallholder farmers

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

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