ACADEMIC REVIEW OF HUMANITIES AND SOCIAL SCIENCES
Vol.: 7 Issue: 1 Year: 2024, pp. 39-59

ARHUSS
ISSN: 2636-7645

EFFECTS OF INPUT INTENSIFICATION AND COST EFFICIENCY ON THE PRODUCTIVITY OF IRRIGATED TOMATO FARMERS IN KADUNA STATE, NIGERIA

Bentley Shalom BAGYA[1]
Yusuf Usman OLADIMEJI[2]
Aderonke Bashirat MOHAMMED[3]
Aisha Simbiat HUSSAINI[2]
Hannatu Ayidejile USMAN[2]
Fatima YISA[2]

Received Date (Başvuru Tarihi): 29/08/2023
Accepted Date (Kabul Tarihi): 27/06/2024
Published Date (Yayın Tarihi): 30/06/2024

ABSTRACT

Keywords

Agriculture, Input intensification, Cost efficiency, Profitability, Irrigation, tomato, Tobit regression

An ergonomics is a diverse range of production-limiting variables ranging from biophysical to agronomic restrictions, socioeconomic and institutional barriers which constrained tomato production. Adoption of contemporary agricultural methods is required for optimal productivity under such limits. This study aims to analyze the effect of input intensification and cost efficiency on the productivity of irrigated tomato farmers in Nigeria. The study used a cross sectional data of 268 irrigated tomato farmers for 2021 cropping season. Net farm income (NFI) and regression models were used to analyze the data. The result established that with the NFI of ₦401,331 ($994.43USD) and net return (1.91), tomato production is profitable. The result of OLS regression showed that normalized input intensification (-0.226) was significant at 1% probability level. The Tobit regression model results, showed that the intensity of input use was significantly influenced by the socioeconomic and institutional variables while the estimated SFC function showed that cost of inputs and transportation were statistically significant. Therefore, input intensification package adopted by farmers requires modification through training by extension agents to enhance tomato productivity in Nigeria.

EFFECTS OF INPUT INTENSIFICATION AND COST EFFICIENCY ON THE PRODUCTIVITY OF IRRIGATED TOMATO FARMERS IN KADUNA STATE, NIGERIA

ÖZ

Anahtar Kelimeler

Agriculture, Input intensification, Cost efficiency, Profitability, Irrigation, tomato, Tobit regression

An ergonomics is a diverse range of production-limiting variables ranging from biophysical to agronomic restrictions, socioeconomic and institutional barriers which constrained tomato production. Adoption of contemporary agricultural methods is required for optimal productivity under such limits. This study aims to analyze the effect of input intensification and cost efficiency on the productivity of irrigated tomato farmers in Nigeria. The study used a cross sectional data of 268 irrigated tomato farmers for 2021 cropping season. Net farm income (NFI), and regression models were used to analyze the data. The result established that with the NFI of ₦401,331 ($994.43USD) and net return (1.91), tomato production is profitable. The result of OLS regression showed that normalized input intensification (-0.226) was significant at 1% probability level. The Tobit regression model results, showed that the intensity of input use was significantly influenced by the socioeconomic and institutional variables while the estimated SFC function showed that cost of inputs and transportation were statistically significant. Therefore, input intensification package adopted by farmers requires modification through training by extension agents to enhance tomato productivity in Nigeria.

Citation: Bagya, B. S., Oladimeji, Y. U., Mohammed, A. B., Hussaini A.S. , Usman, H. A., .and Yisa F., (2024), Effects of Input Intensıfıcatıon and Cost Effıcıency on the Productıvıty of Irrıgated Tomato Farmers in Kaduna State, Nıgerıa, ARHUSS, (2024), 7(1): 39-59.

[1] MSc Graduate, Department of Agricultural Economics, Ahmadu Bello University, Nigeria, bentleyshalom@gmail.com
[2] Institute for Agricultural Research, Department of Agricultural Economics, Ahmadu Bello University, Nigeria, yusuf.dimeji@yahoo.com, huseesha@gmail.com, hannieusman@gmail.com and fatima_yisa@yahoo.com
[3] Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Nigeria. bashrajxp25@gmail.com

1. INTRODUCTION

Nigeria's agricultural sector faces many challenges like many other developing countries, which impact on its productivity. These include low technology (Udemezue, 2019; Melesse 2018), high production cost (Kiet et al., 2020), and poor distribution of inputs (Ayanlere et al., 2018; Zondo, 2020), low adoption of improved inputs as a complete package (Koussoub´e and Nauges, 2017; Alia, 2017; Danso-Abbeam et al., 2017), and cost inefficiency (Degefa et al., 2020). Others are poor land tenure system (Anang et al., 2021), low level of irrigation farming (Oladimeji and Abdulsalam, 2014; Jahangirpour and Zibaei, 2022), climate change (Ali, and Erenstein, 2017; Bamiro, Adeyonu, Ajiboye, and Solaja, 2020), and land degradation (Jenkwe, and Chup, 2016; Oladimeji et al., 2020; Mwaura, 2021). Chronic food insecurity and poverty are the result of inadequate agricultural output. (Diao et al., 2010, Matemilola and Elegbede 2017; Al-Mustapha and Ashiru, 2021). Numerous rural households, particularly tomato farmers mainly rely on farming for both sustenance and income, are severely impacted.

The edible fruits of tomato (Solanum lycopersicum) are highly cultivated due to it being a flowering plant belonging to the Solanaceae family, commonly known as the nightshade family.

It is classified as a vegetable for nutritional purposes, and it is high in vitamin C and the It is phytochemical lycopene (www.britainica.com, 2021). According to FAOSTAT (2020), Europe has more than 400 tonnes of tomatoes are produced each hectare, 10 times the global average. The yields are specifically 507.04 tonnes in the Netherlands, 506.90 tonne in Belgium, and the 416.19 tonne/ha, in United Kingdom. In contrast, many African nations, like Nigeria (3.91 tonnes/ha), Angola (2.70 tonnes/ha), and Somalia (1.44 tonnes/ha), have low tomato yields. According to FAO statistics (2020), Nigeria is the world's 14th largest tomato producer and second in Africa, but it is the world's 13th largest importer of tomato paste and third in Africa. In 2020, Nigeria produced 2.3 million metric tonnes of tomato, up from 1.8 million metric tonnes in 2018 (FAOSTAT, 2020). The national demand is about 3 million metric tonnes per annum and the most recent production capacity of 2.3 million metric tonnes is a 27.8% increase over the corresponding value recorded in 2018 (FAOSTAT, 2020).

A vast range of production-constraints factors exist, ranging from socioeconomic, biophysical, agronomic, and institutional barrier constrain tomato production (Diagne et al., 2013). It is pertinent to note that Under such limits, optimal production necessitates the adoption of current agricultural technology such includes improved methods for managing soil and water, fertilizer, herbicides, insecticides, and hybrid seedlings(Evenson and Gollin, 2003). In light of the green revolution realized by developed countries and the current food security crisis in Africa, input intensification that is sustainable therefore becomes imperative as a means of increasing crop productivity as well as ensuring food sufficiency. Given the limited alternatives for land development currently accessible due to population growth, this is particularly pertinent today. (Muyanga and Jayne, 2014; McDonald, Mansur, Ascensao, and Colbert 2020), soil depletion (Marenya and Barrett, 2009, Oyinbo et al., 2019), and climate change's negative impact(Oladimeji et al., 2020; Hassan, 2020).

The role of input intensification in increasing crop productivity has been increasingly recognized by researchers (Levine and Mason 2014; Alia 2017; Abay et al., 2018); policy makers and development partners (Gollin, Parente and Rogerson, 2002; Yami and Asten, 2017) Since the 2000s, significant utilization of new agricultural inputs has advanced, and agricultural efficiency has increased. (Brooks et al., 2009; Xie, Chen, Huang, Zhang, and Wu, 2019). However, the yield increase rate is far lower than expected. in most developing countries. Intensification of input-use as a means of increasing crop productivity has a consequential effect on the overall cost of production. Since a farmer has profit maximization while producing at the least cost as his major objective, the need for the farmer to be cost efficient cannot be overemphasized. The question of how efficient farmers use their farm inputs is of considerable interest to agricultural economists.

Agriculture policy has always acknowledged and incorporated the relevance of agricultural input intensification in Nigeria. In recent times, successive governments designed and implemented several input subsidies programs such as Anchor Borrowers Program in 2015 and Presidential Fertilizer Initiative in 2016, with the objective facilitating access to crucial agricultural inputs for smallholder farmers, increasing output, and increase food security and reduce the poverty status (Nasiru, 2022). Crop yields have grown modestly, however, still at prices well below what may be regarded as a green rate revolution. (FAOSTAT, 2017). This calls into doubt efficacy present approaches to input intensification as a means to improving agricultural productivity and economic development.

An overview on use of contemporary agricultural inputs in Africa by Sheahan and Barrett (2017), demonstrates that adoption and utilization is low with farmers using only inputs and no other complimentary innovations. Many farmers, for example, employ inorganic fertilizer on their farms but do not use improved seeds varieties. low fertilizer utilization frequently results in a minor improvement in output that maybe insufficient to offset the cost of purchasing fertilizer. Most improved seeds have a high yield potential and have been breed to be more susceptible to mineral fertilizer than traditional seedlings. Past and recent studies: Kebedom and Ayalew, 2012; Gebregziabher, 2014; Burke, Jayne and Black 2017; Ayanlere et al., 2018; and Mwaura, 2021, have also demonstrated that inorganic fertilizer must be supplemented with various organic mineral nutrients, particularly on acidic or non-acidic soil, in order to be effective. In Kenya, Matsumoto and Yamano (2011), posited numerous farmers are currently utilizing nitrogen agronomically rate, further gains in production come with usage of new technology. Moreover, unwanted grasses, and pests can cause severe crop damage if plants are not protected during their vegetative period (Diagne et al., 2013; Kaminski and Christiaensen, 2014). As a result, the primary advantage from solely using mineral fertilizer may never materialize, prohibiting adoption next seasons. Arguably, it is possible that the partial adoption of input technologies might be as a result of farmer's inefficient allocation and utilization of resources necessitated by high input cost.

In view of the above and the observed deficit in tomato output per ha in Nigeria compared to some Asian countries, intensification and efficient allocation and utilization of input is no longer debatable. Increasing production capacity increases productivity, help in bridging the gap between supply and demand as well as increase farmers' income and reduce poverty. Empirical studies by Akinola et al. (2010), Owoeye (2017), and Degefa et al. (2020), only examined input intensification as a single input adoption and not as a complete package adoption. This study tends to examine the effect of input intensification as a complete package on productivity and cost efficiency level of tomato farmers in Kaduna State, Nigeria. The specific objectives were to determine the profitability and effect of input intensification on tomato productivity and, estimate the cost efficiency level of tomato farmers.

2. RESEARCH METHODOLOGY

2.1 The study area

The research was carried out in Kaduna State, Nigeria. It occupies an area about of 46,053 square kilometres, with a projected population of 10,119,645 in 2022 with 3.2 percent yearly growth rate (NPC, 2006; NBS, 2021).Kaduna state is within the derived savannah zone of Nigeria (Adedibu, Opeyemi, Lawrence, Paul and Oguntoye, 2022). The weather is characterized by dry and wet seasons (Abaje, Achiebo and Matazu, 2018). Rainfall is between 1837 and 3236 mm (Yunusa et al., 2017). The State has a mean annual temperature of 25.2 °C, April being the warmest month about 28.6 °C (KADA 2021). The vegetation is of the Sudan Savannah type, with scattered small trees, shrubs, and grasses. (Adedibu, et al., 2022).The soil is pred). Thently loamy to sandy, with some clay thrown in for good measure which is suitable for tomato production (Jimoh, Mbaya, Akande, Agaku and Haruna, 2020). About 80 percent of the population in Kaduna state takes farming as their main occupation (KADP, 2014).

2.2 Data collection and sampling procedure

Data required for this study was obtained from primary sources in 2021 tomato cropping season.

A systematic questionnaire was utilized to obtain quantitative input-output data as well as prices for input and output variables from the respondents. Data from secondary sources such as journals, statistical reports of Food and Agriculture Organization (FAO) and National Bureau of Statistics was use to review relevant literature.

To collect data for this investigation, a multistage sampling procedure was used. The first stage entailed the deliberate selection of the Maigana zone from among the four zones in the state due to the intensity of tomato production in the zone. The second stage consists of a random pick of four of the eight LGAs in Maigana zone namely Ikara, Kudan, Makarfi and Soba. Thereafter, 10 percent of villages was randomly selected from each of the chosen LGAs. This translates into 4, 3, 3 and 4 villages for Ikara, Kudan, Makarfi and Soba respectively. The list of farmers in each village was collected with assistance of ADP staff through the village head. The last stage involved random selection of the 33% of sample frame from each village as sample size using Yamane's formula. Therefore, a total of two hundred and sixty-eight (268) tomato farmers out of eight hundred and twelve (812) was randomly selected for the study, using the same random number table system for selecting villages.

2.3 Analytical Techniques

Descriptive statistics including frequency, mean and percentage, and net income were used to estimate profitability of tomato production. Net farm income was calculated as total revenue minus total production expenditures. (Husna & Desiyanti, 2016).

$$\pi = TR - TC \qquad (1)$$

Where, TR is for Total Revenue, TC stands for Total Costs of Production, and is the net profit. The capital recovery factor (CRF) was used to disperse the initial cost of investment (capital cost) across the useful life of tomato production projects.

Ordinary Least Regression (OLS) regression was used to determine the effect of input intensification on tomato productivity. Input intensification was determined by estimating the index number of the modern technologies adopted by tomato farmers in the 2021 cropping season. The intensity index allows us to examine the simultaneous adoption of many inputs and the effect on crop yield. It is obtained by normalizing the quantity of each of the modern technologies adopted by the ith farmer by the agronomic recommended rate of each of the technologies. That is:

$$Aii = \frac{{q_i}^{obs}}{{q_i}^{max}} \qquad (2)$$

Where Aii is the normalized input intensification, qiobs is the observed input application rate and qimax is the application rate that would produce the highest level of output It is normalized to have the lowest value of one and corresponds to to qi = 0, ∀ i = 1..n and its highest value possible is 2n when qi = 1, ∀ i = 1..n.. OLS were used to estimate the change in yield caused by a modifications in intensity rate in the presence of a set of other factors influencing yield. OLS regression was estimated with tomato yield at the plot level as the dependent variable and A_{ii} as the treatment variable. Unobserved heterogeneity was controlled with the correlated random effects (CRE) approach. Finally, instrumental variable (IV) with control function was combined with the CRE method to estimate the causal effect of A_{ii}on tomato yield per ha. Following previous studies: Akinola et al. (2010), Owoeye (2017), Mutayoba and Ngaruko (2018), variables such assuch as market distance, membership in farmer organizations, and credit availability were used as instruments.

The explicit form of the model is specified as;

$$Y_t = \beta_0 + \beta_1 A_{ii} + \beta_2 X_1 + \beta_3 X_2 + \beta_4 X_3 + U_i \quad (3)$$

Where; Yt = tomato yield (kg/ha), A_{ii}= normalized input intensification, X1 = distance to input market (km), X2 = membership of farmer organization, X3 = access to credit (₦), β0 = constant term and β1 - β4 = parameters to be estimated and Ui = error term

Tobin (1958) developed a censored Tobit model that was used to evaluate the parameters influencing the intensity of modern input utilization. The Tobit model is appropriate for this study since the response variable is censored above zero while the independent variables are observed entirely.The model is specified explicitly below:

$$Z_{ik} = \alpha_0 + \alpha_1 W_1 + \alpha_2 W_2 + \alpha_3 W_3 + \alpha_4 W_4 + \alpha_5 W_5 + \alpha_6 W_6 + \alpha_7 W_7 + \varepsilon_i \quad (4)$$

Where; Z_{ik} = intensity of input use (normalized input intensification), W1 = age (years),

W2 = farm size (ha), W3 = years of education (years), W4 = extension contact (number of contact), W5 = access to credit (₦), W6 = farming experience (years), W7 = membership of association (years), α0 = constant term, and α1- α7 = parameters to be estimated and ε_i = error term.

Cobb-Douglas functional form of the cost frontier function through a single step procedure was used to estimate tomato farmers' cost efficiency level; The following functionality is specified for tomato farms:

$$lnC = \beta_0 + \beta_1 lnP_1 + \beta_2 lnP_2 + \beta_3 lnP_3 + \beta_4 lnP_4 + \beta_5 lnP_5 + \beta_6 lnP_6 + (V_i - U_i)(5)$$

Where; Ci = entire cost of production in naira (₦/ha), P1 =the cost of labour (₦/ha), P2 fertilizer price (₦/ha), P3 = seed price(₦/ha), P4 = agrochemical price (₦/ha), P5 = annual depreciation cost of farm tools.

The inefficiency model (Ui) is defined by:

$$U = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \quad (6)$$

Where; Z1 = age (years), Z2 = farm size (ha), Z3 = household size (actual number), Z4 = years of education (years), Z5 = access to credit (₦), Z6 = distance to input market (km), Z7 = farming experience (years), δ0 = constant term, δ1 - δ7 = parameters to be estimated. Using the program FRONTIER version 4.1c (Coelli, 1996), the estimate for all parameters of the stochastic frontier cost function and the inefficiency model is computed concurrently.

3. RESULTS AND DISCUSSION

3.1 Summary statistics of variables used for OLS and Tobit models

The results in Table 1 summarizes the descriptive statistics of socio-economic and institutional characteristics used in operationalized OLS and Tobit regression models. The mean age was 40 years shows that household heads are within the economically active population and therefore constitute a good labour force for tomato farming in the study area, likely to be able to make rational decisions that will affect productivity and food security positively. The average household size was 10 persons per households, and this may enhance labour availability that can be used for different farm activities, thus increase yield and enhancing food security. The mean experience of the tomato farmers of 16 years indicates that farmers has establish mastery in the effective use of resources. On average, 1.18 hectares were used by the farmers for tomato production. This imply that the tomato producers in the studied area were small scale farmers. Membership of association and number of extensions contact per season had a mean of 2.5 years and less than one contact per season and these implies that tomato farmers relied exclusively on their experiences on agronomic practices and probably lacking in important information needed to adopt input intensification increase their production and may not be able to access credit. The findings of this study are comparable to study of Gebremariam and Tesfaye (2018), who found majority (60%) of the farmers not to have any contact with extension agent. Also, the result contrasts with Adeola (2010), who found that majority (82.5%) of the farmers had at least one contact with extension officer.

Table 1: Socioeconomic and institutional characteristics of tomato farmers

Variables	Mean	Std. dev	Min.	Max.
Age of household heads (years)	40	0.68	18	70
Farm experience (years)	16	8.87	0	45
Household size (number)	10	0.38	0	30
Level of formal education (years)	2.22	1.29	0	4
Amount of credit accessed ('000N)	26.34 ($65.27)	74.87	0	500 ($1,238.91)
Cooperative membership (years)	2.50	0.25	0	20

Extension contacts (number)	0.89	0.11	0	12
Total farm size (ha)	1.18	0.97	0.2	5

3.2 Profitability analysis of tomato production

The profitability analysis of tomato farming enterprise is presented in Table 2.

Table 2: Profitability analysis of tomato production per hectare

	Qty.	Price (₦)	Values (₦)	Values ($)	% TVC	%TC
Total Revenue (kg)	3600	185	660000	1635.36		
Variable cost parameters						
Labour (man-day)	44.16	1494.57	66000	163.54	29.10	26.18
Seed (grams)	8	6000	48000	118.94	21.16	19.04
Fertilizer (kg)	150	240	36000	89.20	15.87	14.28
Agrochemicals (liter)	7.296	1500	10944	27.12	4.82	4.34
organic manure (m)	76	500	38,000	94.16	16.75	15.08
Transportation (₦)			20400	50.55	8.99	8.09
Irrigation	25	300	7500	18.58	3.31	2.98
Total variable cost			226844	562.08	100.0	89.99
Fixed cost parameters						
Rent on land			15218	37.71		6.04
Depreciation			10000	24.78		3.97
Total fixed cost			25218	62.49		10.01
Total cost			251429	623.00		100.0
Profit parameters						
Gross income (₦/ha)			660000	1635.36		
Gross margin			433156	1073.28		
Return on investment			1.91			
Net farm income			408571	1012.37		

The study reveals that 89.99 percent of the total cost (TC) of production was incurred on the variable inputs for tomato farming enterprise while the total fixed cost (TFC) incurred was only 10.01 percent. These results confirmed with the findings of Oladimeji et al. (2019), that fixed cost of production is usually small in subsistence agricultural system. Results also shows a net farm income of ₦401,331 ($994.43USD) per hectare. The budgetary analysis is an indication that tomato farming is profitable in the study area. The ROI is 1.91, which implies that for every ₦1.00 invested in tomato farming, there was 91 kobo return to profit.

3.3 Effect of input intensification on tomato productivity

OLS regression results model that shows the effect of input intensification on tomato productivity is presented in Table 3. The F value (4.74) with the probability value (0.00) was statistically significant at the 1% level. These implies that the model is fit for the data analyse. The R- square (0.8436) is an indication that 84% of the variation that existence in the regressor variable (tomato yield) is explain by the independent variables under consideration whereas 16% has been accounted for by other variables not considered within the model. The result of the OLS regression shows that the coefficient of normalized input intensification (-0.226) is statistically significant at 1% level of probability and is negatively inelastic. This means that every unit increase in input intensification results in a 0.23 loss in tomato yield. Negative coefficient of normalize input intensification corroborates the impression on use of modern agricultural inputs in Africa by Sheahan and Barrett (2017), that the adoption of intensification of input is insufficient and inadequate, with farmers applying only one or two inputs and not utilizing other complimentary technologies. This shows that lack of extension service or contact with extension agent may cause a gap in information to the farmers on standard input package required by tomato farmers. This result is in contrast with the study conducted by Alia (2017), whose findings shows that input intensification (2.21) is positive and is at the significant at 5% level of probability in Tanzania and Burkina Faso. The result is in contrast with the findings of Tasila et al. (2019), which shows a positive affiliation between improved groundnut planting materials and productivity in northern Ghana.

Table 3: Effect of input intensification on tomato yield in Kaduna State, Nigeria

Variable	Coefficient	standard error	t- value
Normalized input intensification	-0.226***	0.009	-25.11
Farming experience (years)	0.045	0.080	0.56
Distance to input market (km)	0.002	0.060	0.03
Quantity of fuel used (litres)	0.169**	0.077	2.19
Number of extensions contact	-0.055	0.055	-1.01
Cooperative membership (years)	0.159***	0.056	2.84

Amount of credit (₦)	-0.023	0.014	-1.64
Constant	0.616	0.565	1.09
Prob > F	0.0000		
Adjusted R- square	0.8907		

***, & **significance level at 1, & 5 %, respectively.

The result further revealed that the coefficient of quantity of fuel used (0.169) for irrigation is statistically significant at 5% level of probability and positively influence tomato productivity. This suggests that a unit rise in the quantity of fuel will cause an increase in tomato yield by 0.169 units. This is because fuel is a very essential input in irrigation farming. The variable quantity of fuel used is an instrumental variable in which it does not influence the dependent variable directly but indirectly. This study is comparable with findings of Yenihebet, Issac, and Ahiale, (2019), which shows that, fuel quantity positively influenced tomato productivity at 5% significant level.

The result also indicated that membership of farmers is very paramount in accessing inputs. The coefficient of years of membership in a cooperative or farmers' association (0.159) is positive and statistically significant at the 1% level of probability as factor affecting tomato yield. These implies that a rise in the number of years per unit of membership of a farmer in an association will allow access to inputs faster than the ones that are not in any association or cooperatives, and these will lead to an increase in tomato yield by 0.159 units. This study's findings are equivalent to those of Teklewold et al. (2018).

3.4 The factors that influence the intensity of input use in tomato production

The result of the Tobit regression model that estimate factors that influence intensity of input use in tomato production is presented in Table 4. The result shows that the probability greater than Chi square was statistically significant at a 1% probability level. It shows robustness and goodness of fit of the models. In other words, the effects of the explanatory variables on the likelihood of using current inputs differ substantially by the respective modern input type.

From the result, the marginal effect of age (-0.079) was statistically significant at a 5% level of probability which imply that age of farmers is a major factor that influence the intensity of input use in this study. This may be because of the synergistic advantage of the younger over the older farmers. As tomato farmers advanced in age there's a negative correlation in the use of inputs. These also reveal that as the farmers advance in age there is tendency of them growing weak and use of agricultural inputs becomes more difficult to handle. The result is consistent with the empirical studies of Kassie et al. (2013), Oloyede et al. (2014), Jenkwe and Chup (2016), Mango et al. (2017), Stein et al. (2018), and Jeetendra et al. (2018) where household head's age was found to significantly influence the likelihood of modern input use. A reduced probability of intensity of input use when age of the farmer increases is also in agreements with the findings of Akinola et al. (2010), Owombo and Idumah (2015), Gebremariam and Tesfaye (2018) that found age to significantly increase the probability of input use.

The result further revealed that farm size (11.256), at a 1% level of probability, was statistically significant. This suggests that an increase in farm size will result in an increase in the intensity of input use by 11.256 units. It shows farm size is directly proportional to input intensification. Farmers with larger plots and greater money, on the other hand, will use more modern inputs and have a higher level of intensification. This result is in line with the findings of Najjuma (2016), that observed the area under cultivation (farm size) had a significant relationship with the intensity of input use. Ibitoye et al. (2015), and Chepngetich and John (2015), reported a relationship a relationsipnder cultivation and intensity used of input. The result further reveals that the marginal effects of fuel quantity (0.030), is statistically significant event at a five percent probability level. Thus, a unit increase in fuel quantity would increase the intensity of input use.

Table 4: Intensity of input use in tomato production in Kaduna State, Nigeria

Variable	Coef.	dy/dx	Std. err.	Z
Age (years)	-0.004	-0.079**	0.002	2.00
Number of extensions contact	0.011	0.661	0.009	1.22
Years of membership	0.001	0.089	0.004	0.27
Amount of credit received	8.63e-08	-4.89e-06	2.19e-07	0.39
Farm size	0.441	11.257***	0.029	15.67
Farming experience (years)	0.002	0.069	0.003	0.67
Distance to input market (km)	0.001	0.262	0.001	1.00
Fuel quantity (litres)	0.0000369	0.030**	0.0000182	2.03

Constant	-0.228	0.059	-3.82
Var(e.AII)	0	0.004841	
LR chi^2	272.90		
Prob > chi^2	0.0000		
Log likelihood	-876.6412		
Pseudo R^2	0.1347		

***, **, * significance level at 1%, 5% and 10% respectively; dy/dx denote marginal effects

3.5 The cost efficiency level of tomato farmers

Table 5 shows the stochastic cost frontier's (SCF) maximum likelihood estimates (MLE)analysis of tomato farmers in Kaduna State, Nigeria. The total sum of input cost coefficients was 0.95 indicating that tomato production experiences a consistent return to scale in the studied area. This suggests that the value of tomato produce double amount if the cost of inputs in the research area rose by specific percentage.

Additionally, the outcome showed a sigma squared (σ2) value of 0.23, which was statistically significant at the 5% level. This indicates that the Cobb-Douglas stochastic frontier cost function model fits perfectly, that composite error term's stipulated distributional assumption is true. According to statistics, the gamma parameter (γ) was 0.99 at the 1% level of probability; as the gamma parameter's value approaches one or equals one, it illustrates the model's applicability and reveals any inefficiencies. This also means that cost-efficiency factors accounted for 99 percent of the variation in tomato yield. Cost inefficiencies existed in the research area, as indicated by the Wald chi-square (272.90) and Log likelihood (-876.64) significant value. Additionally, lambda(λ) had a value of 10.7508 that was significantly different from zero, showing production procedures rather than random fluctuations were to blame for variances between actual and expected tomato yield. Additionally, the likelihood ratio (LR) test, which was 197.07 and higher than the critical Chi square value of 20.972 (provided by Kodde and Palm, 1986), was used to determine the presence of cost inefficiency. As a result, the cost-inefficiency null hypothesis was accepted.

The SCF estimates' findings indicated that the coefficient of labor cost is statistically significant at the one percent level of probability. Hence, if labour increases by one percent, it could increase the total cost by 0.03 percent. It was a noteworthy outcome that the coefficient of labor and cost efficiency had a positive significant relationship. It indicates that cost effectiveness among smallholder farmers in the area as the labor increases. This infers that labour is an important input in tomato production which is labour intensive. Ayerh (2015), Mukhtar et al. (2018), and Ibitoye et al. (2015) all reported similar findings. The coefficients of fertilizer (0.35), and seed (0.08) also has a direct relationship and statisticaly significant at one percent with cost efficiency. This positive effect represents that a raise in these variables will increase total cost of production by their corresponding units. The outcomes supported Shettima et al. (2015) and Nguetti et al. (2018) findings.

From inefficiency variables, educational level and at 5%, access to credit was statistically significant and positively which implies that a percentage increase in both educational level and access to credit will rise the cost of inefficiency by 0.22% and 0.59%. Also, distance to input market (-0.02) is negative indicating that as distance to input market decreases, the cost inefficiency declines by -0.02%.

Table 5: Maximum likelihood estimates of the stochastic cost frontier model

	Coefficient	**standard-error**	**t-ratio**
Constant	1.93***	0.13	14.44
Tomato yield	-0.00	0.00	-0.19
Cost of labour	0.03***	0.0	4.67
Cost of fertilizer	0.35***	0.01	29.61
Cost of seed	0.08***	0.01	9.16
Cost of agrochemicals	0.06***	0.01	7.72
Annual depreciation cost	0.36***	0.01	24.96
Cost of organic manure	-0.00	0.00	-0.83
Cost of transportation	0.07***	0.01	9.28
Cost of fuel	0.00	0.01	0.043
Inefficiency Model			
Constant	-2.79**	1.44	-1.94
Age	-0.00	0.01	-1.21
Farm size	0.47**	0.20	2.32
Household size	-0.02	0.01	-1.60
Educational level	0.22**	0.10	2.14
Access to credit	0.59**	0.29	2.05

Distance to input market	-0.02*	0.01	-1.93
Farming experience	-0.00	0.01	-0.00
sigma-squared	0.23**	0.12	2.17
Gamma	0.99***	0.00	703.63
lambda (λ)	10.7508		
log likelihood function	0.307	41820000	
LR test		197.07	

*, **, *** significant level at 10%, 5%, and 1% respectively

3.6 Cost efficiency distribution

The cost efficiency score ranged from 1.01 to 2.68, the distribution seemed to be skewed towards the frontier as depicts in Table 6. So, the cost efficiency index was more than 1.00 or 100%. The mean efficiency score was 1.11 and this implies that they are 11% inefficient. About 89.93% of the total farm household had scores in between 1.01 to 1.21 and 0.74% in the range of 2.01 to 2.81. A farmer needs a cost savings of 59% (i.e. 1-1.11/2.68) *100 to become the most economically effective producer.

Table 6: Distribution of cost efficiency estimates

Efficiency level	Frequency	Percentage
1.01-1.21	241	89.93
1.21-1.41	19	7.09
1.41-1.61	3	1.12
1.61-1.81	3	1.12
2.01-2.21	1	0.37
2.61-2.81	1	0.37
Total	268	100
Mean efficiency		1.11
Minimum		1.01
Maximum		2.68

4. CONCLUSION AND RECOMMENDATIONS

Knowledge of input intensification and socioeconomic factors and intensity of input use in tomato production, which describing how to combine inputs and save cost is essential for effective agriculture productivity and input market policies. The input index, OLS regression, Tobit regression with stochastic cost function frontier was used the randomly chosen Kaduna tomato farmers State, Nigeria using data of the 2021 tomato production season.

The result established that with the net farm income of ₦401,331 and return on investment (1.91), tomato production is profitable. The result of OLS regression showed that normalized input intensification (-0.226) is statistically ssignificant at 1% level of probability and is negatively inelastic. The input intensification been adopted as a complete package in the study area had negative influence on productivity of tomato. The intensity of input use was significantly influenced by the coefficients of age of household head (-0.079), number of extension contact (0.661), farm size (11.257), and distance to input market (0.262). The coefficients of costs of labour (0.03), fertilizer (0.35), seed (0.08), agrochemicals (0.06), annual depreciation (0.36) and transportation (0.07) were statistically significant and crucial in estimated stochastic frontier cost function. The inefficiency variables that influenced the cost of the tomato farmers include farm size (0.47), educational status (0.22), access to credit (0.59) and distance to input market (-0.02). The study established that input intensification package adopted by tomato farmers requires modification to enhance tomato productivity in Kaduna state, Nigeria. There is urgent need for training of farmers by extension agent particularly on input intensification.

REFFERENCES

Abate, T. M., Dessie, A. B., and Mekie, T. M. (2019). Technical efficiency of smallholder farmers in red pepper production in North Gondar zone Amhara regional state, Ethiopia. *Journal of Economic Structures*, 8(1), 18.

Abaje, I. B., Achiebo, P. J., and Matazu, M. B. (2018). Spatio-Temporal Analysis of Rainfall Distribution in Kaduna State, Nigeria. *Ghana Journal of Geography.* Vol. 10(1), pp 1–21

Abay, K. A., Berhane, G., Taffesse, A. S., Abay, K., and Koru, B. (2018). Estimating input complementarities with unobserved heterogeneity: Evidence from Ethiopia. *Journal of Agricultural Economics*, 69, 2, 495–517.

Adedibu, P. A., Opeyemi, A. A., Lawrence, A. L., John Iyanu Paul, J. I., and Oguntoye, E. (2022). Savanna biomes in Nigeria: Indicator species and plant adaptation strategies. *ScienceOpen*. doi: 10.14293/S2199-1006.1

Adeola, R. G. (2010). Influence of Socio-Economic Factors on the Adoption of Soil Conservation Measures in Ibadan/Ibarapa Agricultural Zone of Oyo State, Nigeria. Reports and opinion. Vol 2 (7).

Akinola, A. A., Arega, D. A., Adeyemo, R., Sanogo, D., Olanrewaju, A.S., Nwoke, C., and Nziguheba, G. (2010). Determinants of adoption and intensity of use of balance nutrient management systems technologies in the northern Guinea savanna of Nigeria. *Quarterly Journal of International Agriculture*, 49, 1, 25-45.

Ali, A., and Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*, 16, 183–194.

Alia, D. Y. (2017). Agricultural input intensification, productivity growth, and the transformation of African agriculture, University of Kentucky: 1-170.

Al-Mustapha, I. I., and Ashiru, A. A. (2021). Challenges faced by crop farmers: A survey of subsistent farmers in Kwara State, Nigeria. *Journal of Agric Sc Food Technol* 7(2): 207-211. DOI: 10.17352/2455-815X.

Anang, B. T., Amesimeku, J., and Fearon, J. (2021). Drivers of adoption of crop protection and soil fertility management practices among smallholder soybean farmers in Tolon district of Ghana. *Elsevier Ltd*: 1–7. https://doi.org/10.1016/j.heliyon.2021.e06900.

Ayanlere, A. F., Omotesho, O. A., and Muhammad-Lawal, A. (2018). Social capital dimensions and intensity of fertilizer usage among farming households in Kogi State, Nigeria. *Applied Tropical Agriculture,* 23(1): 17-24.

Ayerh F. (2015). Technical efficiency of tomato farmers in the Ashanti region of Ghana. Doctoral dissertation, University of Ghana, Legon

Bamiro,O., Adeyonu, A., Ajiboye, O. B., and Solaja, S. (2020). Effects of climate change on grain productivity in Nigeria (1970-2014). IOP conference series. Earth and Environmental science, 445(1):012058

Burke, W. J., Jayne, T. S., and Black, J. R. (2017). Factors explaining the low and variable profitability of fertilizer application to maize in Zambia, 2017. *The Journal of the International Association of Agricultural Economists.* Vol 48 (1) Pp 115-126. https://doi.org/10.1111/agec.12299.

Chepngetich, M., and John, K. (2015). Application of Vector Autoregressive (VAR) Process in Modelling Reshaped Seasonal Univariate Time Series. *Science Journal of Applied Mathematics and Statistics.* Vol. 3, No. 3, 2015, pp. 124-135. doi: 10.11648/j.sjams.20150303.15

Coelli, T. J. (1996). A guide to FRONTIER VERSION 4.1c. A computer program for stochastic frontier production and cost function estimation, Mimeo, Department of Econometrics, University of New England, Armidale, Australia.

Danso-Abbeam, G., Bosiako, J. A., Ehiakpor, D. S., and Mabe, F. N. (2017). Adoption of improved maize variety among farm households in the Northern Region of Ghana. Cogent Economics and Finance, 5(1), 1416896.

Degefa, K., Biru, G., and Abebe, G. (2020). Economic efficiency of smallholder farmers in tomato production in BakoTibe District, Oromia Region, Ethiopia. *Journal of Agricultural Science and Food.* ISSN: 2593-9173

Diagne, A., Alia, D., Amovin-Assagba, E., Wopereis, M. C., Saito, K., and Nakelse, T. (2013). Farmer perceptions of the biophysical constraints to rice production in sub-Saharan Africa, and potential impact of research. Realizing Africa's Rice Promise, 46-68.

Diao, X., Hazell, P., and Thurlow, J. (2010). The Role of Agriculture in African Development, World Development, *Elsevier,* Vol 38, (10), Pp 1375-1383.

Evenson, R. E., and D. Gollin, .D. (2003). Crop Variety Improvement and Its Effect on Productivity: The Impact of International Agricultural Research. *Science,* Vol 300, (5620) pp. 758-762

Food and Agriculture Corporate Statistical Database Special Report, FAOSTAT (2017). Food and Agriculture Organization of the United Nation Statistical Division, Rome, Italy. 8 pp

FAOSTAT, (2020). Food and Agriculture Organization of the United Nations. Production Dataset. http://faostat3.fao

Gebregziabher, K. M. (2014). Agricultural extension service and input application intensity:

Gebremariam, G., and Tesfaye, W. (2018). The heterogeneous effect of shocks on agricultural innovations adoption: Microeconometric evidence from rural Ethiopia. *Food Policy*, 74, 154–161.

Gollin, D., Parente, S., and Rogerson, R. (2002). The role of agriculture in development. *American Economic Review,* 92 (2): Pp. 160-164.

Hassan, M. H. (2020). Impact of climate change on life. *Environmental change and sustainability.*

Husna, N., and Desiyanti, R. (2016). The analysis of financial performance on net profit margin at the coal company. *International Journal of Management and Applied Science*, Vol 2, 4, Pp. 2394-7926

Ibitoye, S. J., Shaibu, U. M., and Omole, B. (2015). Analysis of resource use efficiency in tomato (*Solanum Lycopersicum*) production in Kogi state, Nigeria. Asian *Journal of Agricultural Extension, Economics* and *Sociology*, 220-229.

Jahangirpour, D., and Zibaei, M. (2022). Farmers' Decision to Adoption of Modern Irrigation Systems Under Risk Condition: Application of Stochastic Efficiency with Respect to a Function Approach. *Front. Water* 4:931694.

Jeetendra, P. A., Jat, M. L., Sapkota, T. B., Khatri-Chhetri, A., Kassie, M., Rahut, D. B., and Maharjan, S. (2018) Adoption of multiple climate-smart agricultural practices in the Gangetic plains of Bihar, India. *International Journal of Climate Change Strategies and Management*, 10, 3, 407-427.

Jenkwe E. D., and Chup C. D. (2016). Analysis of structural soil conservation measures in the Federal Capital Territory, Abuja. *Abuja Journal of Geography and Development*, 4, 1, 450-465.

Jimoh, A. I., Mbaya, A. L., Akande, D., Agaku, D. T., and Haruna, S. (2020). Impact of toposequence on soil properties and classification in Zaria, Kaduna State, northern Guinea Savanna, Nigeria. *International Journal of Environmental Quality.* Vol. 38: 48-58

Kaduna Agriculture Development Agency KADA, (2021). *Crop Production Recommendations for Kaduna State.* Kaduna Press Ltd. Nigeria, 39 pp.

Kaduna Agricultural Development Project. (2014). Agricultural production survey in Kaduna State, Nigeria.

Kaminski, J., and Christiaensen, L. (2014). Post-harvest loss in sub-Saharan Africa- what do farmers say? Global Food Security, 3(3), 149-158.

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F., and Mekuria, M. (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technological Forecasting and Social Change*, 80, 525–540.

Kebedom, A., and Ayalew, T. (2012). Analyzing adoption and intensity of use of coffee technology package in Yergacheffe District, Gedeo Zone, SNNP Regional State, Ethiopia. *International Journal of Science and Research,* vol. 3(10): 1945 – 1951.

Kiet, T. H., Thoa, N. T., and Nguyen, P. T. (2020). Applying Cobb-Douglas stochastic frontier profit function: A case study of Hoaloc-Mango in the Mekong Delta, Vietnam. *Journal of Sustainable Development and Planning*, XI: 493 – 502.

Kodde, D. A., and Palm, F. C. (1986). Wald criteria for jointly testing equality and inequality restrictions. Econometrica, 54: 1243-148

Koussoube, E., and Nauges, C. (2017). Returns to fertiliser use: Does it pay enough? Some new evidence from Sub-Saharan Africa. *European Review of Agricultural Economics,* 44(2), 183-210.

Levine, K., and Mason, N. (2014). Do input subsidies crowd in or crowd out other soil fertility management practices? Evidence from Zambia. Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, Addis Ababa, Ethiopia.

Mango, N., Siziba, S., and Makate, C. (2017). The impact of adoption of conservation agriculture on smallholder farmers' food security in semi-arid zones of southern Africa. *Agric and Food Security*, 6, 32.

Marenya, P. P., and Barrett, C. B. (2009). Soil quality and fertilizer use rates among smallholder farmers in Western Kenya. *Agricultural Economics,* 40(5), 561-572.

Matemilola, S., and Elegbede, I. (2017) The Challenges of Food Security in Nigeria. *Open Access Library Journal,* 4: e4185. https://doi.org/10.4236/oalib.1104185

Matsumoto, T., and Yamano, T. (2011). Optimal fertilizer use on maize production in east Africa. In emerging development of agriculture in east Africa: pp. 117-132.

McDonald, R. I., Mansur, A. V., Ascensao, F., and Colbert, M. (2020). Research gaps in knowledge of the impact of urban growth biodiversity. *Nature sustain*. 3, 16-24

Melesse, B. (2018). A review of factors affecting adoption of agricultural new technologies in Ethiopia. *Journal of Agricultural Science and Food Research*, 9(3): 1–4.

Mukhtar, U., Mohamed, Z., Shamsuddin, M. N., Sharifuddin, J., and Iliyasu, A. (2018). Application of Data Envelopment Analysis for Technical Efficiency of Smallholder Pearl Millet Farmers in Kano State, Nigeria. *Bulgarian Journal of Agricultural Science*, 24(2), 213-222.

Mutayoba, V., and Ngaruko, D. (2018). Assessing tomato farming and marketing among smallholders in high potential agricultural areas of Tanzania. *International Journal of Economics, Commerce and Management*, VI, 8, 13.

Muyanga, M., and Jayne, T. S. (2014). Effects of rising rural population density on smallholder agriculture in Kenya. *Food Policy,* 48, 98-113.

Mwaura, G. G. (2021). Adoption intensity, perception and profitability of organic based soil fertility management technologies in Murang'a and Tharaka-Nithi Counties, Kenya. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Economics in the School of Agriculture and Enterprise Development of Kenyatta University, Kenya: 1-106.

Najjuma, E. (2016). Techinical Efficiency of Tomato Production: A Comparative Study between Small Scale Green House and Open field tomato farmers in Kiambu. *Journal of Agriculture Policy* 1, 2(1):16-36.

National Bureau of Statistics NBS, (2021). *Annual Report*. Federal Republic of Nigeria. NBS Publication

National Population Commission, (2006). Provisional 2006 Nigeria Census Figures. 3 pp.

Nasiru, S. (2022). Policy evaluation of the anchor borrowers programme and smallholder farmers in the Federal Capital Territory, Abuja. *Global journal of political science and administration*. Vol 10, No. 3, pp 27-41.

Nguetti, J. H., Imungi, J. K., Okoth, M. W., Wang'ombe, J., Mbacham, W. F., and Mitema, S. E. (2018). Assessment of the knowledge and use of pesticides by the tomato farmers in Mwea Region, Kenya. *African Journal of Agricultural Research*, 13(8), 379-388.

Oladimeji, Y. U., and Abdulsalam, Z. (2014). An Economic Analysis of Dry Season Irrigated Farming in Asa River, Kwara State, Nigeria: Implications for Poverty Reduction. *Journal of Sustainable Development in Africa,* 16(7): 1-15.

Oladimeji, Y. U., Sani, A. A., Hassan, A. A., and Yakubu, A. (2019). Profitability and efficiency of sweet potato production in North central and North western Nigeria: A Potential for Enhancing Food Security. *Applied Tropical Agriculture,* 24 (2), 122 – 131.

Oladimeji, Y. U., Yusuf, O., Sani, A. A., and Iyanda, A. S. (2020). Effect of land degradation on smallholders' farmers' food security and poverty status nexus livelihood diversification in north central, Nigeria. *Agricultural Socio-Economics Journal,* 20(3): 253-264.

Oloyede, A. O., Muhammad-Lawal, A., Ayinde, O. E., and Omotesho, K. F. (2014). Analysis of soil management practices in cereal based production systems among small-scale farmers in Kwara State. *Production and Agricultural Technology*, 10, 1, 164-174.

Owoeye, R. S. (2017). Adoption of improved technologies in maize-based cropping systems on income of farmers in Ondo State, Nigeria. I*nternational Journal of Agricultural Economics* vol. 2(5): 149-153. doi: 10.11648/j.ijae.20170205.12

Owombo, P. T., and Idumah. F. O. (2017). Determinants of agro-forestry technology adoption among arable crop farmers in Ondo state, Nigeria: An empirical investigation. *Springer Agroforest Syst* 91: Pp 919–926.

Oyinbo, O., Chamberlin, J., Vanlauwe, B., Vranken, L., Kamara, Y. A., Craufurd, P., and Maertens, M. (2019). Farmers' preferences for high-input agriculture supported by site-specific extension services: Evidence from a choice experiment in Nigeria. https://doi.org/10.1016%2Fj.agsy.2019.02.003

Sheahan, M., and Barrett, C. B. (2017). Ten striking facts about agricultural input use in subSaharan Africa. *Food Policy*, 67, 12-25.

Shettima, B. G., Amaza, P. S., and Iheanacho, A. C. (2015). Analysis of Technical Efficiency of Irrigated Vegetable Production in Borno State, Nigeria. *Journal of Agricultural Economics, Environment and Social Sciences*, 1(1), 88-97.

Stein T. H., Monica F., Samson P. K., and Christian T. (2018). Can lead farmers reveal the adoption potential of conservation agriculture? The case of Malawi. *Land Use Policy,* 76, 113–123.

Tasila, K. D., Mabe, F. N., and Oteng, F. R. (2019). Profitability and Profit Efficiency of Certified Groundnut Seed and Conventional Groundnut Production in Northern Ghana: A Comparative Analysis. *Cogent Economics and Finance*, 1631525.

Teklewold, H., Mekonnen, A., and Kohlin, G. (2018). Climate change adaptation: a study of multiple climate-smart practices in the Nile Basin of Ethiopia. *Climate and Development,* doi: 10.1080/17565529.2018.1442801.

Tobin, J. (1958). Estimation of Relationship for Limited Dependent Variables. *Econometrica* 26, pp. 24-36.

Udemezue, J. C. (2019). Challenges and opportunities of agricultural sector among youths in the twenty first century: the case of Nigeria. *Advance Biotechnology Microbiology,* 14(5): 555896. DOI: 10.19080/AIBM.2019.14.555896

Xie, H., Chen, Q., Huang, Y., Zhang, Y., and Wu, Q. (2019). Prospects for agricultural sustainable intensification; A review of research. *Land*, 8 (11), 157

Yami, M., and Asten, P. V. (2017). Policy support for sustainable crop intensification in Eastern Africa. *Journal of rural studies*. Vol 55, pp 216-226.

Yunusa, B. K., Yusuf, S., Zahraddeen, I., and Abdussalam, A. F. (2017). Characteristics of rainfall variation in Kaduna State, Nigeria. *Asian journal of Advances in Agricultural Research,* 4(3), 1-11.

Zondo, B. S. (2020). Determinants of adoption and use intensity of organic fertilizer: A case of smallholder potato farmers in KwaZulu-Natal, South Africa. SA-TIED Working Paper No.135: 1-18