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Resource Productivity and Allocative Efficiency on Improved Cassava-Based Mixed Cropping System in Ebonyi State, Nigeria

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Abstract
The study examined the resource productivity and allocative efficiency in an improved cassava-based mixed cropping system in Ebonyi State of Nigeria. A multistage sampling procedure was employed to select 120 respondents (comprising 60 adopters and 60 non-adopters of improved cassava-based mixed cropping system) to whom structured questionnaires were administered. Inferential statistics involving the Cobb-Douglas production function and descriptive statistics were used for data analysis. The regression results revealed that all five resource inputs including land, labour, cassava stem cuttings, agrochemicals and miscellaneous variable capital inputs for the adopters and four resource inputs including land, labour, cassava stem cuttings and miscellaneous variable capital inputs for the non-adopters of the improved cassava-based mixed cropping system positively contributed to output of the respondents in the area. The results further showed that except for labour input, other resource inputs were of higher productivity (contribution to output) under the adopters than the non-adopters. The results also showed that whereas the adopter sunder utilized land, labour, cassava stem cuttings and agrochemicals, but overutilized only the miscellaneous variable capital inputs, the non-adopters underutilized land and cassava stem cuttings, but overutilized labour and miscellaneous variable capital inputs. The result of the deviation from unity (one) of the ratio of the Marginal Value Product (MVP) to Marginal Factor Cost (MFC) revealed that the adopters were more efficient in the allocation of land, cassava stem cuttings and miscellaneous variable capital inputs than the non-adopters of the improved cassava-based mixing cropping system in the area. Major constraints to increased cassava production in the area include lack of finance, high cost of farm inputs, lack of cassava processing/storage facilities, scarcity and high cost of improved cassava cuttings among others. Policy measures aimed at liberalization of agricultural credit schemes to enhance farmers' access to finance, effective planning and implementation of inputs distribution programmes and introduction of labour-saving techniques to farmers among others were recommended towards increased cassava production and profitable cassava value chain business in Nigeria.
Keywords: Improved cassava, productivity, cropping system, farm resources, and Nigeria

Introduction

The revitalization of the African economy through sustainable agricultural development has severally taken the front burner in national and international conferences organized to proffer strategies for solving the problems of food insecurity, poverty, hunger and lagging socio-economic growth and development in most developing nations including Nigeria. Suggesting a solution to the food and economic crisis in Africa, Amin (2018) and Odhimabo (1997) maintained that the newly designed and contracted paradigm for the sustainable transformation of Africa's agricultural economy for food and cash income in the 21st century would be hinged on market-based agricultural system under which food and cash crop production systems should be adopted to optimize and exploit available scarce resources for profitable farming. Awolowo *et al.* (2019), strongly recommended an improved cassava-based cropping system as being of great importance in this regard in the West African sub-region, especially Nigeria.

In Nigeria, the importance of cassava (*Manihot esculenta Crantz*) in the nation's food economy has steadily been on the increase in the past decades (Woosen *et al.,* 2018). The authors stressed that the crop; its tubers, derivatives and constituent parts serve as sources of food and cash income to several millions of rural and urban households, adding that it serves as essential raw materials in the production of domestic and industrial products including confectionaries, ethanol, starch etc. Nigeria is reputed to be the highest producer of cassava in the world (FAO, 2016). Through the Cassava Adding Value for Africa, CAVA Project Phase I (2008 - 2014) and CAVA Project Phase II (2014 - 2019); a project supported by the Bill and Melinda Gates Foundation, in five African countries including Nigeria, several improved cassava varieties have been developed and pushed to farmers (Awolowo *et al.*, 2019; Adebayo and Weathy, 2018). Some of these varieties include the Tropical *Manihot esculenta* (TME) 419, 96 (1632), Tropical Manihot Species (TMS) 1412 (Vitamin A Yellow Cassava), NR 8082, TMS 30555, TMS 30572 etc. Although Awolowo *et al.*(2019), argued that up to 60% of cassava-producing households in Nigeria have adopted the cultivation of improved cassava varieties resulting in increased cassava yields and output in the country, domestic production still largely cannot cope with the domestic consumption demand and needs for the ever-growing cassava export market. Also reports from NBS (2022) indicate that though the production of cassava in Nigeria increased from 9.6 million tonnes in 1973 to 60.8 million metric tonnes in 2022, at a growth rate of 4.2%, there still exists a scary gap between supply and demand of cassava and its constituents in Nigeria's domestic food economy. For instance, the supply-demand gap for high-quality cassava flour (HQCF) stood at 485,000 metric tonnes while the gap for cassava starch stood at 290,000 metric tonnes per annum during the decade (NBS, 2022). Bennet *et al.*(2012); Adebayo and Weathy (2018), and Amin (2018) attributed Nigeria's inability to meet the required supply capacity to the fact that cassava production in the country is dominated by smallholder farmers heavily characterized by low farm yields and low productivity occasioned by myriads of resource use and allocation challenges in their farm resources management. Whereas resource productivity is generally, the efficiency with which resource inputs are converted to output within the production process, allocative or price efficiency refers to the measure of a farm firm's success in choosing profitable sets or levels of inputs (Ayetombi, 1998). Reddy *et al.* (2009) emphasized that allocative efficiency occurs when no possible reorganization of production can make anyone better off without making someone else worse off. Although there have been attempts to document issues of resource use and allocative efficiency in smallholder food and cash crop production systems (Nwakpu 2019, Lawal *et al*, 2018; Enya and Alimba, 2008, Iheke *et al.* 2008, Nwakpu, 2008) there has been significant differences in time, location and weather pattern occasioned by climate change impacts on farm resources with concomitant variations in input-output mix, input combinations and allocation patterns.

With these conflicts in focus, this study was conducted to help document empirically resource productivity and allocative efficiency in improved cassava-based mixed cropping system in Ebonyi State of Nigeria. Specifically, the study determined, analyzed and compared resource productivity and allocative efficiency among adopters and non-adopters of improved cassava-based mixed cropping systems in the area. It also identified major constraints to increased cassava production and advanced recommendations based on findings.

Methodology

Study Area

The study was conducted in Ebonyi State of Southeast Nigeria. The State was selected for the study based on the fact that Ebonyi is a major food-producing area in the country and cassava production, processing and marketing represent key agricultural enterprises for farmers in the State. Ebonyi State was created out of the former Abia and Enugu States on 1st October 1996.Ebonyi is made up of thirteen Local Government Areas and divided by the Ebonyi State Agricultural Development Programme (EBADEP) into three agricultural zones; Ebonyi North Zone, Ebonyi Central Zone and Ebonyi South Zone. According to the National Population Commission (NPC), Ebonyi State has a population of about 3.4 million people based on the 2022 population projection of the 2006 National Population Census. Out of this population, 80% engage in agriculture growing different types of food and cash crops including cassava, yam, rice, cocoyam, maize etc where most of these crops except rice are grown through mixed cropping system; the farmers also tend small ruminants and keep cattle (Echiegu, 2002). Geographically, the state lies between latitudes 7°30' N and 8°30' N and longitudes 5°40'E and 6°45'E. The State has a landmass of 5,935Km^2 most of which is arable and fertile for agricultural production (Egwu, 2002). The state lies in the tropical rainforest zone characterized by heavy rainfall and equable temperatures. The mean annual temperature is 80^{0}F while the mean annual rainfall varies between 2250mm to 2000mm with a marked dry season from November to March and a rainy season between April and October (Eze and Idike, 1997).

Sampling and Data Collection

A multistage sampling procedure was employed to select a total of 120 smallholder farmers involved in cassava-based mixed cropping production systems (comprising 60 adopters and 60 non-adopters of improved cassava-based mixed cropping systems). In the first stage, one Local Government Area was purposively selected from each of the three agricultural zones in the State. These Local Government Areas were Izzi from Ebonyi North Zone, Ikwo from Ebonyi Central and Onitsha from Ebonyi South Agricultural Zone. Their selection was based on the fact that cassava is greatly produced in these areas, accessibility to the farmers and exposure on the part of farmers. In the second stage, four autonomous communities were randomly selected from each of the three Local Government areas making it a total of 12 autonomous communities. In the third and final stage using farmers' listing from the three Zonal Offices of Ebonyi State Agricultural Development Programme (EBADEP) as sample frame, five households each for adopters and non-adopters of improved cassava-based mixed cropping system were randomly selected from each of the 12 communities to give a total of 120 respondents on whom structure questionnaire were administered for the study during the 2022/2023 cropping season. In determining who was an adopter and a non-adopter, the researcher defined a farmer as an adopter if he or she had cultivated at least one of the improved cassava varieties in his or her cassava-based mixed cropping system for at least one cropping season. On the other hand, a farmer who did not plant any of the improved cassava varieties but stuck to the traditional unimproved practices in his or her unimproved local cassava varieties-based mixed cropping system is considered a non-adopter. Variable inputs studied include; land, labour, cassava stem cuttings, agrochemicals and miscellaneous variable capital inputs.

Method of Data Analysis

Inferential Statistics involving the Cobb-Douglas Production Function was used to determine, analyze and compare the productivity of farm resources under the improved and unimproved or traditional cassava-based mixed cropping system. The ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) was used to determine the allocative efficiency by farmers of various factor inputs under the two categories of the cassava-based mixed cropping system in the area. Descriptive statistics such as mean, frequency, percentages, etc were employed to determine the constraints to increased cassava production in the area.

Model Specification

The Cobb-Douglas Production Function model used in realizing the first objective was explicitly stated as follows:

$Y = aX_1b_1 + X_2b_2 + X_3b_3 + X_4b_4 + X_5b_5 + e$

Where;

Y= Cassava and other minor crops output in kg -------- (1)

X_1= Land use in hectares

X_2= Labour use in man-days

X_3= Cassava stem cuttings in bundles

X_4=Value of agrochemicals (including fertilizers, herbicides and pesticides only occasionally sparingly used by adopters).

X_5 = Value of miscellaneous variable capital inputs (including the cost of seeds of minor crops such as maize, melon, pepper, jute bags, transportation interest on loans).

b_1, b_2, b_3, b_4, and b_5= Partial elasticity of response of x_1, x_2, x_3, x_4 and x_5 to output respectively.

a= Intercept

e= Error term

This analytical method was applied to both adopters and non-adopters of the improved cassava-based mixed cropping system in the area; except X_4 which was nil for non-adopters as they did not use any agrochemical of any sort. To determine the allocative efficiency of the survey farmers, the ratio of the Marginal Value Product (MVP) of each input to its factor price or Marginal Factor Cost (MFC) under two categories of the cassava-based mixed cropping households in the area was estimated thus;

$$PAE = \frac{MVP}{MFC} = 1 \text{-------- (2)}$$

Where:

PAE= Point of Perfect Allocative Efficiency

MVP= Marginal Value Product of the resource input

MFC= Marginal Factor Cost of the resource input

Decision Rule: If the value of the above ratio is above one, it means that the survey farmers under-utilized the production resource; if on the other hand, the value of the above ratio is less than one, it implies that the survey farmers were over utilizing farm production resources. If the value of the ratio is equal to one (unity) there exists a perfect allocation of resources which rarely obtained in agricultural production.

Results and Discussion

Resource Productivity

The effect of the farm production resources on output by adopters and non-adopters of the improved cassava-based mixed cropping system in the study area was presented in Table 1. Out of the three functional forms fitted to estimate the effect of production factors on output for adopters and non-adopters, the double log model was chosen as the lead functional form as it best satisfied the statistical, economic and econometric criteria in each case. This function yielded the following results when transformed. The aggression results as indicated by the coefficient of multiple determination (R^2 = 0.6907) for adopters and R^2 = 0.5213 for non-adopters show that the combined effects of the explanatory variables (the farm resources) explained 69% and 52% of the total variation in output for the adopters and non-adopters of the improved cassava-based cropping system respectively. The results appear plausible since other factors such as volume of rainfall, pests and diseases, soil fertility status etc not included in the regression model might have combined with the stochastic or error term to account for the remaining 31% and 48% variation in output not explained by the combined effect of the stated farm production resources under the adopters and non-adopters respectively. The F calculated from the data (90.43 for adopters) and (62.43 for non-adopters are each greater than the tabulated F statistics) (3.70) at 5 and 30 degrees of freedom and a 5% level of probability in each case. This indicates that the overall double-log regression model is statistically adequate to explain the observed variation in each case. The test of significance which is the t-test of the independent variables showed that except for miscellaneous variable inputs which were significant at a 10% probability level for the non-adopters, the rest were significant at 5% levels. This implies that all the explanatory variables (farm production resources) were positively related to the output of the cassava-based cropping system under the two categories. The productivity of the individual resource inputs as indicated by the regression coefficients or b-values which measure the elasticity of response of each independent variable to output showed that a 1% increase in land, labour use, cassava stems, value of agro-chemicals and miscellaneous variable capital inputs would bring about 24%, 14%, 41%, 5% and 7% increase in output respectively under the adopters of improved cassava-based mixed cropping system in the area. Except for labour use where a 1% increase contributed a higher percentage (19%) increase to output for non-adopters than adopters (13%) percentage increase, a 1% increase in every other farm input by adopters contributed a higher percentage increase to output than those of the non-adopters. This implies that with the exemption of labour, the productivity or contribution to the output of the production resources was higher under the adopters than under non-adopters of the improved cassava-based mixed cropping system in the area. Similarly, the b-values ($b_1b_2b_3b_4$ and b_5) for the five independent variables added together (measuring Return to Scale: RTS) resulted in 0.91. This implies that the survey farmers were positively producing at a decreasing return to scale. This is because one unit increase in all the independent variables combined would bring about less than one unit increase in output. The elasticity of production for individual farm resources and the sum of b-values are less than one in each case implying that the survey farmers operated under stage II or rational stage of the production function. The findings agree with the earlier ones by Amos *et al* who found that a 1% increase in most of the farm resources used in cocoyam production in Edo and Ekiti States of Nigeria resulted in various percentage increases in cocoyam output of surveyed farmers in those states. They also found that the survey farmers produced at decreasing return to scale and in the rational stage II of production function. The above findings are also in agreement with earlier findings by Nwakpu (2019) who found that farm resources significantly and positively contributed to the rice output of both adopters and non-adopters of recommended rice technologies in Ebonyi State, Nigeria.

Allocative Efficiency

The ratio of the Marginal Value Product (MVP) to the Marginal Factor Cost and their relative deviation from unity (one) for all the farm resource inputs were estimated for the adopters and non-adopters of the improved cassava-based mixed cropping system to determine the allocative or resource use efficiency as indicated under the two categories of respondents. Results from Table 2 show that the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) for the adopters were 4.28, 2.53, 3.95, 1.03 and 0.94 with deviation from unity (one) values of 3.28, 1.53, 2.95,0.03 and -0.06 for land, labour, cassava stems agrochemicals and value of miscellaneous variable inputs respectively. Economic theory postulates that perfect resource use or allocative efficiency in production occurs when every naira spent acquiring one or more additional units of a given factor input into the production system adds exactly one more naira to the total revenue. In other words, perfect allocative efficiency occurs when the MVP is at equilibrium or parity with the MFC of the resource input. (MVP=MFC) or =1(unity). However, in the real world, farmers rarely achieve perfect allocative efficiency but varying levels of allocative efficiency. Therefore with the MVP to MFC ratios greater than one (unity) for land, labour, cassava stem and agrochemicals, the adopters inefficiently allocated and underutilized these resource inputs. These values also indicate that the survey farmers used less than the profit-maximizing levels for these inputs. They needed to perfectly increase output by using higher levels of these four inputs towards the point where the MVP to MFC ratio tends closer to one (unity). On the other hand, the MVP to MFC ratio of the adopters under the miscellaneous variable capital inputs was less than one (unity) implying that the survey farmers overutilized this resource input. The farmers needed to profitably reduce output by using less resource input to the point where the MVP to MFC ratio positively tends closer to one (unity). Results from Table 3 show that the ratio of the MVP to MFC for the non-adopters were 5.49, 0.95, 4.36, Nil and -0.09 for land, labour, cassava stems, agrochemicals and miscellaneous variable capital inputs respectively (noting that the non-adopters did not use agrochemicals). These ratios for land and cassava stems being greater than one implied that the non-adopters underutilized these two resource inputs but overutilized labour and miscellaneous variable capital inputs with ratios less than one for the two resource inputs respectively. The non-adopters needed to increase profit by increasing output through higher use of land area and cassava. On the other hand, they needed to have increased profit by reducing output through the use of lesser quantity of labour and miscellaneous variable capital inputs. The adopters had MVP to MFC ratios deviation from unity (one) values less than those of the non-adopters for land, cassava cuttings and miscellaneous variable capital inputs implying that the adopters were allocatively more efficient than the non-adopters in the allocation of these three resource inputs. Again, the findings are in agreement with earlier ones by Amos *et al.*(2019) that whereas the cocoyam farmers in Edo State underutilized land, the quantity of fertilizer used, labour use, other agrochemicals and over-utilized planting materials, cocoyam farmers in Ekiti State underutilized land, fertilizer, and other agrochemicals but over-utilized labour and planting materials. Nwakpu (2019) also found that whereas adopters of recommended rice technologies for lowland and upland rice systems in Ebonyi State underutilized land, rice seed input, and agrochemicals, they over-utilized labour and miscellaneous variable capital inputs. Enya and Alimba (2008) also found that sweet potato farmers in Cross River State of Nigeria inefficiently underutilized labour.

Major Constraints to Increased Cassava Production

This section described the major constraints to increased cassava production in the area. These constraints were scarcity and high cost of improved cassava variety stem cuttings, poor yield, pests and diseases, high cost of farm inputs, lack of finance, poor agronomic practices, high post-harvest spoilage, lack of processing/storage facilities, inadequate market and high level of illiteracy among farmers. The results of the analysis are presented in Table 4. Results from Table 4 show that with 22.50% of the respondents, lack of finance on the part of farmers ranked first as the major constraint to increased cassava production in the area. This was followed by 16.67% of the respondents who ranked high cost of farm inputs as 2nd major constraint, 15% of the respondents for lack of processing and storage facilities as 3rd major constraint, 12.5% for scarcity and high cost of improved cassava stem cutting (planting material as 4th major constraints). Others that ranked as 5th, 6th, 7th, 8th, 9th and 10th constraints include high illiteracy levels of farmers, high post-harvest spoilage, poor agronomic practices by farmers, pests and disease, poor yield and inadequate market respectively. The findings are in agreement with earlier ones by Lawal *et al.* (2018), who reported that poor finance, lack of government support, scarcity of improved cassava varieties and high cost of farm inputs were major constraints to increased cassava production in Gwazo local government area of Kano State in Nigeria.

Conclusion

The study revealed that all the production resources under the adopters and non-adopters positively contributed to output. The study further revealed that except for labour use, all the other three resource inputs recorded higher productivities for the cassava-based mixed cropping system for adopters more than the non-adopters, implying that the improved cassava-based system increased the productivity of farm resources employed in the production of cassava-based mixed cropping system in the area. The study also revealed that whereas the adopters underutilized land, labour, cassava stem cuttings and agrochemicals, but overutilized only miscellaneous variable capital inputs, the non-adopters underutilized land, and cassava stem cuttings but overutilized labour and miscellaneous variable capital inputs. It also revealed that the adopters were more efficient in land, cassava stem cuttings and miscellaneous variable capital inputs than the non-adopters in the area. Constraints to increased cassava production in the area include lack of finance, high cost of farm inputs, lack of cassava processing/storage facilities, scarcity and high cost of improved cassava stem cuttings and high level of illiteracy of the farmers among others. The study recommends policy measures aimed at credit liberalization, especially through government-owned financial institutions. This will help farmers have easier access to finance to procure the hitherto underutilized farm resources and profitably increase their production scale and output. Elegant input distribution policies with subsidies where necessary, should be religiously planned and implemented by Governments as well as introduction to the farmers, labour' saving techniques such as the use of herbicides and prototype shoulder-hung weeding and harvesting machines. These would help farmers increase their production scale and thus ensure increased and profitable cassava farming in Nigeria.

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Table 1: Effects of Production Resources on Output by Adopters and Non-Adopters of Improved Cassava-Based Mixed Cropping System

Explanatory Variables	Adopters Elasticity	t-values	Non-adopters Elasticity	t values
Land use in ha (x_1)	0.2416	2.46**	0.2008	2.14**
Labour use in man-days (x_2)	0.1392	2.56**	0.1951	2.36**
Cassava stems in bundles (x_3)	0.4136	2.49**	0.2952	2.46**
Value of agrochemicals in (x_4)	0.0521	2.37**	Nil	Nil
Value of misc. var. inputs (x_5)	0.0729	1.76**	0.0541	1.63***
Constant	2.116312	2.21** (0.5213)	1.84613	3.14*
R^2	0.6907	0.5213		
F^{cal}	90.43	62.43		

Note: one, two and three asterisks indicate that the coefficient (Elasticity) is significant at 1%, 5% and 10% levels respectively. Source: Field Survey, 2022/2023 cropping season

Table 2: Allocative Efficiency for Adopters of Improved cass ava-based mixed Cropping System

Variables	MVP	MFC		Deviation from unity	Allocative Efficiency
Land (ha)	66,310	15500	4.28	3.28	Underutilized
Labour (man-days)	6320	2500	2.53	1.53	Underutilized
Cassava Stem (bundles)	12650	3200	3.95	2.95	Underutilized
Value of agrochemicals	1085	1050	1.03	0.03	Underutilized
Value of misc var. cap. Inputs	1210	1250	0.94	-0.06	Over utilized

Source: Field Survey, 2022/2023 cropping season

Table 3: Allocative Efficiency for Non-Adopters of Improved Cassava-based Mixed Cropping System

Variables	MVP	MFC		Deviation from unity	Allocative Efficiency
Land (ha)	63100	11500	5.49	4.49	Underutilized
Labour (man-days)	4050	4250	0.95	-0.05	Overutilized
Cassava stem (Bundles)	1980	2580	4.36	3.36	Underutilized
Value of Agrochemicals	Nil	Nil	Nil	Nil	Nil
Value of misc. var. cap. Inputs	820.6	900	0.91	-0.09	Overutilized

Source: Field Survey, 2022/2023 cropping season

Table 4: Major Constraints to Increased Cassava Production

Constraints	Freq=120	%	Rank
Scarcity and high cost of improved cassava variety stem cuttings.	15	12.50	4th
Poor yield	4	3.33	9th
Pests and diseases	5	4.17	8th
High cost of farm inputs	20	16.67	2nd
Lack of finance	27	22.50	1st
Poor agronomic practices	7	5.83	7th
High post-harvest spoilage	10	8.33	6th
Lack of processing/storage facilities	18	15.00	3rd
Inadequate market	2	1.67	10th
High level of illiteracy among farmers	12	10.00	5th

Source: Field survey 2022/2023 cropping season