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ARTICLE

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Effect of public spending on agricultural productivity in Nigeria (1981-2018)

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Abstract
This study examines the effect of public spending on agricultural productivity in major agro-ecological regions in Nigeria (1981-2018). Using public finance data from agricultural and the non-agricultural sectors at a national level, agricultural productivity returns were analysed. Public spending on drivers of agricultural growth such as education, farm feeder roads and health care facilities and their effect on agricultural productivity were also examined. Data were analysed using descriptive statistics and three-stage simultaneous equations. Descriptive statistics analysis results indicated that agricultural public spending as a part of total public spending averaged 4.88% between 1981 and 2018 across zones in Nigeria. Less than 25% of this allocation was spent on agricultural developmental/capital project. Elasticity results computed from the 3-stage simultaneous equation showed that the access to moderate farm feeder roads variable was 0.045, the access to education variable was 0.071 and the access to health care facilities (within 15-30 minutes' walk to health facility) variable was 0.013. These variables were all significant at 1%. Such outcomes suggest that a 1% increase in the funding of education, farm feeder roads and health care facilities will enhance agricultural productivity per capita by 0.043. Hence, the results revealed an estimated benefit-cost-ratio of 4.3:1. Consequently, public expenditure on education, farm feeder roads and health care facilities of 4.3% would enhance agricultural productivity by 1%. However, the assessed marginal consequences and returns vary for four agro-ecological regions. Hence, harmonizing along with quality public spending on access to health care facilities, education and farm feeder roads would enhance agricultural productivity.

Keywords
Public expenditure and financings/ Marginal returns / Agricultural output / Agro-ecological zones / Nigeria.

O efecto do gasto público na produtividade agrícola en Nixeria (1981-2018)

Resumo
Este estudo examina o efecto do gasto público na produtividade agrícola nas principais rexións agroecolóxicas de Nixeria (1981-2018). Utilizando datos das finanzas públicas nacionais procedentes tanto dos sectores agrícola coma non agrícola, analízanse os rendementos da produtividade agrícola. Tamén se estuda o gasto público nos motores do crecemento agrícola como a educación, as vías de acceso ás granxas e as instalacións de atención médica, e mais o seu efecto sobre a produtividade. Os datos analizáronse mediante estatística descritiva e ecuación simultánea en tres etapas. Os resultados da análise estatística indicaron que o gasto público agrícola, como parte do gasto público total, foi do 4,88% de media entre 1981 e 2018 en todas as zonas de Nixeria. Menos do 25% desta asignación foi empregado en proxectos de capital/desenvolvemento agrícola. Os resultados de elasticidade calculados a partir da ecuación simultánea de tres etapas mostraron que a variable vías de acceso ás granxas foi de 0,045, á educación de 0,071 e ás instalacións de atención médica (a 15-30 minutos camiñando ao centro de saúde) de 0,013. Todas estas variables resultaron significativas ao 1%. Estes resultados suxiren que un aumento do 1% no financiamento na educación, nas vías de acceso ás granxas e nas instalacións de atención médica melloraría a produtividade agrícola per cápita un 0,043. Polo tanto, os resultados revelaron unha relación custo-beneficio de 4,3:1. En consecuencia, un gasto público en educación, nas vías de acceso ás granxas e nas instalacións de atención médica dun 4,3% melloraría a produtividade agrícola nun 1%. Porén, as consecuencias marxinais avaliadas e mais os retornos varían nas catro rexións agroecolóxicas. Xa que logo, harmonizar un gasto público de calidade nas instalacións de atención médica, na educación e nas vías de acceso ás granxas mellorará a produtividade agrícola.

Palabras clave
Gasto público e financiamento / Rendibilidade marxinal / Produción agrícola / Zonas agroecolóxicas / Nixeria.

JEL Codes: Q10.

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1. Introduction

Public spending/expenditure is the basis of budget building and an expectation for development for today and, also, for the future. During the scope years (1981-2018) sustainable public spending in Nigeria has been a debatable concern in economic development (Anisimova, 2016; Arndt, Pauw & Thurlow, 2015; Babalola, 2015; Kareem, Bakare, Ademoyewa, Ologunla & Arije, 2015; Makhtar, 2017; Mogues, Morris, Freinkman, Adubi & Ehui, 2008). Past studies have argued that the notion of public spending is connected to sustainable development. It is argued that a sustainability concept is in the scope of government expenditure (Aregbeyemi & Kolawole, 2015; Baldos, Viens, Hertel & Fuglie, 2018; Goyal & Nash, 2016). Public spending is an economic instrument that government uses to maintain the economy and for development. Agriculture is the prime sector in terms of its contributions to Gross Domestic Product (GDP) and employment for most developing countries (Tenaye, 2020). Moreover, the majority of people existing in poverty globally obtained their income from agriculture and agricultural correlated activities in rural areas (Petkovová, Hartman & Pavelka, 2020; Peón Pose, Martínez-Filgueira & López-Iglesias, 2020; Siebrecht, 2020). Therefore, developing an effectual agricultural policy in developing countries must be highly significant and efficient government mechanisms must be put in place to propel agricultural growth (Alshahrani & Alsadiq, 2014; Arndt et al., 2015; Fan, Hazell & Thorat, 2000; Ojiako, Chianu, Johm & Ojukwu, 2016; Rodrik, 2016).

Karamba & Winters (2015) and Babatunde (2018) argued that cost-effective agricultural public expenditure enhances poverty reduction. Fan & Zhang (2008) and Wu, Tang & Lin (2010) indicated that cost-effective funding of drivers of agricultural growth like extension services, efficient credit delivery systems, research and development among others, bring about agricultural growth. However, evidence has shown that in developing countries, public expenditure on agriculture and on the drivers of agricultural growth is too low to bring about meaningful development (Diao, Fan, Kanyarukiga & Yu, 2010; Manyong et al., 2005). Zhang & Fan (2004) and Makhtar (2017) contended that identifying the drivers of growth and funding these drivers promptly is the key to meaningful agricultural growth.

Nigeria, since its inception, has set out policies that could transform the agricultural sector. Past studies argued that the country's huge agricultural resource base, which offers great potential for growth, has not really achieved that feat, due to poor funding , hence these policies could not influence agricultural growth (Chan, Ramly & Abdkarim, 2017; Mogues et al., 2008). Manyong et al. (2005) revealed that in the 1960s, agriculture in Nigeria influenced about 64% of the total GDP, owing to the substantial investment the sector enjoyed both from public and private organizations. Kareem et al. (2015) indicated that in the 1970s agricultural contribution to GDP declined from 65% in 1986 and to 48% in 1995. There was a further decrease to 15% in 2008. This study indicated that the root cause of this decline was the poor funding given to major drivers of agricultural growth which led to poor agricultural outputs (Takesshima & Liverpool-Tasie, 2015). Evidence from other African countries like Zimbabwe revealed that government spending on agriculture was extraordinarily high (1990-2010) which yielded substantial agricultural outputs (Ansari, Gordon & Akuamoah, 2007).

Coelli & Prasada Rao (2005) examined the levels and trends in agricultural output and productivity in 93 developed and developing countries from 1980 and 2000. The results revealed that in Asia, the highest annual Total Factor Product (TFP) growth of 2.9% was achieved, followed by North America (US and Canada), Australia, Europe, and South America. However, developing countries (Sub Saharan Africa SSA, West Asia, Caribbean, and Oceania) experienced a decline of TFP because the regions (SSA) continued to rely on resource-led agricultural activities rather than productivity which the developed countries imbibed. Agricultural productivity returns on public spending in European countries are enormous (De Olde, Sautier & Whitehead, 2020). The increase in enhanced agricultural productivity in developed countries derives from more intensive input use, advanced modern use of agricultural technology (which is highly funded), efficiency, managerial skills and organization of production

(European Commission, 2016b; Kostlivý, Fuksová & Dubec, 2017; Quiroga, Suárez, Fernández-Haddad & Philippidis, 2017; Svilokos, Vojinić & Tolić, 2019).

The above indicates that huge public spending brings about enhanced agricultural productivity. In most developing countries, like Nigeria, high public spending allocated to agriculture has not enhanced agricultural productivity. This is the gap the study has identified and the factors/drivers influencing these outcomes need to be studied. Consequently, the study examines factors/drivers of agricultural growth and public spending in Nigeria and whether the level of public spending prompts agricultural productivity. The main objective of the study is to examine quantity and quality of public spending and its effect on agricultural productivity. The study also explores the consequence of public spending on education, farm feeder roads and health care facilities and its effect on agricultural productivity. It is hoped that the outcome of this research would increase knowledge that can contribute to policy decision making in agricultural development. The paper hopes to contribute to literature about the efficiency of public spending and agricultural productivity.

Although there are large bodies of researchers that have examined the productivity effects of public expenditure, fewer studies have examined the drivers of agricultural growth and productivity effects, especially in Africa. The limited research on productivity effects of public agricultural expenditure in many developing countries was largely due to the lack of extended time series expenditure data and when they used were, it was for short periods of time (not more than 10 years). However, fewer studies –Benin & Nin-Pratt (2015) for Africa; Benin, Mogues, Cudjoe & Randriamamonjy (2012) for Ghana; Mogues, Fan & Benin (2015) for Ethiopa; Fan, Nyange & Rao (2012) for Tanzania; and Fan & Zhang (2008) for Uganda– used longer period data and revealed that public expenditure influenced productivity and economic growth thus providing established evidence of the effect of public spending on agricultural productivity.

Understanding this effect can offer beneficial policy visions for the government to enhance the efficiency of its public spending on agriculture. In addition to physical inputs, agricultural productivity can also be enhanced by quality spending on health care services, educational services and farm feeder roads among others (Baldos et al., 2018). This paper eeks to achieve this objective by examining the effect of public funding on agricultural productivity in Nigeria across main agro-ecological regions (1981-2018), as well as assessing marginal effects of public spending on health care facilities, education and farm feeder roads and their returns to agricultural productivity.

The paper is ordered as follows: section one is the introduction; section two looks at the methodological approaches used in this study, while section three presents results and discussions. Section four concludes the paper.

2. Methodology

2.1. Area of study

The study area is major agro-ecological regions in Nigeria (Figure 1, Table 1). These are marginal/ short grass savannah, derived woodland/long grass savannah, rainforest and mangrove/swamp. Nigeria has a geographical area of 923,768 square kilometres with an estimated population of about 170 million (Central Bank of Nigeria's [CBN] 2016 estimates). It lies wholly within the tropics along the gulf of Guinea on the western coast of Africa. The country has highly diversified agro-ecological conditions, which makes it possible to produce a wide range of agricultural products. Less than 50% of the country's cultivable agricultural land is under cultivation. Moreover, smallholder and traditional farmers who use rudimentary production techniques, with resultant low yields, cultivate most of these lands. The country is divided into seven agro-ecological regions but four are distinctive and are used as the basis of analysis for this study (Figure 1).

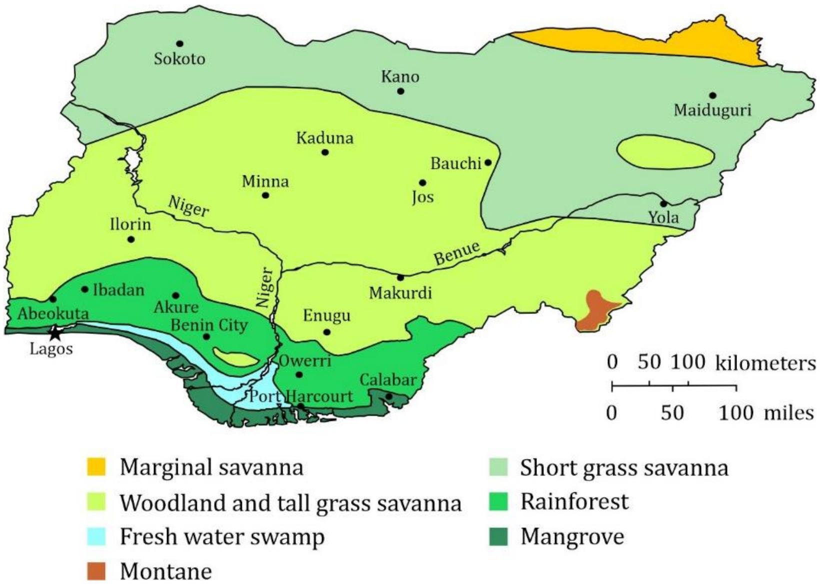

Figure 1. Map of Nigeria showing agro-ecological regions. Source: www.nigerianstat.gov.ng/nada/index.php/catalog

Table 1. Major agro-ecological regions in Nigeria

s/n	Major agro-ecological zones	States	Major agricultural activities	Vegetation
1	Marginal/Short grass savanna.	Bauchi, Borno, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara.	Cotton, groundnut, sorghum, millet, maize and wheat. Locust bean trees (*Parkia filicoidea*), tamarind tree (*Tamarindus indica*) and mango (*Mangifera indica*).	Low average annual rainfall of 657.3 mm and prolonged dry season (6-9 months).
2	Derived woodland/Long grass savanna.	Abuja, Adamawa, Benue, Gombe, Kaduna, Kogi, Kwara, Nassarawa, Niger, Plateau and Taraba.	Grazing livestock such as cattle, goats, horses, sheep, camels, and donkeys. Maize, cassava, yam and rice.	This zone experiences lower rainfall, shorter rainy season and long dry period.
3	Rainforest.	Abia, Anambra, Ebonyi, Edo, Ekiti, Enugu, Ogun, Ondo, Osun, and Oyo.	Staple crops like, yam, cassava, cocoyam, sweet potatoes, melon, groundnut, rice maize and oil palm (*Elaeis guineensis*), cocoa (*Theobroma cacao*), rubber (*Hevea brasiliensis*) banana/plantain (*Musa* spp.), cotton and kola nut (*Cola nitida*). Cowpeas and beans as well as several fruits. Various timber trees such as the African mahogany, the scented sapele wood *Entandrophragma cylindricum*) and iroko (*Chlorophora excelsa*).	Prolonged rainy season, resulting in high annual rainfall above 2000 mm.
4	Mangrove/Swamp.	Akwa Ibom, Bayelsa, Cross Rivers, Delta, Lagos and Rivers.	Oil-palm, cocoa, cassava, maize, yam. Various palm and fiber plants such as *Raphia* spp., *Raphia vinifera*, the wine palm and *Raphia hookeri*, the roof-mat palm.	Prolonged rainy season and lagoons overflow banks in the wet season (8-9 months). Thus longer rains, has led to badly leached soils and severe erosion.

Sources: [1] https://soilsnigeria.net; [11] Oyenuga (1967); [iii] Materials from https://www.fao.org; [iv] Sowunmi & Akintola (2010).

2.2. Method of data collection

Due to the nature of this research, public expenditure on agricultural and related non-agricultural enterprises data were collected. Data were sourced from the Ministry for Agriculture and other significant ministries, departments, agencies, and offices responsible for finance, budget and planning. The study conceptualized agriculture and agricultural activities to include arable and covers crop, livestock, forestry and fisheries. Public expenditure was deduced as annual and complementary appropriations (budget) that support funding of direct and indirect agricultural activities. Public finance data were also sourced from the Ministry of Finance (Nigeria), public expenditure data from other key sectors, the Central Bank of Nigeria's (CBN) Statistical Bulletin (2018). Public expenditure data (1980-2018) on agriculture was obtained from the Budget and Economic Planning office (Federal Ministry of Finance Abuja), the National Bureau of Statistics' (NBS) annual abstract (various issues), and the Agricultural Development Project (ADP) Offices.

While public expenditure data on the non-agricultural sector at the national level for education, health care facilities and farm feeder roads were taken from the individual government ministries, departments and agencies, data on agricultural production, private farm investments and other farm-household physiognomies were sourced from the most recent National Living Standards Survey. Data on education and health care facilities and services access were acquired from the latest report of the Core Welfare Indicators Questionnaire (CWIQ). Data on farm feeder roads and associated information were sourced from the Federal Ministry of Transport and Aviation and State Ministries of Transport. These variables used in the analysis were presented in Table 2. All monetary values were changed into year 2000 constant prices using the local consumer price index to exclude the influence of inflation and other temporal monetary and fiscal trends.

Table 2. Description and statistical summaries of major variables used

Variable name	Variable description	Mean	Standard dev.	Data source
TOAGR	Total value of agricultural-output per capita of a household. It's also the value of total agricultural investments made and inputs used by the household in the survey scenario (₦6500 naira per capita).	5,872.27	138.26	Min. of Agric.
PUEXP	Labelled as a function of public expenditure in agriculture. It is also based on:			Annual Budget (various issues)
	(i) developmental expenditures and	43.05	6.16	
	(ii) recurrent expenditures.	148.19	13.62	
FACDEV	Other factors influencing public-investment that motivate enterprise growth in agriculture, like infrastructures (good farm access roads, storage facilities), education, health care facilities.	2.25	0.62	Annual Budget (various issues)
Access farm roads	This is to deduce the quality of farm-access roads to residences and markets and its significance on income generation: rainforest/mangrove			CWIQ
	(i) Good farm access roads: 0.5 0.25 0.0 0.0	1.5	0.58	
	(ii) Moderate farm access roads: 0.5 0.75 0.75 0.5	1.75	0.50	
	(iii) Poor farm access roads: 0.0 0.0 0.25 0.5	2.25	0.52	
Education	Proportion of household members that have completed level of formal education and its significance on income generation: rainforest/mangrove			Min. of Education
	(i) No formal-education: 0.5 0.5 0.0 0.0	1.5	0.57	
	(ii) Completed primary school: 0.5 0.5 0.25 0.5	2.5	0.58	
	(iii) Completed secondary school: 0.0 0.0 0.25 0.5	3.25	0.96	
	(iv) Post-secondary attempt/completed: 0.0 0.0 0.5 0.0	2.5	0.58	

Table 2 (continuation). Description and statistical summaries of major variables used

Variable name	Variable description	Mean	Standard dev.	Data source
Access to health care	*Proportion of households living within vicinity of health facility:*			CWIQ
	(cf.: up to 15 minutes): rainforest/mangrove			
	(i) 15-29 minutes: 0.00 0.00 0.25 0.00	2.0	0.82	
	(ii) 30-44 minutes: 0.25 0.50 0.50 0.25	2.5	0.58	
	(iii) 45 minutes or more: 0.75 0.50 0.25 0.75	2.75	0.50	
SOCIOXT	*Household characteristics:*			CWIQ
	(i) Household size: Number of household members (adult equivalents)	5.93	1.65	
	(ii) Gender of head: Male = 1 and Female = 0	0.62	0.31	
	(iii) Age of head: Age of household head (years)	51.23	5.28	
	(iv) Adult labour: Proportion of members aged 18 to 64	0.32	0.17	
	(v) Male labour: Proportion of members that are male	0.47	0.21	
	(vi) Female labour: Proportion of members that are male	0.52	0.43	
	(vii) Employment: Proportion of members employed	0.35	0.08	
	(viii) Income diversification/strategy rainforest/mangrove			
	Subsistence farming only: 0.0 0.0 0.50 0.50	1.57	0.48	
	Semi commercial farming only: 0.0 0.0 0.0 0.0	0.0	0.0	
	Subsistence farming + Market-oriented crops: 0.25 0.25 0.25 0.25	2.0	1.41	
	Semi commercial farming + Market-oriented: 0.0 0.0 0.0 0.0	0.0	0.0	
	Subsistence farming + Non-farm activity: 0.50 0.25 0.25 0.25	3.25	0.96	
	Semi commercial farming + Non-farm activity: 0.25 0.5 0.0 0.0	3.0	0.82	
	(ix) *Farm assets characteristics rainforest/mangrove*			
	Population 2009 projections: 63500175 45889717 22175254 18640172	1502053	4,423.85	
	Proportion of households living below poverty line (%): 36.53 33.87 32.43 38.73	18	2	
	Total land area (1000 sq. km): 338,206 380,728 121,355 69,100	36.39	2.80	
	Farm size: Acres of farmland (%): 37.17 41.90 13.51 7.42	227347	38,431	
	Livestock assets:			
	No of tropical livestock units: 11,936.41 5427.92 482.52 215.30			
	Value of crop production equipment			
	(N20,000 per capita): 7203.15 917.31 728.17 253.28			
	% of population with agriculture as main activity: 71.26 65.03 41.03 35.17			
AGRO ZONE	*Agro-ecological zones:*			CWIQ
	(i) Marginal/Short grass savanna; public expenditures on agriculture	31.58	3.82	
	Marginal/Short grass savanna; agriculture contribution to GDP	29.98	4.17	
	(ii) Derived woodland and long grass savanna; public expenditures on agric.	47.17	5.24	
	Derived woodland and long grass savanna; agriculture contribution to GDP	31.32	3.02	
	(iii) Rainforest; public expenditures on agriculture	36.71	4.14	
	Rainforest; agriculture contribution to GDP	25.27	5.02	
	(iv) Mangrove/Swamp: Public expenditures on agriculture	17.64	6.16	
	Mangrove/Swamp: Agriculture contribution to GDP	13.34	5.28	

Source: Various federal and state government agencies.

2.3. Empirical links between public expenditure and agricultural growth

Public expenditure is a significant factor which aims at financing the incentives for development, creating a fertile ground for the promotion of private sector investments and enterprise growth. Hence, it could also influence enterprise growth. Several models have been used to examine this link. Fan et al. (2000) and Benin et al. (2009) modelled a simultaneous equation approach to establish the links between public expenditure and agricultural growth. These studies argued that the composition of public expenditure for major agricultural drivers should be paramount. Taking a lead from the works of Wu et al. (2010), the composition of government-expenditure is modelled:

$$V_{it} = k\ (PEXPGDP_t, GDP\%_t, DV_t, U_t) \quad (1)$$

Where V_{it} is the share of *ith* sector (agricultural) in total government expenditure, *t* for time, *PEXPGDP* is public expenditure as a percentage of GDP, $GDP\%_t$ is per capita GDP, DV_t is a dummy variable that is equal to 1 when macroeconomic regulations are implemented and equal to 0 otherwise. Macroeconomic regulations regulate monetary, fiscal, trade policies, exchange rate and inflation. U_t are unexplained factors in the equation and can influence government expenditure efficiency. In order to avoid the possibility of an endogeneity problem with the independent variables, the GMM instrumental variable was adopted (Dhrymes, 1973). Moreover, GMM[1] take care of any possible presence of unit roots or non-stationarity of variables that may cause spurious regression results. Hence equation (2) was structured to reflect this procedure and presented as:

$$TOAGR = f\ (PUEXP, FACDEV, PRODET, DRIVERS, IDFACT, SOCIOXT, \beta_0\ \beta_1\ \beta_2) \quad (2)$$

where

TOAGR: Total value of agricultural output per capita of a household.
PUEXP: Function of public expenditure in agriculture (where $PUEXP_p = PUEXP_{ca} + PUEXP_{rc}$).
$PUEXP_{ca}$: Public capital expenditure in agriculture.
$PUEXP_{rc}$: Public recurrent expenditure in agriculture.
FACDEV: Other factors that motivate agricultural enterprise growth like infrastructures, farm feeder roads, education, access to quality health-care facilities.
PRODET: Production functions of the determinants of public spending to use.
DRIVERS: Drivers of agricultural growth that motivate enterprise-development like, research and development, credit delivery services, extension services.
IDFACT: Indirect factors influencing agricultural enterprise growth.
SOCIOXT: Socioeconomics characteristics and institutional factors that could influence production process.
$\beta_0\ \beta_1\ \beta_2$: Are vectors of parameters to be estimated for the equation.

$$FACDEV = f\ (PUEXP, PRODET, DRIVERS, IDFACT, SOCIOXT, \beta_1\ \beta_2) \quad (3)$$

$$DRIVERS = f\ (INTERPOL, PRODTE, IDFACT, \beta_1\ \beta_2) \quad (4)$$

INTERPOL: Intervention policies of the government to stimulate and motivate enterprise growth in agriculture.
$\beta_1\ \beta_2$: Are vectors of parameters to be estimated for the respective equations (3) and (4).
TOAGR: Captures the level of impact of public investments for enterprise growth in agriculture (equation 2).

Equation (3) examines enterprise growth within public expenditure and the indirect effects of public expenditure on enterprise growth. Equation (4) considers the location effects (agro-ecological zone of the country) of public expenditure and government intervention on the drivers of enterprise growth programs. Thus, by including public expenditure and intervention in other sectors in equation (4), the study tried to capture possible interactions between expenditure on the non-agricultural and agricultural sectors.

[1] Dickey-Fuller approach have been used for tests of presence of unit roots or non-stationarity.

2.4. Marginal effect of public expenditure on agricultural growth

Marginal effect of public investments on agricultural growth was estimated as:

$$\in DRIVERS = \frac{dTOAGR}{dPUEXP} = \frac{\partial TOAGR}{\partial PUEXP} + \frac{\partial TOAGR}{\partial FACDEV}\ X\ \frac{\partial FACDEV}{\partial PUEXP} \text{----------} \quad (5)$$

$\in$ *DRIVERS* is the marginal effects of the drivers of agricultural growth that motivate enterprise development such as research and development, credit delivery services, extension services. Therefore, this equation measures the direct effect of public investment in agriculture.

$$Thus\ = \frac{dTOAGR}{dPUEXP}\, and\ \frac{\partial TOAGR}{\partial PUEXP} + \frac{\partial TOAGR}{\partial FACDEV}\ X\ \frac{\partial FACDEV}{\partial PUEXP} \text{-captured the indirect effect}$$

Equation (5) hypothesized the typical vector of production function estimates with respect to farm investments (i.e. factors of production and inputs). This equation captured the elasticity of agricultural productivity with respect to public investment in the other sectors ($\in$ *IDFACT*), which is a function of βp βk and βa, and can be obtained by:

$$\in IDFACT = \frac{dFACDEV}{dIDFACT} = \frac{\partial FACDEV}{\partial IDFACT} + \frac{\partial FACDEV}{\partial PRODET}\ X\ \frac{\partial PRODET}{\partial IDFACT} + \in DRIVERS\ X\ \frac{dTOAGR}{dPUEXP} \quad (6)$$

2.5. Marginal returns on public spending

Marginal returns on public investments (i.e. the benefit-cost ratio or *BCR*) can be computed by multiplying equations (7) and (8) with the relevant ratio of agricultural output per capita to public investment (Benin et al., 2009; Fan et al., 2000):

$$BCR\ DRIVERS = \in DRIVERS\ X\ \frac{FACDEV}{DRIVERS} \quad (7)$$

$$BCR\ IDFACT = \in IDFACT\ X\ \frac{FACDEV}{IDFACT} \quad (8)$$

Marginal returns provide information for comparing the relative benefits of an additional unit of public spending.

2.6. Estimation techniques and concerns

The study adopted estimation techniques of a Three-Stage Least Squares (3SLS) method to appraise equations (1), (2), (3), and (4) simultaneously, following a previous study (Amemiya, 1977). Past studies argued that the 3SLS method is best fit to estimate all coefficients in the equations simultaneously, while, equations that are under-identified are disregarded in the 3SLS estimation (Gallant & Dale, 1979; Jorgenson & Laffont, 1975). The 3SLS estimates were used to estimate the linear equations (eqns. 1-4) with cross-equation constraints (public expenditure) imposed, but with a diagonal covariance matrix of the disturbances across equations (Dhrymes, 1973).This process helps to obtain the parameter estimates that form a consistent estimate of the covariance matrix of the disturbances, which was used as a weighting matrix, this led to a model re-estimation to obtain new values of the parameters used in the subsequent equations.

Past studies argued that when these techniques and estimations are considered, some issues and concerns need to be clarified (Benin et al., 2009; Fan et al., 2000). Firstly, the estimation techniques require an equal number of observations for each of the independent variables and to address this concern, each low independent variable data will be aggregated upwards to be the same as others (Gallant & Dale, 1979). In addition, in estimating the variance and standard errors, the study emulates the work of Hsieh & Lai (1994) who adopted the delta method (∈) for the estimation technique. Hence, the typical form of the probable elasticities of the method:

$$\in = f\ (\widehat{\beta_0}\ \widehat{\beta_1}\ \widehat{\beta_2}) \tag{9}$$

Also, the variance of the probable elasticities, adopting the delta method and the variance-covariance matrix of the coefficients (∑ ∈^), can be achieved using the general form:

$$Var\ (\in) = \left[\left(\frac{\partial f}{\partial\beta 0}\right)\left(\frac{\partial f}{\partial\beta 1}\right)\left(\frac{\partial f}{\partial\beta 2}\right)\ x\ \sum\left[\ \left(\frac{\partial f}{\partial\beta 0}\right)\left(\frac{\partial f}{\partial\beta 1}\right)\ \left(\frac{\partial f}{\partial\beta 2}\right)\right]T\right. \tag{10}$$

Moreover, the identification issue in the equation that might occur during estimation especially in the equation (1) was addressed by exploiting exclusion restrictions i.e. excluding some of the explanatory variables (or instruments) used in estimating the equation (2). Another concern the study dealt with was the issue of multicollinearity due to a large set of explanatory variables data. Hence, the Variance Inflation Factor (VIF) was adopted to take care of this (Greene, 1993). The results of this study, however (to the knowledge of the researcher), do not reflect any biased estimates.

3. Results and discussion

3.1. Public expenditure on agriculture in agro-ecological regions and contribution to Gross Domestic Product (1981-2018)

Table 3 reviewed public spending on agriculture in main agro-ecological regions and its contribution to GDP from 1981-2018. The results indicated that from 1981-2018, the share of statutory budget (public spending) allocation to agricultural development was 4.88% across zones, but the marginal/short grass savanna agro-ecological region received the highest (7.32%), while the mangrove/swamp agro-ecological zone received 2.39%. The agricultural contribution to GDP (%) from 1981-2018 averaged 35.14% with the marginal/short grass savanna agro-ecological area reaching 29.13% while the mangrove/swamp agro-ecological area stood at 4.32%. Total funding (shares) to the agricultural sector also indicated 32.52%, 47.16%, 37.80%, and 17.82% for marginal/short grass savanna, derived/woodland long grass savanna, rainforest and mangrove/swamp agro-ecological areas respectively.

The results revealed that public spending on agricultural sectors across the agro-ecological zones had been very poor. Often, intervention of both local and foreign direct investments has been used to augment and finance agricultural projects in Nigeria. Intervention of both local and foreign direct investments on agriculture during the years under focus showed 63.47%, 76.51%, 80.34% and 74.69% in marginal/short grass savanna, derived/woodland long grass savanna, rainforest and mangrove/swamp agro-ecological regions respectively (Table 3). This finding was corroborated by the studies of Mongues et al. (2008) and Manyong et al. (2005) who acknowledged the role these intervention agencies (local and foreign direct investments) played in agricultural development in Nigeria.

Concerns arise about whether public funding in agriculture enhanced agricultural productivity in the identified agro-ecological zones, particularly the marginal/short grass savanna. This may be considered in future research.

Table 3. Agricultural budget and expenditure appropriation for agro-ecological zones and contribution to GDP (1981-2018)

Major agro-ecological zones	Share of States Statutory Budget allocation to agricultural development (%)	Share of Federal Government intervention to agricultural develop. (%)	Share of Local and International Aids/Intervention to agricultural development (%)	Total funding (shares) to agricultural sector (%)	Agriculture contribution to GDP (%)
1981-1985 35.10*					
Marginal/Short grass savanna	07.62	05.01	26.02	38.65	40.02
Derived/Woodland and long grass savanna	06.72	06.03	41.05	53.80	24.94
Rainforest	05.27	04.92	24.02	34.21	23.01
Mangrove/Swamp	02.62	02.72	08.91	14.25	12.03
1986-1990 36.58*					
Marginal/Short grass savanna	07.02	06.12	29.83	42.97	23.71
Derived/Woodland and long grass savanna	05.62	05.14	42.88	53.64	39.52
Rainforest	03.18	03.83	22.81	29.82	25.04
Mangrove/Swamp	02.16	02.92	07.27	12.35	11.73
1991-1995 32.66*					
Marginal/Short grass savanna	05.17	05.04	13.07	23.28	24.84
Derived/Woodland and long grass savanna	04.04	05.20	29.83	39.07	27.47
Rainforest	03.92	03.18	45.05	52.15	29.31
Mangrove/Swamp	02.02	02.03	12.05	16.10	18.38
1996-2000 33.08*					
Marginal/Short grass savanna	06.05	05.21	12.45	23.71	26.01
Derived/Woodland and long grass savanna	05.47	05.82	31.54	42.83	31.36
Rainforest	03.45	03.29	41.29	48.03	27.38
Mangrove/Swamp	02.37	02.05	14.72	19.14	15.25
2001-2005 38.42*					
Marginal/Short grass savanna	07.67	04.86	11.85	24.38	31.05
Derived/Woodland and long grass savanna	06.25	05.14	28.18	39.57	26.91
Rainforest	04.46	03.06	35.07	42.59	27.82
Mangrove/Swamp	02.84	02.64	24.90	30.38	14.22
2006-2010 31.72*					
Marginal/Short grass savanna	8.20	04.52	27.81	40.53	32.61
Derived/Woodland and long grass savanna	7.60	04.38	42.06	54.04	34.05
Rainforest	4.70	02.91	17.85	25.46	22.28
Mangrove/Swamp	2.31	01.63	12.28	16.22	11.06
2011-2015 21.35*					
Marginal/Short grass savanna	6.82	03.85	23.43	34.10	30.80
Derived/Woodland and long grass savanna	6.31	03.82	37.06	47.19	33.05
Rainforest	3.82	02.03	26.47	32.32	23.63
Mangrove/Swamp	1.70	01.57	13.04	16.31	12.52
2016- 2018 24.85*					
Marginal/Short grass savanna	7.01	04.39	24.05	36.28	33.82
Derived/Woodland and long grass savanna	6.48	04.17	37.28	47.44	36.17
Rainforest	5.16	04.02	28.05	36.11	28.02
Mangrove/Swamp	3.01	02.06	13.41	18.05	14.17

Notes: *aggregate value for the scenarios considered. Sources: Federal Ministry of Agriculture and Rural Development (FMARD), FAOSTAT data 2005 and 2015, World Bank, NBS: Annual abstract of statistics (various issues), Central Bank of Nigeria - Statistical Bulletin (various issues), Federal Ministry of Finance (Budget office), Authors' computation based on data from SPARC (2014): Based on data from Federal Ministry of Agriculture and Rural Development, and State Ministries (1981-2014).

3.2. Regression estimates of the determinants of agricultural production in the agro-ecological zones of Nigeria

Three-stage least squares (3SLS) regression results were presented in Tables 4 and 5. Analyses were done in phases, firstly, by means of the joint total sample and then separately for the four agro-ecological zones. The analysis was based on the data provided to update equations (2) and (3).

Table 4. Three-stage least squares regression estimates of the determinants of agricultural production in Nigeria (Equation 2: Ln $TOAGR_k$): Using aggregate public agricultural expenditures

Explanatory variables	Total sample	Agro-ecological zone			
		Marginal savanna	Derived savanna	Rainforest zone	Mangrove/ Swamp zone
Total value of agricultural output per capita of a household: Ln *TOAGR*	0.037***	0.015***	0.006***	0.312**	-0.436**
Public capital expenditure in agriculture: Ln $PUEXP_T$					
(i) Developmental expenditures and	0.251**	0.044***	0.328**	0.427**	-0.512*
(ii) Recurrent expenditures	0.712	0.682	0.841	-0.735*	-0.438**
Ln *FACDEV*					
Access farm roads					
(i) Good farm access roads	0.004***	0.062***	0.092***	0.037***	0.731
(ii) Moderate farm access	0.382**	0.061**	0.639*	0.839*	0.829
(iii) Poor farm access roads	0.885	0.993	0.841	-0.382*	-0.751*
Education:					
(i) No formal education	-0.0716**	0.917	0.310	0.082	0.904
(ii) Completed primary school	0.071*	0.091*	0.852	0.554	0.628
(iii) Completed secondary school	0.005***	0.018**	0.031**	0.001***	0.048*
(iv) Post-secondary attempt/completed	0.000***	0.010**	0.049**	0.000***	0.006***
Access to health care:					
(i) 10–30 minutes	-0.0716**	0.917	0.310	0.082	0.904
(ii) 31-45 minutes	0.071*	0.091*	0.852	0.554	0.628
(iii) 46 minutes or more	0.005***	0.018**	0.031**	0.001***	0.048*
SOCIOXT:					
(i) Gender of head: Dummy variable for head of household: 0 = female, 1 = male	0.028	0.082	0.175	0.098*	0.497
(ii) Ln Household size	-0.002***	0.091*	0.852	0.554	0.628
(iii) Ln Age of head: Age of household head (years)	-0.028**	0.048**	0.073*	0.008***	0.937
(iv) Adult labour: Proportion of members aged 18 to 64	0.006***	0.027**	0.076*	0.005***	0.184
(v) Male labour: Proportion of members that are male	0.0911*	0.082*	0.063*	0.492	0.739
(vi) Female labour: Proportion of members that are male	0.583	0.073	0.279	0.048	0.078
(vii) Ln Employment: Proportion of members employed	0.004***	0.007***	0.028**	0.059*	0.066*
Agro-ecological zones:					
Public expenditures on agriculture	0.005***	0.018**	0.027**	0.073*	0.846
Agriculture contribution to GDP	0.000***	0.000***	0.001***	0.004***	0.732
Intercept	7.058***	4.927***	5.924***	3.017***	-2.018*
Model estimation statistics					
(i) Chi-square	1902.07	428.93	631.04	310.73	294.61
(ii) R-square	0.371	0.282	0.341	0.258	0.225
Number of observations					
Model identification test (exclusion restriction)	3.061	2.301	2.934	1.947	1.305
Hansen's *J* chi-square statistic					

Notes: See Table 2 for a detailed description of the variables. All continuous variables are transformed by natural logarithm, which is indicated by Ln *, ** and *** means that the coefficient is statistically significant at the 10 percent, 5 percent or 1 percent level, respectively. Source: own elaboration.

Table 5. 3SLS regression estimates of the determinants of agricultural production in Nigeria (Equation 3: Ln $FACDEV_p$): Using aggregate public agricultural expenditures

Explanatory variables	Total sample	Agro-ecological zone			
		Marginal savanna	Derived savanna	Rainforest zone	Mangrove/ Swamp zone
Ln *PUEXP*	0.005***	0.0400**	0.0410**	0.062*	-0.942
(i) Developmental expenditures and	-0.0301*	0.714*	0.649	-0.021**	-0.007***
(ii) Recurrent expenditures					
Ln Access farm roads					
(i) Good farm access roads	0.023**	0.075*	0.029**	0.713	0.615
(ii) Moderate farm access	0.016**	0.032**	0.062*	0.912	0.814
(iii) Poor farm access roads	-0.062*	0.617	0.153	-0.032**	-0.077*
Education:					
(i) No formal education	-0.005***	0.013**	0.418	0.995	-0.043**
(ii) Completed primary school	0.034**	0.083*	0.401	0.703	0.001***
(iii) Completed secondary school	0.000***	0.001***	0.004***	0.000***	0.010**
(iv) Post-secondary attempt/completed	0.000***	0.000***	0.000***	0.000***	0.000***
Access to health care:					
(i) 10–30 minutes	0.003***	0.044**	0.005***	0.013**	0.037**
(ii) 31-45 minutes	0.031**	0.084*	0.852	0.930	0.111
(iii) 46 minutes or more	-0.003***	-0.038**	-0.048**	-0.008***	-0.017**
SOCIOXT:					
(i) Gender of head	0.014**	0.015**	0.008***	0.042**	0.067**
(ii) Ln Household size	0.000***	0.000***	0.005***	0.006***	0.910
(iii) Ln Age of head: Age of household head (years)	0.084*	0.017**	0.027**	0.003***	-0.025**
(iv) Adult labour: Proportion of members aged 18-64	0.009***	0.047**	0.000***	0.018**	0.837
(v) Employment: Proportion of members employed	0.927	0.187	0.672	0.816	0.328
Income diversification/strategy:					
(i) Subsistence farming only	0.048**	0.946	0.074**	0.007***	0.729
(ii) Subsistence farming + Market-oriented crops	0.008***	0.010**	0.000***	0.006***	0.071*
(iii) Subsistence farming + Non-farm activity	0.008***	0.004***	0.000***	0.006***	0.067*
(iv) Semi commercial farming + Non-farm activity	0.001***	0.002***	0.004***	0.027**	0.927
Intercept	0.082*	0.962	0.091*	0.052*	0.862
Model estimation statistics					
Chi-square	6281.06	2800.14	4320.91	3006.16	1104.52
R-square	0.574	0.497	0.503	0.417	0.389
Number of observations					

Notes: See Table 2 for a detailed description of the variables. All continuous variables are transformed by natural logarithm, which is indicated by Ln. *, ** and *** means that the coefficient is statistically significant at the 10 percent, 5 percent or 1 percent level, respectively. Source: own elaboration.

Tables 4 and 5 clearly indicated the significant role public spending played in agricultural output and factors influencing agricultural productivity. Public spending on the agricultural sector (1981-2018) had a significant and positive impact on agricultural output. The Model Statistics R-square of 52.3% indicated a moderately goodfit. Moreover, most of the variables considered had their explanatory variables coefficients statistically significant at the 10%, 5% or 1% level, respectively. The regression results reveal that public spending on the agricultural sector in recent years has had a substantial positive influence on agricultural productivity, either directly or through better private farm investments . For all the zones together, the marginal effect is assessed at 0.037 (Table 4). This means that a one percent increase in agricultural public expenditure is related to a 0.04 percent increase in the value of agricultural production per capita.

3.3. Public agricultural spending and marginal agricultural productivity effects

Regression estimates of the drivers of agricultural public expenditure in Nigeria were presented in Table 6. Model fit indicators revealed R^2 of 0.54, which is 54% of the independent variables considered and thus explained the model. The access to farm road variable was 0.045, the access to education variable was 0.071 and access to health (within 15-30 minutes' walk to health facility) was 0.013, all significant at 1% level suggesting that a 1% increase in the funding of education access, farm feeder roads and health facilities will enhance agricultural productivity per capita by 0.043. Regression estimates of the drivers of agricultural public expenditure in Nigeria (Equation 4: Ln $PUEXP_T$) were presented in Table 6. Moderate access to farm roads was significant and positive (for capital expenditure), but insignificant for recurrent expenditure. This result suggests that poor farm access roads contributed negatively to agricultural productivity. In addition, secondary school education completing the above variables was a significant factor enhancing human development which translates to productivity. The access to health care variable (where the majority could walk to health facilities centres within 45 minutes) revealed a positive significance.

Table 6. Ordinary least squares regression estimates of the drivers of agricultural public expenditure in Nigeria (Equation 4: Ln $PUEXP_T$) using aggregate public agricultural expenditure

Explanatory variables	$PUEXP_{Total}$	$PUEXP_{capital\ exp}$	$PUEXP_{recurrent\ exp}$
DRIVERS			
Ln Access farm roads:			
(i) Good farm access roads	0.045***	0.032**	0.326*
(ii) Moderate farm access	0.067*	0.082*	0.824
(iii) Poor farm access roads	-0.072*	-0.062*	-0.007***
Education:			
(i) No formal education	0.842	0.518	0.739
(ii) Completed primary school	-0.041**	0.619	0.618
(iii) Completed secondary school	0.071***	0.043**	0.042**
(iv) Post-secondary attempt/completed	0.000***	0.000***	0.007***
Access to health care:			
(i) 10-30 minutes	0.013***	0.007***	0.025**
(ii) 31-45 minutes	0.036**	0.052*	0.839
(iii) 46 minutes or more	-0.033**	-0.025**	-0.046**
SOCIOXT:			
Ln Population	0.583	0.618	0.528
Ln Proportion of households living below poverty line	0.937	0.738	-0.045**
Ln Total land area	0.617	0.613	0.816
Ln Farm size: Acres of farmland	0.056*	0.043**	-0.068*
Ln Livestock assets:	0.038**	0.017**	0.062*
Ln Value of crop production equipment	0.052*	0.048**	-0.082*
Ln % of population with agriculture as main activity	-0.071*	0.005***	-0.083*
Agro-ecological zones:			
(i) Marginal/Short grass savanna	0.006***	0.000*	0.835
(ii) Derived/Woodland and long grass savanna	0.002***	0.000*	0.628
(iii) Rainforest	0.032**	0.015**	-0.081*
(iv) Mangrove/Swamp	0.069*	0.052*	-0.095*
Intercept	6.045***	5.015***	4.927***
R-square	0.525	0.473	0.620
Number of observations	8500	8500	8500
F-test statistic	9.717***	8.205***	7.417***

Notes: See Table 1 for a detailed description of the variables. All continuous variables are transformed by natural logarithm, which is indicated by Ln. *, ** and *** means that the coefficient is statistically significant at the 10 percent, 5 percent or 1 percent level, respectively. Source: own elaboration.

3.4. Marginal effects (elasticities) of public expenditure on agricultural productivity in Nigeria

Table 7 indicated the effect of public spending on the value of agricultural production per capita. This result fluctuates substantially across the four agro-ecological zones. The marginal effect of the analysis was positive and statistically significant across all four. The marginal effects of $PUEXP_{CE}$ were insignificant only for the mangrove/swamp zone but significant in the other agro-ecological areas, with elasticities of 0.782, 0.041, 0.042 and 0.35 in mangrove savanna, derived savanna, rainforest and mangrove/swamp zones respectively (Table 7). Access to education, access to farm roads and access to health care variables all played a significant and positive role in enhancing agricultural productivity. However, there were a few exceptions, particularly, the variable $PUEXP_{RE}$ on access to farm roads. The resulting effect of the insignificance of $PUEXP_{RE}$ in the mangrove/swamp zone was due to the neutralizing negative effects related to recurring spending. In addition, recurrent expenditure was negative and significant in the rainforest area due to the response of the variable as an exclusive driving force of agricultural productivity (Table 7).

Table 7. Marginal effects (elasticities) of public expenditures in Nigeria

Explanatory variables	Total sample	Agro-ecological zone			
		Marginal savanna	Derived savanna	Rainforest zone	Mangrove/ Swamp zone
Agriculture					
$PUEXP_{TN}$	0.026**	0.014**	0.017**	0.037**	0.071*
$PUEXP_{CE}$	0.018**	0.035**	0.042**	0.041**	0.782
$PUEXP_{RE}$	-0.047**	-0.028**	0.037**	-0.031**	0.419
Education					
$PUEXP_{TN}$	0.064*	0.092*	0.084*	0.025**	0.626
$PUEXP_{CE}$	0.077*	0.062*	0.033**	0.080*	0.506
$PUEXP_{RE}$	0.006***	0.011**	0.025**	0.062*	0.371
Access farm roads					
$PUEXP_{TN}$	0.004***	0.002***	0.009***	0.064**	0.001***
$PUEXP_{CE}$	0.007***	0.005***	0.002**	0.048**	0.817
$PUEXP_{RE}$	-0.024**	-0.017**	0.047**	-0.062**	0.502
Access to health care					
$PUEXP_{TN}$	0.008***	0.001***	0.000***	0.000***	0.004***
$PUEXP_{CE}$	0.007**	0.002***	0.002***	0.000***	0.021**
$PUEXP_{RE}$	0.219	0.772	0.618	0.529	0.916

Notes: Authors' calculations based on Tables 9 and 10 and equations and (4), (4') and (9). Estimate is statistically significant at the 10 percent, 5 percent or 1 percent level, respectively. Source: own elaboration.

3.5. Marginal cost of public services and agricultural productivity

Literature has revealed that public spending on drivers of agricultural growth such as infrastructural development and provision of basic amenities - access to good roads and primary health is *sine qua non* to agricultural development. Therefore, evaluating the requisite cost that would achieve this purpose is significant. To assess marginal returns of public spending on these indicators would require accessing information on the unit cost. Evaluating the financial implication of how much it would cost to educate the majority of Nigerians to attend at least primary school level entails assessing various channels that can facilitate attendance and knowledge impartation. These include provision of primary school institutions closer to the people, adequate teachers and motivation of teachers to provide quality teaching among others. Hence, the financial implication was estimated based on these criteria (Table 8).

Data were sourced from the Federal Ministry of Education, non-governmental agencies and other relevant sources. Average annual spending on public institutions was calculated and divided by the total number of pupils enrolled in the corresponding educational system. Thus, the estimated (on average) annual cost was computed. The result revealed ₦12,550.00/pupil/year ($34.86) for primary school pupils over the years under consideration. This was then multiplied by the number of people that completed at least primary education to arrive at the marginal cost (Table 8). The question arises: can this cost enhance human capital development? This is a matter to be discussed in future research. Data on access to health care were sourced through numerous outlets to estimate marginal cost using the methodology of Benin et al. (2009) that estimated the average unit cost from previous investments, where the accrued public capital stock is divided by total expenditure over several years. Due to data limitation, the study modified this approach. Firstly, data were sourced to calculate the average annual spending on provision of health facilities and second, access to health care services by most Nigerians. These steps enabled the study to source for data on the proportion of households living within 45 minutes of health-care facilities and that have access to moderate/quality health care. For example, access will improve when people themselves move closer to an existing facility or service or when they invest in ways to reach the facility for prompt service delivery.

Table 8. Marginal (one-percent increase in) stock and costs of public expenditures (1981-2018)

Explanatory variables	Total sample	Agro-ecological zone			
		Marginal savanna	Derived savanna	Rainforest zone	Mangrove/ Swamp zone
Education (₦ billion)	902.52	206.65	213.29	234.96	247.65
Marginal stock (population completed at least primary education) No in % of the population	65.67	38.17	56.48	89.72	78.29
marginal cost (%) (₦ billion)	12.30	3.04	3.25	2.49	1.83
Access to health care (₦ billion)	341.43	77.25	79.29	89.20	95.75
Marginal stock (households within 45 minutes' walk to health centre) No in %	36.74	28.16	33.28	47.26	38.26
marginal cost (%) (₦ billion)	37.53	12.16	10.78	7.12	4.85
Access farm roads (₦-Billion)	48.49	13.45	12.61	11.78	10.05
Marginal stock (farm access of km per sq km) No in %	62.77	81.06	72.92	58.36	38.72
marginal cost (%) (₦ billion)	21.54	12.15	7.90	3.05	1.70

Sources: www.epdc.org/Nigeria_coreusaid, www.ibe.unesco.org, www.nigerianstat.gov.ng/nada/index.php/catalog/27.

Following this deduction, the study sourced data and estimated the total number of households that resided within 45 minutes of a health facility and the number of people who visited these facilities for their health concerns. Thus, the total number of households were divided by the number of years under consideration to get the average annual change of the number of households existing within 45 minutes of a health centre. Therefore, the study estimated the average annual cost of providing public health services by the Federal Ministry of Health to be ₦68,006.00 ($188.91) (study estimate), and divided by the number of households living within 45 minutes of a health facility. To get the marginal cost, the unit cost of one household member within 15-45 minutes' walk to a health facility to obtain quality health services was then multiplied by the number of people that accessed these facilities (Table 8).

Similarly, estimating the marginal stock (i.e. farm access of km per sq. km in %) of people that have access to modest farm-roads was estimated by calculating how much it would cost to build one kilometre of rural road and the number of people that have access to these roads. To obtain the marginal cost concerning access to farm roads, total length of feeder roads was multiplied by the number of kilometres of road to farms and local markets and this outcome was used to obtain the marginal cost. Hence, the estimated unit cost of ₦23, 602.00 ($65.56) (study estimate) was gotten (Table 8). These marginal costs are then divided by their respective marginal effects to obtain estimated marginal returns.

3.6. Public investments and marginal agricultural productivity returns in Nigeria

Table 9 presents marginal agricultural productivity returns on public spending while Tables 7 and 8 present estimates of marginal cost and the marginal effects that were used for the estimate.

Table 9. Marginal agricultural productivity returns to public investments in Nigeria

Explanatory variables	Total sample	Agro-ecological zone			
		Marginal savanna	Derived savanna	Rainforest zone	Mangrove/ Swamp zone
Agriculture	12.97***	8.05**	7.08***	5.92**	2.05**
Education	3.03**	1.91	1.34	0.82***	0.42
Access to health care	5.14**	3.02***	2.61***	1.63**	1.71*
Access farm roads	5.03**	3.06***	2.91***	-2.35*	-0.82

Notes: See Table 1 for a detailed description of the variables. All continuous variables are transformed by natural logarithm, which is indicated by Ln. *, ** and *** means that the coefficient is statistically significant at the 10 percent, 5 percent or 1 percent level, respectively. Source: own elaboration.

Marginal effects were derived using Tables 4 and 5 as a guide and were presented in Table 7. The study computed the marginal cost by estimating the current population and then multiplied it with the unit cost (Table 8). Hence, marginal cost and marginal effects results were then used to assess the marginal agricultural productivity returns on the various types of public investment in the four agro-ecological zones (as displayed in equations 7 and 8). The results were presented in Table 9. The study revealed that significant amounts were extended to these indicators but returns were not commensurable (Table 9). For the years under consideration, the country had invested over ₦71.37 billion ($190M), while the marginal Nigerian naira (₦) invested in the agricultural sector was ₦12.97 ($0.036) as a margin of the total value of agricultural productivity returned. Surprisingly, drivers of agricultural productivity recorded low marginal Naira invested, (education ₦3.03, access to health care ₦5.14 and access to farm-roads ₦5.03). These results established a benefit-cost ratio of 4.4:1, meaning that increasing public spending on education, farm feeder roads and health care by 4.4% would enhance agricultural productivity by 1%. Although these indicators are significant and positive, according to world indicators, they are very low. Results of the agricultural productivity returns from access to farm roads indicated a negative in the rainforest and mangrove swamp zones. These outcomes thus suggest that vegetation in these zones did not create a smooth access for agricultural activities. The assessed marginal returns on the various types of public investments vary among the four agro-ecological zones, the highest being the marginal and derived savannah zones, followed by the rainforest area (Table 9). Marginal returns on public spending on education are the highest, followed by the health sector and finally, access to farm roads.

3.7. Policy implications of major findings

Public spending on agriculture in Nigeria remains low regardless of the signs used. Allocation to agriculture from total public spending (annual budget) averaged 4.88 percent between 1981 and 2018. The marginal/short grass savannah agro-ecological zone received the most (7.32%), while the mangrove/swamp agro-ecological area saw only 2.39%. Budgetary allocation to agriculture compared with other key sectors was also low despite the sector's role in the fight against poverty, hunger, and unemployment and in the pursuit of economic development. Agricultural contribution to GDP (%) from 1981-2018 averaged 32.70%, while total funding (shares) to the agricultural sector also indicated 32.52%, 47.16%, 37.80% and 17.82% across the zones respectively. In this regard, intervention of local and foreign direct investments in public spending on agriculture showed 63.47%, 76.51%, 80.34 and 74.69 in marginal/short grass savannah, derived/woodland long grass savannah, rainforest and mangrove/swamp agro-ecological areas respectively. This finding was supported by the studies of Mongues et al. (2008) and Benin & Nin-Pratt (2015) which recognized the role local and foreign direct investment intervention agencies played in agricultural development in Nigeria and in Africa.

Evidence from other African countries revealed that public expenditure on agriculture in Ghana averaged 3.5-6.9% in 1995-2005, in Kenya (6.5-7.5%) and in Uganda (3-10%). In Uganda, development/capital spending reliably accounts for around 15% of total sector spending, leaving 85% of the budget for recurrent costs. Hence international donor agencies have traditionally provided the majority of funding for development/capital operations in Uganda (Makhtar, 2017; Ministry of Foreign Affairs, 2005; Otsuka & Hayami, 1988). Recurrent expenditure (personnel stipends and general administration) took 70-80% in Ghana, and in Kenya, 69%. Intervention funding (such as international donors) i.e., non-government funding in agriculture (both local and direct investment) in Ghana is between 59.1-73.5% and in Kenya 62-83% (Ministry of Foreign Affairs, 2005). Moreover, Asia, China, India and Thailand allocated 10-15% of the state budget to agriculture with capital expenditure accounting for 75% of spending; only 25% of the budget is for salaries, operations and maintenance. In the European Union public spending and related spending to agricultural development is between 43.5% and 51.5% (European Commission, 2016a, 2017, 2018). These countries witnessed higher returns on agricultural productivity. Proof from the regression results show the positive and significant role public spending played in agricultural productivity. This suggests the significant role quality public spending plays in agricultural growth.

The marginal effect of educational access in Nigeria was positive in the savannah zones, suggesting that people with higher education also work on the farms. This finding was supported by Quiroga et al. (2017) and Kostlivý et al. (2017). Access to quality health services holds universally true, hence, inclusive access to health services enhanced productivity. The study's result of the marginal effects (0.028) for access to farm roads was significant and positive indicating that a 1% increase in agricultural public spending on road development is related to an 0.028 increase in the value of agricultural production per capita. Meanwhile improved spending on health and rural roads independently could motivate better agricultural productivity. Hence, this study suggests that harmonizing along with quality spending on access to health, education and rural roads for the enhancement of agricultural productivity is paramount.

Annual budget allocation to education is the largest among all sectoral public spending in Asia: at $87 per person, while in Europe it reaches $115, and in South America $45-52 per person (European Commission, 2017, 2018) whereas in sub-Saharan Africa (SSA) countries spent a meagre $11per capita for education and $8 for infrastructure from 2007 to 2013 (Ojiako et al., 2016). In Nigeria, the study indicated $8 per person was spent to acquire a minimum education (at least primary education). Hence, public spending on the educational sector in Nigeria is low compared to other countries. In Asia, Europe, South America and other developed countries the educational sector received precedence in resource allocation, with about 16% of the government budget dedicated to educational related activities (Kostlivý et al., 2017; Quiroga et al., 2017), while in Nigeria less than 9% is allocated to education, and less than 7% to health and roads during the years under review.

4. Conclusions

The study examined the effect of public spending on agricultural productivity in Nigeria (1981-2018). The results revealed that public spending on agriculture in Nigeria is poor by international standards and therefore limited agricultural productivity. Also, public spending on drivers of agricultural growth such as access to quality health care, education and farm feeder roads that can enhance agricultural productivity was poor throughout the years under review, hence, meagre agricultural productivity returns. Benin & Nin-Pratt (2015), Benin (2015), Alene & Coulibaly (2009), Fan et al. (2008) and Thirtle, Lin & Piesse (2003) revealed evidence of agricultural productivity returns on quality public spending on agricultural sectors as well as on drivers of agricultural growth (access to health care facilities, education and farm feeder roads).

Consequently, quality public spending can be efficiently used to motivate agricultural growth and improve agricultural productivity. Nigerian governments need to increase public spending on agriculture and drivers of agricultural growth (farm feeder roads, education and healthcare.) The study revealed that in Nigeria, these drivers were not effectively motivated and were poorly funded. In addition, the low budget (less than 5%) appropriated to agriculture during the reviewed years influenced poor agricultural productivity returns. Hence, the study recommends that governments should improve on the existing public spending in the agricultural sector and drivers of agricultural growth to improve agricultural productivity.

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