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Agricultural Infrastructure and Food Security in Nigeria

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Abstract

This study sought to investigate the impact of agricultural infrastructure on food security in Nigeria. The study was informed by the acute shortage and rising prices of staple foodstuff in the country. The study considers the roles of agricultural professionals, technology use in agricultural practices, provision of social amenities in the rural communities and adequate security of life and property of rural farmers as determining factors of food production in Nigeria. It employed Autoregressive Distributed Lag (ARDL) and bounds testing co-integration approach to empirically examine the relationship between food production and agricultural infrastructure, using time series data obtained from World Development Indicators for the period of 1990 to 2022. The result of the analysis indicates the presence of significant co- integrating (long-run) relationship between food security, agricultural professionals, technology use in agricultural practices, provision of social amenities in the rural communities, and adequate security of life and property of rural farmers. The result also reveals that availability of agricultural professionals, provision of social amenities, technology use in agricultural practices and adequate security of life and property significantly influence food security positively in the long run. Also, agricultural professionals, provision of social amenities, and adequate security of life and property are also positive and significant in the short run, while technology use in agricultural practices is not. Agricultural infrastructure demonstrates an increasing function on food security in Nigeria. Therefore, increasing the number of agricultural professionals. improvement in security of life and properties, road transportation network and technology use in agriculture increases food production in the country. On the basis of the findings, it is necessary for the government to improve on agriculture infrastructure by ensuring increased number of agricultural professionals and social amenities, There is also need for increase in the use of technology in agriculture. The government should ensure that adequate security of life and property are provided for farmers in rural communities. These measures will definitely result in increase in food production in the country.

Keywords: *Agricultural Infrastructure, Food Security, Autoregressive Distributed Lag model, autocorrelation, heteroscedasticity*

Introduction

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food summit, 1996). Thus, food security is having means to adequate food consumption to enjoy good health. The United Nations Food and Agriculture Organization (U.N.F.A.O) and the International Fund for Agricultural Development (IFAD) (United Nations, 2021) identified food security as availability, access, utilization, and stability of food. According to United State Agency for International Development (USAID) (2020) above 800 million people in the World go to bed hungry every night, most of which

are subsistence farmers who depend on agriculture to make a living. A country is food secure when the citizens are not living in hunger or fear of hunger. Food insecurity is often rooted in poverty and has long-run impacts on inability of countries with underdeveloped agricultural sector.

However, The Declaration of Human Right on Right to Food in 1984 infers that countries should engage in the development of their agricultural sector. It is on this note that Nigeria through her diversification policies aimed at achieving a hunger-free economy. According to Ibukun and Oluseye (2021) one of the greatest challenges of the Nigerian economy is hunger. Nigeria is one of the food deficient countries in the world. The country's food production is very low compared to its growing population. Although the country has not suffered any scourge of famine, the prices of agricultural products have persistently been on increase. The International Monetary Fund (IMF) (2022) reported that food prices index in Nigeria surged to 21.79% in February, 2021, dropped to 17.11% in 2022 same month, the highest rate recorded ever. Consequently, the irony remains that the country which is the sixth world highest producer of crude oil and earns upwards of US$ 15 billion annually cannot adequately feed her population (Ibukun & Oluseye, 2021).

The Nigerian agriculture practice was frustrated on discovery of oil late 1950s. Thus, rise in the oil price in the international market in the 1970s increased government interest in oil and neglect of agriculture in Nigeria. This additively compounded the problem of food shortage in Nigeria, as the country abandoned agriculture practices. Today, Oil account for 95% of the country's foreign exchange earnings (Okotie, 2018). It was estimated that between 1973 and 1981, Nigeria earned over N60 billion (about US$90 billion then) from oil and the country thus became overly dependent on oil for its foreign exchange earnings, with food production across zones declining abysmally. Following the total neglect of agriculture, the country therefore had to contend with rising food prices, particularly the prices of essential foods. The Nigerian rice consumption requirement was 2.5 million metric tons annually, while the local rice production was less than 5 hundred thousand metric tons per year (IMF, 2022).

Consequently, with the vast arable land for agriculture, Nigeria has yet economically utilized the land resources for agricultural productivity. This confirms why the country's population is battling with hunger and starvation. Nigeria has a total landmass of 92.4 million hectares. The arable land is 34 million hectares, only 13.94 million hectares or 41% of the arable land is put to cultivation. According to Okotie (2018), about 70% of the Nigerian population live on less than N100 per day (US$0.7per day), and about 90% youth are unemployed. Peasant farmers make up 80% of all farm holdings in the country. The farmers are weakened with commercial food import practices. The juxtaposition of food situation and agricultural production in Nigeria lies in the fact that agricultural infrastructure are not adequately addressed. In the study by Udemezue and Osegbue (2018), over the years, the Nigerian agricultural sector has never received up to 10% allocation in federal budget which is the minimum requirement according to Maputo Declaration for sufficient food production. The highest the sector has received is 7% in 2008 budget, 1.37% in 2021 and 1.8% in 2022. Infact on average, the budgetary provision to agriculture in Nigeria is less than 3% of annual budget (Udemezue & Osegbue, 2018).

However, the practice of agriculture in the country is left to the poor aged farmers in the rural habitation. The youths have left the rural communities for the cities in search of industrial and white coller jobs. The rural dwellers are denied access to electricity, communication network, portable water source, and accessible roads. The farming techniques adopted by the few farmers involves are crude type with human labour. Consequently, the hope to support agricultural sector in achieving full utilization of human and material resources to increase production of food and nutrition, raw materials, employment, and foreign exchange are continuously thwarted by the activities of banditry, terrorism, herders clash, and activities of unknown gunmen (Richardson, Nelson, Janefrancis, & Winnie, 2020).

Amaechi (2019) reveals that in the southeast areas, kidnapping and secessionists' agitation have increased. The Eastern Security Network (ESN), formed in late 2020, as the armed wing of the terrorist-designated Indigenous People of Biafra (IPOB) separatist group has increasingly attacked and killed security forces. The ESN has strategically mobilized men against open grazing for livestock and also threatening state governments to enforce laws regulating pastoral activities within the region. In response, the police announced Operation Restore Peace to curtail ESN and IPOB. Some pastoralists were attacked. resulting in the loss of livestock assets. Similarly, the farming communities were displaced due to fear of reprisal attacks by the pastoralists. The pastoralists attacked villages in the southeast destroying lives and properties, raping women, setting houses ablaze and kidnapping farmers. These attacks in different communities across southeast resulted to limited engagement of farmers in agricultural activities, and sharp decline in agricultural output produced in the region. Thus, the populations of the southeast faced severe difficulty meeting their food needs, and risk of famine persists thereof in the region (Anuka, 2019).

The determinants of food production in countries have been widely delved by researchers. Richardson, et. al, (2020) confirmed evidence-based agricultural productivity models. The study examines agricultural productivity and demonstrates that the determinants of food production were the human resources, land holdings, rural socio-economic, environment, and infrastructure. The agricultural professionals, namely, agricultural extension workers, agricultural engineers and agriculturists are just a mere academic studies in the universities and are rarely put to practices in Nigeria. The farmers in the country are characterized by small landholdings which hamper mechanization. The illiteracy level of the farmers, conservatism, superstitious and small market economy, with no agro-allied industries hinders modern methods of agricultural practices (Emily, Stephan and Johanna 2020). The rural social amenities; health facilities, education, access to clean water, electricity, and accessible road network are not adequately provided, which added to rural-urban drift. These have starved the agricultural sector the needed youths labour.

Problem Statement

Global food security is on the front burner of governments' policy statement across countries. According to World Health Organization (2022) hunger contributes about 35 million deaths world over, out of which 9.5million are in Africa. IMF (2022) report over 713.4 million people in Africa, is malnourished and live in abject poverty. Majority of the population is

rural dwellers who engaged in subsistence agricultural practices to meet their daily food survival. Undoubtedly, about 20% of the entire African population especially Nigeria experiences hunger daily. The country suffered food shortage and poverty prior the discovery of oil and neglect of agriculture in 1970s. The food shortage has shown on the steady increase in the prices of staple food over the years. The country's population grows at 3.1%, while food production grows at 2.7% in 2018. In 2021 the population growth is 2.6%, and food production is 1.2% (FAO, 2022). This indicates that food insecurity is worsening in the country. It is apparent to note that problem of food shortage in the Nigeria is traceable to low agricultural practices/output. The problems deficiency in agricultural infrastructure including: inadequate agriculturalist/extension workers, low agricultural technology, lack of rural social amenities and insecurity of lives and properties.

However, appraisal of the past studies shows that successive administrations in Nigeria had initiated policies and programmes to curb food shortage in the country. These programmes include Farm Settlement Scheme (FSS), National Accelerated Food Production Programme (NAFPP) initiated by Gen. Yakubu Gowon. Operation Feed the Nation introduced by Murtala/Obasanjo administration. River Basin and Rural Development Authority; Green Revolution and World Bank funded Agricultural Development Project (ADP); Directorate for Food, Road and Rural Infrastructure (DFRRI) implemented under Shehu Shagari and Ibrahim Badamasi Babangida administration. Yar'Adua/Goodluck administration took a proactive measure by outlining agriculture as part of the government agenda and vision 2015. The programme was initiated for curbing hunger and poverty in Nigeria. Also, Anchor Borrower's Programme (ABP), Presidential Fertilizer Initiative (PFI), Youth Farm Lab (YFL), Presidential Economic Diversification Initiative (PEDI), and Food Security Council (FSC) were the present agricultural initiatives of president Muhammadu Buhari geared towards ameliorating food shortage in Nigeria. These government efforts have remained a kind of mirage as food shortage remained very high in the country. It is on this premise that this study seek to investigate the impact of agricultural infrastructure on food security in Nigeria.

Based on the above statement, the following objectives were raised; i. evaluate impacts of availability of agricultural professionals on the food security in Nigeria. ii. estimate the extent technology use in agricultural practices impact on food security in Nigeria. iii. investigate how provision of social amenities in rural communities impact on food security in Nigerian. iv. examine whether adequate security of lives and properties of rural famers impact on food security in the Nigerian.

Literature Review

Food Security

Food security is the ability of food-deficit regions or countries, or households within these countries, to meet target levels of food consumption on a yearly basis. World Food Summit (2021) defines food security as when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Sophie (2020) also reported that food security is the

relationship between the total numbers of people as against food available at a particular people on a time. It is the state where all people at all times have access to adequate supply of food.

According to World Bank (2022), food security is of three folds, these are food availability, food accessibility and food affordability. Food availability for farming households means ensuring sufficient food for the households through production. It means access to adequate food for a healthy life. It includes; access to available food and adequate nutrient intake for sustainable health. It is complex and tricky task to formulate a one-size-fits-all set of food security targets. However, it should be noted that simply making food available is not enough; one must also be able to purchase it, especially the low income households (Tyohmmba, 1981). Hence, food security connotes physical and economic access to adequate food for all household members, without undue risk of losing the access. The concept of food security has expanded beyond the strict biological requirements of sustenance for survival. Food security does include consuming at a level adequate for physical and mental health and also includes the right to cultural preferences. It also includes obtaining the food in appropriate proportion (Manjunath & Elumatai, 2017). Food security therefore involves interconnected domains, with questions of agriculture, society, environment, employment and income, marketing, health and nutrition, and public policy.

NEPAD (2005) adds that food security requires an available and reliable food supply at all times. At the global, regional and national levels, food supply can be affected by climate, disasters, war, civil unrest, population growth, lack of effective agricultural practices, and restrictions to trade. Government initiatives that encourage a policy environment based on macroeconomic stability and competitive markets can improve food availability. According to Malik and Nusrat (2019) food security at the community level, food security is essentially a matter of access to food. Insecurity can be temporary or chronic. It may vary with age, status, gender income. geographic location and ethnicity. Poverty is the main cause. Sustainable progress in poverty reduction is critical to improve access to food. Individuals need access sufficient, safe and nutritious food. Food security is closely linked to the economic and social health of a nation, society and individual. However, for sustainable agriculture to occur for food security in Nigeria, rural farmers must be encouraged by the government. Rural development will as well encourage agricultural sustainability such as provision of amenities, infrastructure, telecommunication. electricity, silo and irrigation (UNDP, 2021).

Determinants of Food security in Nigeria

Income inequality: Most of the individuals and households in Nigeria are characterized with low income, making the people not able to buy food with adequate nutritional content to assure food security; spatial factors such as living in a vicinity without an affordable retailed foodstuffs store, markets or other outlets; disproportionate income allocation to other areas, such as rent. leaving an insufficient budget for food; and isolation, loss of autonomy or a lack of a social network. These sources of food insecurity are not related to food availability. Instead, hunger is most often attributed to problems of distribution, with gaps increasing

between poor and rich in the country. Income inequality is one source of food insecurity common in the Nigerian economy. Other common perpetrator of food insecurity in the country is unemployment and the welfare crisis (Manggat, Zain, & Jamaluddin, 2018).

Herders-Farmers Clash and Crises: The consistent clashes between herdsmen and farmers on pasture and water negatively affect food security in Nigeria. According to Miyetti Allah, an association of the herdsmen on the clashes states "It is a conflict basically about resource use. It is the issue of pasture and water" (Tyohmba, 2014). He, however, admitted the conflict has recently been infused with politics, legal issues, religion and ethnicity. But he expressed conviction that if the resource use conflict is solved, the clashes would go away. According to him, neglect of agricultural development and Nigeria's inability to regulate influx of foreign herdsmen has contributed immensely to the buildup of the crises that now engulfs Nigeria's arable farm and graze-lands. He recommended the revival of the "jangali" (cattle tax) system, as well as other measures to curb the growing clashes.

Consequently, the devastating effect of the Boko Haram insurgency in the North and the activities of Eastern security network (ESN) in the South-East are having its negative impact on the states in the country, especially when it has to do with the supply of foodstuffs as farmers abandoned their farm lands for fear of rape, kidnap and lost of their lives. Particularly affected food items are beans, rice, yam, maize, pepper and tomatoes, which mostly come from the Northern states and cassava, banana, cocoyam and palm oil from the South East states. The supply of these major food items, which happen are essential delicacies in an average home, is in short supply and is sold at a very costly price (Fadare, Akerele, Mavrotas & Ogunniyi, (2019). This therefore implies that the conflicts and crises in the country has not only caused scarcity of food supply but has also affected the prices in the market.

Agricultural Technology: The popular technology used in the Nigerian agricultural practices are primitive, which lower outputs from given inputs. It is paramount to note that indigenous techniques like crop rotation, manpower and other cultural farming practices which have been used to preserve the soil structure and its fertility and cultivation are not adequate or even relevant in the present efforts to boast food production. According to Agaptus, John and Modupe (2019) the use of machines, chemical and organic fertilizer has been widely promoted in many countries, but Nigeria has been reluctant in the use of these modern farming technologies. Government intervention to increase food production through technical and economic assistance to the small-scale farmers for land improvement schemes is therefore, not a misallocation of resources, but good direction to increase food production.

Agricultural Professionals: Agricultural biotechnology includes using genetics to modify crops and plants to produce more nutritious food, cloning of livestock; tissue culture technique and genetic engineering. Apart from its potential to produce higher yields the one of biotechnology gives shorter gestation and maturity periods to crops, plants and livestock as well as will continue to use biotechnology to produce genetically modified foods (Adepoju & Salman, 2013). Parts of these foods are sold and sometimes given as food aid to developing countries, despite safety concerns raised by some anti-biotechnology campaigners in EU countries against genetically modified foods produced in the United States (Abeeb, Saidat,

Luke & Abiodun, 2020). Nigerian government has embraced the idea of using biotechnology to boost food production as a pre-condition for food security. It established the National Biotechnology Development Agency at Abuja (Federal Capital Territory) setting aside the sum of 26 million naira (about $185,000) to be invested in the project, and specifically mandating the Institute of Agriculture Research, Ahmadu Bello University, Zaria, to apply biotechnology for the improvement of farming systems for various crops such as Sorghum, maize, cowpea, cotton and sunflower (Adesina, 2017). Furthermore, Nigerian agricultural scientists have been very enthusiastic in advancing the frontier knowledge of biotechnology. They have been making efforts to assure the people that genetically modified foods do not pose any higher risk to consumers than conventionally cultivated crops, and have been calling on the government to allocate more research funds to enhance the application of biotechnology in agriculture to optimize yield potentials (Anuka, 2019).

According to Anuka (2019) the amount set aside for investment in the project is grossly inadequate. While it appears to make economic sense to invite the private sector participation in biotechnology research as the government seems to be doing at the moment, it must, however, be borne in mind that majority of the companies that have the financial capability to go into such venture are foreign-owned and are most unlikely to consider in a viable investment option to venture into purely local agricultural research endeavour. Second, the quality and the effectiveness of extension services needed to increase the awareness of the peasant farmers of the potentials of biotechnology are still low and need to be upgraded. Not only that, the mass media most especially, electronic media (radio in particular) have a role to play in educating rural farmers in their local language and dialects on the associated problems vis-à-vis abuse of agrochemicals.

Finally, there are still unwarranted public fears to contend with in the safety of genetically modified foods, stemming from scare-stories, reinforced by superstition and crass ignorance of the danger in the consumption of genetically modified foods. The incontrovertible fact is that without the help of agricultural biotechnology, success in food security will continue to elude Nigeria (Abeeb, et. al, 2020).

Review of Empirical Studies

Several studies have examined the influence of infrastructural development on agricultural output and agricultural employment with varying outcomes. Using district level data for 30 years, Manjunath and Elumatai (2017) analyzed the effect of rural infrastructure on agricultural development in the southern Indian state of Karnataka. The regression analysis showed that rural infrastructure had positive and significant effect on agricultural productivity growth. Further, the combined effect of availability and utilization of infrastructure had larger effect on agricultural productivity. In the same vein, the finding collaborates with the findings of Lokesha and Mahesha (2017) that infrastructural development fosters agricultural productivity, reduces transaction costs associated with agricultural activities and by so doing increase the income of farmers. Also rural infrastructural stimulates agricultural productivity, economic growth and overall quality of life.

However, in a related study, Abeeb and Abiodun (2020) compared the effect of road infrastructure on agricultural productivity of farmers living near rehabilitated roads to suitable controls in Peru. Results show that rehabilitated road accessibility can be related to changes in income sources, as the rehabilitated road enhances non-agricultural income opportunities, especially from wage employment sources. Also, Malik and Nusrat (2019) examined technological advancement on total factor productivity of cotton in Pakistan and India. The study employed autoregressive distribution lag regression model (ARDL) on a time-series data from 1954 to 2017. The variables used are: area of cotton, fertilizer consumption kg/ha, high yield varieties (HYV) seeds, electricity consumption in agriculture sector, agriculture labor force, and irrigation by canal water and tube well water, besides tractors to find the technological advancement impact on the TFPC of cotton. The results demonstrates that overall improvement in farm inputs has a more stable impact on the productivity of cotton in Pakistan, whereas HYV seeds, mechanization, and area are the real reason for the growth of cotton in India.

Richardson, Nelson, Janefrancis and Winnie (2020) examine effect of infrastructural development on agricultural output and employment in Economic Community of West African States (ECOWAS). The study utilized panel autoregressive distributed lag (PARDL) method. The findings demonstrate that infrastructures support agriculture productivity and foster employment creation. It also reveals that information and communication technology and access to electricity positively influence agricultural output and employment. Transport infrastructure had negative and insignificant effect on agricultural performance.

Manggat, Zain and Jamaluddin (2018) examined the impact of transportation infrastructure on agriculture productivity in Ghana using data at a very fine spatial level. The study found a strong positive effect of rail- road on cocoa production. While Kipromo and Matsumoto (2014) implemented a differences-in-differences estimation to assess the impact of the change in road access on agricultural productivity of smallholder farmers in Kenya. The findings suggest that, since road access improvement occured more in poorer road access areas, investment in rural road infrastructure enhances the productivity of rural farmers.

In another study, Emily, Stephan and Johanna (2020) accessed food security among smallholder farmers in North-West Mount Kenya. The study was guided by the theory of Access developed. with the role of bundles of rights and powers that influence household food security in the North- West Mount Kenya. 76 households were interviewed, 38 on food security and 38 on food insecurity who were sub-sampled from a previous food security survey of 380 households. Results showed that household's food insecurity was not exclusively the result of a lack of private property rights as many farmers had retained their property rights. Instead, a major factor preventing access to productive resources was the difficulty faced by food insecure households in accessing farm technology (i.e. hand tools and implements). Access to authority and via social relations was significantly correlated with access to technology.

In Nigeria, various studies have examined the effect of infrastructure on agricultural productivity and employment. However, a notable feature of all the studies in the use of

survey data. Adepoju and Salman (2013) examined access to agricultural infrastructure and its effects on agricultural productivity using descriptive statistics and total factor productivity model. The total factor productivity model adopted reveal that farm size and labour had positive and significant effect on productivity. In terms of the infrastructural elements, improvement in soil practices and extension visits had positive effects on productivity. In a similar study, Adesina (2018) investigated the effects of road transport infrastructure on agricultural productivity, using annual data from 1985-2014. The study concluded that a positive and statistically significant relationship exists between road transport infrastructure and agricultural productivity. Evidence was found of a unidirectional causality from agricultural sector development to transport infrastructure.

However, in a similar study Abeeb, Saidat, Luke and Abiodun (2020) studied the impact of rural infrastructure on production efficiency of food crop on rural farmers in Ogun State, Nigeria. A total of 160 farming households from 20 communities in Abeokuta and Ilaro in Ogun State Agricultural Development Programme (OGADEP) were randomly selected. Descriptive statistics, budgeting, Infrastructure Index Estimation (IIE) and Stochastic Production Frontier (SPF) were used to analyze the data collected. Results revealed that rural dwellers' major economic and livelihood activities were farming (51.9%), trading (26.3%) and food processing (19.4%). The budgeting analysis showed that food crop production was more profitable in developed areas than in less developed areas with Net Farm Income (NFI) of $328.900 (N119,402.90/hectare) and $179.496 (N65,163.68/hectare), respectively. SPF showed that total land cultivated ($p<0.05$), family labour ($p<0.01$), hired labour ($p<0.05$) as well as cost of planting inputs ($p<0.01$) significantly influenced food crop output.

However, a study on factors of food security, Sophie (2020) examined factors of Nigerian food security. The study variables are: climate change, economic development, and violent conflict. The thesis used a mixed-methods approach. Quantitative data were retrieved from several data- bases that gave measurements on food security, climate change, economy, and conflict. Qualitative data were reports and interviews that were conducted with Nigerian NGO's. Cautious findings show that all three factors could lead to food insecurity and, therefore, can explain why there is food insecurity in Nigeria. Also, Ibukun and Oluseye (2021) investigated food security status of households during the pandemic and examined its determinants using the COVID-19 National Longitudinal Phone Survey (COVID-19 NLPS). Descriptive statistics, bivariate as well as multivariate analysis were employed to analyze the data obtained from the COVID-19 NLPS. Findings from the descriptive statistics showed that only 12% of the households were food secure, 5% were mildly food insecure, 24% were moderately food insecure, and over half of the households (58%) experienced severe food insecurity. The result from the ordered probit regression identified socioeconomic variables (education, income and wealth status) as the main determinants of food security during the pandemic. It demonstrates that more than 60 per cent of the households' lives were threatened by food insecurity in Nigeria.

Theoretical Framework

Endogenous Growth Theory (Arrow, 1962)

Endogenous growth theory is a theory which explains the long-run growth rate of an economy on the bases of endogenous factors as against the exogenous factors of the neoclassical growth theory. The theory was developed by Arrow (1962). The theory emphasizes technical progress resulting from the rate of investment, the size of the capital stock and the human capital as major determinant of economic growth. Endogenous growth models are built on technical progress resulting from the rate of investment, the size of capital stock, and the stock of human capital. The assumptions of the endogenous theory are that there is (1) knowledge or technological advancement is non-rival good (2) there is increasing returns to a single factor, at least one. (3) Technological advancement comes from things people do. This implies that technological advancement is based on the creation of new ideas. The model of the theory arises from increasing returns to scale in the production that leads to economic growth. The model is in the form:

$Y1 = A(K)F(K¿L()$ (1)

Where Y denotes output of firm i, K; denotes firm capital stock, L; denotes its labour stock, K denotes the aggregated stock of capital and A is the technology factor. For output of an economy to grow, it involves that the capital stock, skilled labour and technological advancement must be highly encouraged.

Arrow introduced the concept of learning by doing in 1962; he regards learning as endogenous in the growth process. His assumption was that new capital goods incorporate all the knowledge available based on experience and subsequent learning. Arrow's model is in the form: $Y = A(K)F (K, Li)$ (2)

Where Y denotes output of country i, K, denotes capital stock of country i, L; denotes labour stock of country i, K without subscript denotes the aggregate stock of capital and A is technology factor in a country i. He showed that if the stock of labour is held constant, growth ultimately comes to halt because socially very little is invested and produced.

The theory summarily depicted that an increase in productivity largely depend on technological progress. It provides a framework for analyzing technological development in agricultural sector, for production, processing and storage of agricultural output. In this study, quantity of food production in Nigeria is a function of agricultural infrastructure, to include; number of agricultural professionals in practice, level of technological inputs applied in agricultural practices in the country, rural capital formation and security of lives and properties. Therefore. food security is explained by the growth in quantity of food produced in the country per year.

Research Method and Data

Model Specification

This study adopts Arrow growth model as the theoretical framework. Specifically, the model for this study captured Food Security as the dependent variable, while Availability of Agricultural Professionals. Use of Technology in Agriculture, Provision of Social Amenities and Adequate Security of Life and Properties are the independent variables. This study functionally specifies agricultural infrastructure on food security for Nigeria as:

Where;

FS = f(AAP, SLP, PRT, UTA)

FS = Food Security proxied by food production index, it is measured as food edible and contain nutrients.

(3) crops considered

AAP Availability of Agricultural Professionals proxied by employment in agriculture, it is measured as employment in agriculture (% of total employment in a country) to include; activities in agriculture, forestry, hunting, and fishing as well as cultivation of crops and livestock production.

SLP Security of Life and Property, proxied by access to communication network in rural communities, measured as number of individuals using the Internet (% of population) in rural communities. Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.

PRT Provision of Rural Transportation, it is measured as Public private partnerships investment in transport (current US$). Public Private Partnerships in transport (current US$) refers to commitments to infrastructure projects in transport that have reached financial closure and directly or indirectly serve the public.

UTA = Use Technology in Agricultural proxied by Agricultural machinery, tractors per 100 sq. km of arable land. It includes; number of wheel and crawler tractors (excluding garden tractors) used in agriculture at the end of the calendar year specified or during the first quarter of the following year.

To measure and ascertain the size and signs of these factors empirically, the model to be estimated is specified as follows:

FS, Bo+BAAP + B2SLP + B3PRT: + B4UTA, +ut = (4)

Where; Bo is the intercept: B1-B4 are the slope coefficients; t denotes the number of time series observations; and u is the error term.

A priori Expectation

A priori expectations refer to the expected sign of the coefficient of explanatory variables and which shows the expected impact of explanatory variables on the dependent variable. The a priori expectations for the explanatory variables in this study are:

Estimation Techniques

B10, B20, B30, B3 <0.

For us to estimate short and long run coefficients of a regression, it is necessary to ascertain if the variables in the model of equation (4) are stationary or not. To this effect, Augmented Dickey-Fuller unit root test was applied on the series. Thus, if all the series are stationary at level I(0), Equation (3) will be estimated using Ordinary Least Square (OLS) technique. Consequently, if the series are stationary at first difference I(1), the residual-based (Engle & Granger, 1987) Error Correction Mechanism (ECM) will be used to estimate Equation (3). The short-run ECM model is specified as follows:

= AFS, BECM-1+JAFS+EjjQAAP;_; +Σ6jASLP;-) + E-pjAPRT-j+VjAUTAt-j +&t -i (4)

Where; Bo is constant, is the coefficient of error correction term lagged by one period t 1 which captures the speed of adjustment of the series towards long-run equilibrium; 7, 28, 4, and Y are short-run parameters and & is the error term which is expected to be well behaved. A denotes the differenced identity.

Furthermore, we estimate autoregressive distributed lag (ARDL) model if the stationarity of the series are a mixture of 1(0) and I(1). The parameters of Auto-Regressive Distributed Lag (ARDL) bounds test method developed by Pesaran. Shin & Smith, (2001) will be estimated to determine the existence of a longrun equilibrium relationship among the variables.

FS = Bo+YJAFS-+-AJAAAP-+-8jASLP-1 +Σ-jAPRT:-) + AUTA+h (5)

Bound Test Co-integration

The ARDL bound testing procedure is based on the comparison of the F-statistics obtained from equating the coefficient of the un-differenced variables in the conditional ECM with the critical values provided by Pesaran et al. (2001), which is hence used to test the null hypothesis that no cointegration exist against the alternative hypothesis that cointegration exists among the series. When the f-statistics is greater than the upper bound I(1), we reject the null hypothesis that no cointegration exists among the series. If the f-statistics is less than the lower bound I(0), we fail to reject the null hypothesis that no cointegration exist among the series. Accordingly, if the F- statistic falls between I(0) and I(1), our inference would be inconclusive. The conditional ECM is specified as follows:

FS=ao+B1-0 AFS-1-B2 E0 AAAPt-1 - B30 ASLPt-1 - B4 E0 APRT-1

-Bs -0 AUTAt-1+01FSt-1-02AAPt-1 - 03SLPt-1-04PRT-1+04UTAt-1

He (6)

Where; a 4 are the coefficient of the un-differenced variables in the model to be used in obtaining the test statistics for comparison with the upper and lower bound. When there exist co- integration (long-run relationship) between the series, Equation (3) will be estimated to capture the long-run dynamics of the series, while the short-run dynamics will be captured by the ARDL model specified in equation 7;

FS=αo+B1-0 AFS-1-B2 E0 AAAPt-1 - B3-0 ASLPt-1 - B40 APRTt-1

β. Στο ΔOTA -1 + με (7)

Results and Discussion

Table 1: Augmented Dickey Fuller Unit Root Test Results

Trend and Intercept @ level

Variables	**Level**	**First Difference**
FS	-3.6793	-3.6892
	(0.0396)	(0.0621)
AAP	-2.2828	-5.5377
	(04307)	(0.0005)
SLP	-2.1557	-3.8559
	(0.4963)	(0.0441)
PRT	0.3323	-5.4369
	(0.9976)	(0.0462)
UTA	-0.5672	-5.7010
	(0.9743)	(0.0003)

Sources: *Researchers' compilation from E-view (version 9.0)*

The ADF unit root test results conducted are presented in table 1. The test result indicates a mixed order of intigration. While food security variable is stationary at levels; the rest of the variables are stationary at first difference.

Bound Test Cointigration Result

Table 2. Bound Test Result

Dependent Variables

Dependent Variables	FUNCTION				K-1	F-statistic
FS	f(FS/AAP,SLP, PRT, UTA)				4	4.48616
	Asymptotic critical value bounds for the F- statistic					
1%	5%				10%	
1(0)	1(1)	1(0)	1(1)	1(0)	1(1)	
3.74	5.06	2.86	4.01	2.45	3.52	

From the presented ARDL bound testing output in Table 2, the computed F-statistics (4.486161) is greater than the upper bound I(1) at 5% and 10%. Therefore, the null hypothesis of no cointegration among the series is rejected. This result thus implies that a long-run relationship exists among the series (FS, AAP, SLP, PRT and UTA). With the presence of co-integration among the series established, Equation (3) and Equation (7) are estimated for the long-run and short-run estimates, respectively.

Long Run ARDL Result

Since the ARDL bound test cointegration result suggests the existence of longrun equilibrating relationship among the series in the model. The long-run and short-run model are therefore estimated to obtain the long-run and short-run estimates of the model. The result of the long-run estimates is presented Table 3

Table 3. Long-Run Estimates

Variables	Co-efficient	STD Error	t-Statistic	Prob.
AAP	1.866124	0.404628	4.611950	0.0001
SLP	0.687481	0.115950	5.929120	0.0000
PRT	2.406558	0.61655	3.903045	0.0006
UTA	19.625983	2.088235	9.398358	0.0000

Discussion of Long Run ARDL Result

From the long-run estimates in Table 3, availability of agricultural professionals, adequate security of life and property, provision of road transportation and use of technology in agriculture exhibits positive long-run relationship on food security in Nigeria. A unit increase in agricultural professional, adequate security of life and property, provision of road and technology in agricultural practices in Nigeria, will increase food production by approximately 1.87, 0.69, 2.41 and 19.63 times respectively. The variables are all statistically significant on food security in the long-run.

Discussion of Short Run ARDL Result

The short-run model is estimated using the ARDL technique, with optimum lag length indicated by AIC as (1, 0, 0, 0, 1). To test the plausibility of the ARDL model, it was subjected to post estimation diagnostics such as the test for autocorrelation, homoscedasticity, normality and the stability of the model. As presented in Table 5, the diagnostic tests show that the model is free from autocorrelation, heteroscedasticity and the error terms are normally distributed.

Table 4. Short-Run Estimates

Variables	Co-efficient	STD Error	t-Statistic	Prob.
Constant	**-140.082746**	**28.6700575**	**-4.885941**	**0.0001**
AAP	1.617575	0.483315	3.346836	0.0026
SLP	0.595915	0.155750	3.826112	0.0008
PRT	2.086029	0.724119	2.880781	0.0080
UTA	6.651077	5.614527	1.184619	0.2473
εt-1	-0.866810	0.182269	-4.755650	0.0001

R^2=0.98, Adj. R^2-0.97, F-stat.-168.31, Prob.(F-stat.-0.0000), DW Stat. = 2.385

From the short-run dynamics in Table 4, akin to the long-run estimates, availability of agricultural professionals, security of life and property, provision of road transport in the rural communities and food production exhibit significant positive relationship in the short-run. In the same vein, use of technology in agricultural practices is positive but not significant on food production in the short-run in Nigeria. The coefficients indicates that a unit increase in the number of agricultural professional, security of life and property, road transportation network in the rural villages and technology increase food production by 1.6, 0.60, 2.1 and 6.7 respectively in the short-run .in Nigeria.

The coefficient of the error correction term lagged by one period (-1) is negative, fractional and statistically significant, and therefore meets the a priori expectations. The sign of the coefficient indicates a relatively high speed of adjustment to equilibrium from the short-run disequilibrium of food production of approximately 87% annually.

Conclusion and Policy Implications

The study utilizes the ARDL bounds testing technique to examine the impact of agricultural infrastructure on food security in Nigeria from 1990 to 2022. The result demonstrates the presence of cointegrating (long-run) relationship between food security and agricultural infrastructure in the country. The results revealed that availability of agricultural professionals, access to internet communication and provision of road transportation has a long term as well as short-term significant positive influence on food production, while use of technology in agricultural practices is positive but not significant in the short-run. In the same

vein, availability of agricultural professionals, improved security network and use of technology in agriculture are positive and statistically significant in the long run in Nigeria.

Recommendations

Based on the findings, it is necessary for the government to increase the number of agricultural professionals, improve on rural security network and provision of good road transportation in the rural communities in Nigeria. Also, it is advisable to exploit technology in agricultural practices to increase food production in the country.

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