Evaluating Human Capital Development and Sustainable Agricultural Development in Nigeria

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ABSTRACT

The study examined how Nigeria's agricultural output sustainability was impacted by human capital development during a 44-year period, from 1981 to 2024. The study specifically looked at the effects of labour force participation, government spending on health, education, and agriculture on real agricultural GDP. The autoregressive distributed lag model method was used to the data set, which included labour force participation, government investments agriculture, health, education, and real agricultural GDP. The information came from the statistics bulletins published by the CBN and NBS. Long-term relationships between Nigeria's agricultural output and the development of human capital are demonstrated by the findings. The study also found that labour force participation, government investment on agriculture, health, education, impacts real agricultural GDP in a favourable and substantial way in the short run.

Furthermore, labour force participation and government investment on agriculture has a positive and significant influence on real agricultural GDP, but government expenditure on health and education has no discernable long-term impacts. Nigeria's sustainable agricultural output is favourably and considerably influenced by human capital development, according to the study's results. It suggests that more investment should be made in the development of human capital in order to stabilise agricultural output and contribute to economic growth.

The study concludes that while human capital development is crucial for sustainable agricultural growth, the effectiveness of public spending in health and education depends on improved targeting, institutional efficiency, and alignment with agricultural sector needs. The findings provide evidence-based policy guidance for strengthening workforce development, agricultural financing, and sustainable economic diversification in Nigeria.

Keyword: Agricultural Development, Agricultural Sustainability, Government Investment, Education, Health, Human Capital Development, Labour Force Participation, Nigeria.

INTRODUCTION

Human capital development is an essential part of agricultural production, particularly in developing countries like Nigeria where agriculture is a major economic driver (Ukpe, 2024). In the agriculture industry, it integrates people's skills, knowledge, intelligence, health, and experience to boost productivity, foster innovation, and support sustainable growth (Jerry et al., 2025; Sima et al., 2020). Around the world, it is widely used as an important indicator of social and economic progress (Gruzina et al., 2021; Kotsantonis & Serafeim, 2020). Agricultural productivity has not been able to sustainably improve in any nation without substantial expenditures in human capital. Most people agree that a nation's human resources have a major role in determining its degree of global prosperity (Madukwe et al., 2022).

The concept of human capital has been influenced by several significant transformations and revolutions that have fundamentally changed socioeconomic relationships throughout history. According to Gruzina et al. (2021), Hippe (2020), and Surya (2020), these changes have affected innovation, knowledge development, and the

establishment of the global order. Beyond physical capital, human capital—which includes technical know-how and knowledge—is seen as a major driver of increased productivity. According to James (2021) and Ndibe (2022), it is the whole economic value of human beings employed in economies, encompassing attributes such as intelligence, training, sound judgement, wisdom, knowledge, skills, habits, experience, and general health.

Moreover, human capital development may be divided into six groups: health care facilities and services, such as investments in life expectancy, strength, stamina, vigour, and vitality; b) on-the-job training, including traditional apprenticeships offered by employers; c) formal education up to all basic education levels; d) adult education programs outside of agriculture; e) family or individual migration to accommodate shifting employment opportunities (factors mobility); and f) knowledge transfers both internally and externally, along with technical assistance, expert opinions, and recommendations (Ogunniyi, 2018; Ndibe, 2022).

Understanding that human capital both contributes to and is influenced by the expansion of the agro-economy is essential. In the global economy, agricultural production is one of the major determinants of overall productivity and well-being. According to the World Bank (2023), it is anticipated to feed 9.7 billion people, improve food security, and end extreme poverty by 2050. According to Nebo et al. (2023), agricultural production on average contributed 24% of Nigeria's GDP between 1990 and 2021, surpassing the contributions of the oil and industrial sectors (NBS, 2021). This is enough to say that agriculture is the primary source of revenue in Nigeria. To meet the demands of a world population that is predicted to surpass nine billion people by 2050, agricultural production must thus increase. Aside from guaranteeing food security, agriculture provides a substantial amount of raw materials for the manufacturing and processing industries, which in most nations produce more than 80% of the raw materials needed in the manufacturing sector to create finished goods (Janet et al., 2018). The simplest path for mankind to overcome poverty and reach a position of relative material abundance is also widely acknowledged to be increasing agricultural output to satisfy future demands.

Nevertheless, agricultural output could not be really increasing in the absence of funds or loans. A poor land tenure system, little irrigation farming, climate change, land degradation, low technology, high production costs, poor input distribution, limited financing, high post-harvest losses, poor market accessibility, and average levels of education are all characteristics of small-scale farmers, whom comprise the majority of the agricultural workforce, especially in Nigeria, where they are mostly rural residents. The inaccessibility of farmers' finances hinders agricultural productivity, and their continuous lack of credit has detrimental effects on household-level outcomes like technology adoption, agricultural productivity, food security, health, and farmers' overall well-being (Adewale et al., 2022). The sector's percentage of the national GDP has been impacted by the difficulties in agricultural output (United Nations, 2022).

Despite Nigeria's expanding population, which has spurred agricultural expansion, the country still depends on food imports from neighbouring countries. According to Iwu (2020), ₦334.3 billion was spent on imports largely consisting of food, beverages, tobacco, spirits, and alcohol between January and June 2019. This represents a 47 percent increase over 2018. The Nigeria-Africa Trade and Investment Promotion Program, the Presidential Economic Diversification Initiative, the Agriculture Promotion Policy (APP), and the Economic and Export Promotion Incentives are some of the actions and programs the government has started to increase agricultural output for both export and domestic demand (www.fao.org; Ndibe, 2021). Nevertheless, the outcomes have not lived up to the hype. This suggests that despite a number of government initiatives, the agricultural sector has consistently underperformed, which may be related to a lack of adequate financial and infrastructure resources, as well as the government's lazy attitude towards worker welfare, low technical expertise, poor skill acquisition, a shortage of workers, etc. A number of these problems contribute to the nation's agriculture sector's poor performance. It is past time for the government to take notice and address the problems, just like in other rural nations.

Furthermore, the governments of Nigeria need to put in place a number of aggressive policies and initiatives to boost agricultural output and ensure food security. To accelerate human capital that can lead to greater agricultural growth, these should include investments in people's skills, training, research and development, understanding gaps, technology, education, and health, among other areas. Prior research indicates that prominent scholars have concentrated their efforts on the relationship between economic growth and agricultural

financing (Adewale et al., 2022; Akintunde et al., 2025; Ibeinmo & Akidi, 2023; Momodu et al., 2025); human capital development and economic growth (Jerry et al., 2025; Nduka et al., 2025; Oladapo & Oyaromade, 2025; Omokugbo & Imogiemhe, 2020); however, there have been few studies on the relationship between agricultural development and human capital in Nigeria (Ofem et al., 2023; Ogunjobi et al., 2025; Okechukwu & Ikeije, 2025).

Nevertheless, this study was different from previous research in the literature since it used the labour force, health, education, and agricultural indices as indicators of human capital all at once in a single study. Furthermore, by examining the 44-year period (1981–2024) that has not been empirically documented in the literature, our study closed a temporal gap noted in previous research. Lastly, this study used the ARDL model to examine long-term effects, in contrast to many previous studies that evaluated short-term effects using least square regression. Based on the aforementioned, the primary goal of the study is to examine the relationship between human capital development and Nigeria's sustainable agricultural output over a range of 44 years, from 1981 to 2024. The study explicitly examined the relationship between government spending on agriculture, health, and education, as well as labour force participation, and agricultural productivity in Nigeria. The study's other components are the literature review, data and methods, outcome, and conclusion.

LITERATURE REVIEW

Theoretical Underpinning: Human Capital Theory and Endogenous Growth Theory

According to theoretical jurisprudence, the human capital theory was developed by Schultz (1961) and Becker (1993), who saw knowledge, ability, and personal skills as irreplaceable assets that boosted a society's economic prosperity. As per the idea, a country can only grow and progress by investing heavily in the education, health care, training, and skill development of its people. In the end, this will result in economic stability by raising individual productivity. Nigeria's shift from an oil-based to a non-oil-based economy has been very challenging throughout the years due to the inadequate development of its human capital. Nigeria's economy must be diversified away from oil if it is to have a high literacy rate and the knowledge and skills necessary to foster innovation and competitiveness. This corroborates the claim stated by Adeola and Adebisi (2020) that underdeveloped infrastructure, low educational investment, and inadequate healthcare systems severely hinder Nigeria's human capital development, making it difficult to achieve diversification objectives. In addition, the theory supports the notion that some policies designed to overcome these constraints will encourage the growth of the agriculture industry, among other industries, in order to support economic growth.

Romer's (1990) endogenous growth theory, on the other hand, proposed that investments in knowledge, innovation, and human capital significantly boost economic growth (Gruzina et al., 2021). Jones (2019) argues that endogenous growth theory highlights how academics and entrepreneurs work to develop new technologies in response to financial incentives. Stated differently, economic activity is fuelled by human capital (Mastromarco & Simar, 2021). Accordingly, anything that influences their work—for instance, tax laws, financing for fundamental research, and education—may have an impact on the economy's long-term prospects (Jones, 2019). Additionally, the proponents of endogenous growth models believed that the economic environment determines the growth rate of production, suggesting that human capital is the primary driver of an economy's growth (Anyanwu et al., 2015). Since the agricultural sector is a part of an economy's entire growth process, investments in the development of human capital, particularly in the areas of health, education, and skills, have the potential to boost agricultural production, which in turn affects the country's overall economic performance.

In order to increase productivity and actively support economic growth and social well-being, human capital development is the process of enhancing the collective skills, knowledge, experience, and well-being of individuals. Education, training, and healthcare are all included because they are essential to developing a workforce that is knowledgeable and productive. Unlike property like buildings or machinery, human capital is intangible and acquired via investments in people. Eze. (2022). By enhancing people's abilities, these investments help individuals innovate, finish difficult tasks, and adapt to changing market conditions (Jerry et al., 2025). To boost productivity, promote innovation, and achieve sustainable economic growth, it is imperative

to maximise the potential of the workforce, as the concept of human capital development emphasises (Omoniyi, 2018).

By improving its human capital development, every country may improve living conditions, reduce unemployment, and create a more dynamic and competitive economy. The notion is particularly relevant to developing nations like as Nigeria, where prudent expenditures in health, education, and skill development are critical to long-term prosperity and the mitigation of economic disparity. Employees are the organisational resource that determines effectiveness and efficiency and impacts an organization's performance, hence human capital development is essential, claim Okochi and Ateke (2021). Because health improves the usefulness of human capital and education improves its quality, spending money on both is thus not a waste. The other component of human capital benefits from health since it is the basis for obtaining higher education. The study states that increased agricultural productivity is reliant on the development of human capital.

Investment in Education and Agricultural Development

Due to the increasing problems in the workplace, which is a factor in economic growth and development, investments in education and better health are quickly becoming highly crucial in today's global economies. Ofem et al. (2023) looked at the relationship between the expansion of human capital between 1981 and 2022 and Nigerian agricultural output using the least square estimate technique. The findings showed a positive and substantial correlation between life expectancy at birth, labour force participation, and total education spending and agricultural output. In contrast, Nigeria's agricultural output was negatively and insignificantly impacted by the total amount spent on healthcare and the literacy rate. Similar findings were made by Adesoye et al. (2018) and Sadiq (2020), who discovered that both public and private education spending had no effect on Nigeria's overall production. To maintain the country's economic stability and growth, this requires on the government and private investors to be proactive in making significant investments in human capital, particularly in education. From 1990 to 2018, Omokugbo and Imogiemhe (2020) investigated the relationship between Nigeria's real sector growth and the development of its human capital. The results demonstrated a sustained relationship between the development of human capital and the rise in output in the two industries studied. The results demonstrated that current government expenditure on education and health did not boost Nigeria's agriculture sector, but it did boost the country's production of natural gas and petroleum. In light of this, government spending on human capital (education) is growing in importance; nonetheless, additional funding and infrastructure are required for education in order to boost agricultural productivity, particularly by achieving national food security. Consequently, the research postulated that:

H_1: Investment in education has significant effect on agricultural development in Nigeria.

Health and Agricultural Development

It is believed that human capital boosts profitability. A company's chances of success and productivity increase with the amount of investment it puts in its workforce. Because human capital affects how farmers use and mix inputs, it has a direct impact on agricultural output. The output of the agricultural producer's labour supply and, consequently, agricultural growth are determined by his or her health. The immeasurable opportunity cost suffered when a farmer is damaged is one way that health capital contributes to agricultural progress (Ofem et al., 2023). Using time series data, Jerry et al. (2025) examined the relationship between social welfare, healthcare, and education—three crucial measures of human capital—and their effects on lowering poverty and fostering economic growth in Nigeria. Economic growth and human capital development are strongly positively correlated, according to the results of research utilising the Autoregressive Distributive Lag Model (ARDL). This suggests that more investment in healthcare and education directly leads to higher economic productivity. The study also reveals a substantial inverse relationship between human capital development and poverty rates, suggesting that increasing access to healthcare and education might considerably lower poverty levels. Ukpe (2024) examined the relationship between the expansion of human capital between 2000 and 2023 and Cameroon's agricultural output. The findings indicate that 78% of the variation in agricultural production can be attributed to land use, agricultural labour, health spending, and education spending. Agricultural output is positively and significantly impacted by each of these elements. This paper highlights that balanced investments in health and education are essential for enhancing agricultural productivity, even while disparities in these

expenditures may result in reduced yield. Anowor et al. (2019) used the dynamic error correction model to study agricultural productivity and health consequences in Nigeria. The results showed that agricultural output potentials are significantly impacted by health outcomes. It follows that a massive expansion of the agriculture industry is unquestionably anticipated if the administration is serious and prioritises the healthcare system. In order to maximise agricultural productivity, the research begged for a quick and urgent push in worker healthcare. According to the study's hypothesis:

H_2: Investment in health has significant effect on agricultural development in Nigeria

Investment in Agriculture and Agricultural Development

It is assumed that government spending on agricultural amenities and facilities will greatly boost the agricultural sector's output. Momodu et al. (2025) investigated the agricultural sector's performance and economic growth in Nigeria from 1981 to 2023 in order to verify this assertion. The findings indicated that while forestry production had a little impact on GDP, the output of livestock, fishery, and agriculture all had positive and significant benefits. Thus, it is possible to draw the conclusion that agricultural investments increase agricultural fortune, which unavoidably helps the sector succeed. Akintunde et al. (2025) investigated the impact of rural spending on Nigeria's financial sustainability using additional agricultural investment indicators from 1981 to 2020. The analytical conclusion is that export loans, agricultural lending, and capital investment all have a significant, long-term, and favourable effect on GDP. Ogunjobi et al. (2025), on the other hand, looked at the relationship between Nigerian agricultural output and the growth of human capital throughout the years 1988–2023. In short, there is a significant adverse relationship between agricultural productivity and human capital development. Another paper by Ibeinmo and Akidi (2023) examines the connection between Nigeria's economic progress from 1986 to 2022 and agricultural funding. Statistics show that government spending on agriculture, bank loans to farmers, and the Agricultural Credit Guarantee Scheme Fund all significantly affect Nigeria's real gross domestic product. The study found evidence of a long-term relationship through Johansen cointegration. Consequently, it was determined that Nigeria's economic development was significantly influenced by agricultural finance. Consequently, the research postulated that:

H_3: Investment in agriculture has significant effect on agricultural development in Nigeria

Labour Force Participation and Agricultural Development

Nduka et al. (2025) used the Autoregressive Distributed Lag (ARDL) model to determine the impacts of human capital indicators (education, healthcare, and labour force skill development) and economic diversification (i.e., the proportion of GDP that is not generated from oil). The results showed that economic diversification and human capital development were positively correlated and statistically significant. Similar to this, Okechukwu and Ikeije (2025) looked at the connection between food security and human capital development, or the labour force's skill gap. Regression analysis of 150 randomly selected agro-farmers revealed that increases in agricultural technical abilities, capacity for research and development, environmental consciousness, and extension services all directly result in more food being accessible. Food security and human capital development were impliedly shown to be significantly positively correlated. In another empirical study, Oladapo and Oyaromade (2025) examined the short- and long-term relationships between human capital development and inclusive growth, including life expectancy, secondary school enrolment, labour force participation, and gross fixed capital formation. They discovered that human capital development has a significant impact on inclusive growth in Nigeria. The results of the study show that, among other things, labour force participation and steady investments in human capital are necessary for inclusive growth in Nigeria. The autoregressive distributive lag (ARDL) technique was used by Adediyan and Omorenuwa (2021) to estimate the study of labour productivity and human capital investment in Nigeria between 1986 and 2019. The study's findings are centred on two folds, according to the predicted model. Under the first scenario, human capital investment directly boosts labour productivity; however, poverty over time directly lowers labour productivity in all three sectors. In the second scenario, poverty only momentarily lowers the contribution of investments in human capital to the growth of labour productivity in the agricultural and industrial sectors. This suggests that without active labour force engagement, a country's agricultural sustainability and production cannot be ensured. Consequently, the research postulated that:

H_4: Labour force participation has significant effect on agricultural development in Nigeria.

Comparative evidence from other developing economies such as Ethiopia, Kenya, and India indicates that sustained investment in rural education, agricultural extension services, and primary healthcare significantly enhances farm productivity and rural income levels. Unlike Nigeria, where expenditure efficiency challenges persist, these countries have implemented targeted agricultural human capital programs that directly link training and health services to farm-level productivity. This comparative perspective highlights that Nigeria's challenge may lie less in investment presence and more in investment effectiveness and institutional coordination.

DATA AND METHODOLOGY

In order to organise the data on human capital development and sustainable agricultural production, an ex post facto research design was appropriately selected. The selected data came from the CBN and NBS statistics bulletin for 1981 to 2024. The 44-year research period is definitely enough to ascertain the long-term relationship between the explanatory and dependent variables. Consequently, Pesaran et al. (2001) proposed the Autoregressive Distributed Lag Model as the main estimation test. Before the test, pre-estimation and post-estimation tests are equally assessed to determine the nature of the data for any potentially erroneous regression result.

The confirmed model from James's (2021) study was adjusted and adapted for this study's intended use in order to meet the model definition. Thus, the model is shown as follows:

$$RAGDP = f(GIE, GIH, GIA, LFP) \quad \text{---------- } 3.1$$

Where:

RAGDP = Real Agric sector gross domestic product

GIE = Government investment in education

GIH = Government investment in health

GIA = Government investment in agriculture

LFP = Labour force participation

To put in econometric form, the equation becomes

$$RAGDP = \beta_0 + \beta_1 GIE + \beta_2 GIH + \beta_3 GIA + \beta_4 LFP + \mu_t \quad \text{---------- } 3.2$$

Where:

β_0 = Constant, $\beta_1 - \beta_4$= beta coefficients of the independent variables; μ_t = error term. Other variables are as earlier defined.

Equation 3.2 was restated in loglinearized form as:

$$lnRAGDP = \beta_0 + \beta_1 lnGIE + \beta_2 lnGIH + \beta_3 lnGIA + \beta_4 lnLFP + \mu_t \quad \text{---------- } 3.3$$

The features of each individual arrangement are evaluated in equation (3.4) and the ADF test was used to determine whether a unit root exists in order to test for stationarity in this study.

$$\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta Y_{t-2} + \gamma_3 \Delta Y_{t-3} + \gamma_4 \Delta Y_{t-4} + \gamma_k \Delta Y_{t-k} + \varepsilon_t \quad \text{----} 3.4$$

Following the establishment of the unit root's characteristics on the examined data, the Autoregressive Distributed Lag Model (ARDL), created by Pesaran et al. (2001), was succinctly utilised to determine the

immediate and long-term effects of human capital development on sustainable agricultural output. Thus, the ARDL system's unrestricted representation is as follows:

$$\Delta \ln(RAGDP)_t = \lambda_0 + \sum_{i-1}^{p} \lambda_1 \Delta ln(GIE)_{t-1} + \sum_{i-1}^{q1} \lambda_2 \Delta ln(GIH)_{t-1} + \sum_{i-1}^{q2} \lambda_3 \Delta ln(GIA)_{t-1} + \sum_{i-1}^{q3} \lambda_4 \Delta ln(LFP)_{t-1} + \lambda_1 \ln(RAGDP)_{t-1} + \lambda_2 ln\,(GIE)_{t-1} + \lambda_3 ln\,(GIH)_{t-1} + \lambda_4 ln\,(GIH)_{t-1} + \lambda_5 ln\,(LFP)_{t-1} + \mu_{it} \quad -----3.5$$

Where:

Δ denotes the first difference operator.

The short-term dynamics are represented by the first summation terms (in differences).

The lagged level terms $RAGDP_{t-1}$, GIE_{t-1}, GIE_{t-1}, GIA_{t-1}, LFP_{t-1} capture the long-run equilibrium relationship.

The coefficients γ on differenced variables indicate short-term adaptations, while the coefficients λ_1, λ_2, λ_3, and λ_4 indicate long-term elasticities of some kind.
It is assumed that the white noise error term, μt, is independently and identically distributed.
The corresponding robust error revision model is evaluated using the condition roar in order to ascertain the pace of change (short run) caused by the ECT model.

$$\ln(RAGDP)_t = \lambda_0 + \sum_{i-1}^{n} \lambda_1 + \Delta ln(GIE)_{t-1} + \sum_{i-1}^{n} \lambda_2 + \Delta ln(GIH)_{t-1} + \sum_{i-1}^{n} \lambda_3 + \Delta ln(GIA)_{t-1} + \sum_{i-1}^{n} \lambda_4 + \Delta ln(LFP)_{t-1} + (ECT)_{t-1} \quad ------3.6$$

Although the ARDL model is robust in estimating both short-run and long-run dynamics, it may not fully capture structural breaks arising from major economic reforms, policy shifts, global food crises, or climate-related shocks that occurred within the 1981–2024 period. Nigeria experienced episodes such as structural adjustment reforms, oil price volatility, exchange rate instability, and climate variability, which may have influenced agricultural productivity. While ARDL partially accommodates dynamic adjustments, future studies could incorporate structural break tests (e.g., Zivot-Andrews test) or dummy variables to better isolate these macroeconomic disruptions.

Description/Measurement and *Apriori* Expectation

Proxies	**Description/Measurement**	**Signs**	**Source**
RAGDP	Total production of the agriculture sector as a proportion of GDP.	NA	CBN
GIE	Spending on education as a proportion of total recurring government spending (%).	+	CBN
GIH	The proportion of total government spending on health infrastructure (%).	+	CBN
GIA	The proportion of government spending that goes towards agricultural infrastructure as a percentage of total spending (%)	+	CBN
LFP	total number of workers between the ages of 15 and 65. (value)	+	NBS

Source: Author's compilation (2025)

Following the underpinning theory of human capital where it strongly advocates for maximum investment in education, health and skill. It would be expected government investment in health, education, and agriculture as well as labour force participation will directly affect sustainable agriculture development. Summarily,

$$\frac{\partial RAGDP}{\partial GIE} > 0; \frac{\partial RAGDP}{\partial GIH} > 0; \frac{\partial RAGDP}{\partial GIA} > 0; \frac{\partial RAGDP}{\partial LFP} > 0 \quad ---------- 3.7$$

Limitations of Data and Scope of Study

This study relies exclusively on secondary data obtained from the Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS). While these sources are credible and nationally representative, they do not capture qualitative dimensions such as farmer-level experiences, institutional bottlenecks, implementation gaps in public expenditure, and regional disparities in human capital deployment. Consequently, the findings reflect macro-level relationships rather than micro-level behavioural dynamics. Future research may adopt a mixed-methods approach incorporating field surveys and stakeholder interviews to enrich interpretation and enhance contextual understanding of agricultural sustainability in Nigeria.

RESULT AND DISCUSSION

Descriptive Statistics

Table 4.1: Descriptive Statistics

	RAGDP	GIE	GIH	GIA	LFP
Mean	3.276143	1.428646	1.100067	0.572214	3.950145
Minimum	1.231780	-0.790072	-1.383897	-1.893813	2.143984
Maximum	4.751887	2.936381	2.700557	1.967993	5.814957
Std. Dev.	1.133167	1.254713	1.337805	1.299258	1.130452
Observations	44	44	44	44	44

Source: EViews 11

Analysis in Table 4.1 shows that on the average, RAGDP, GIE, GIH, GIA and LFP have mean values of 3.27, 1.42, 1.10, 0.57 and 3.95. The variable's data varies from minimum of 1.23, -0.79, -1.38, -1.89, 2.14 to 4.75, 2.93, 2.70, 1.96 and 5.81 respectively and possessed STD value of 1.13, 1.25, 133, 1.29 and 1.13 respectively. Following the report of the mean and ST. D, it implies that the data evolves around the mean.

Correlation Matrix

Table 4.2 Correlation Matrix Analysis

	RAGDP	GIE	GIH	GIA	LFP
RAGDP	1.000000				
GIE	0.484580	1.000000	0.494495	0.576714	0.574758

GIH	0.487361	0.494495	1.000000	0.571719	0.580888
GIA	0.574564	0.576714	0.571719	1.000000	0.658412
LFP	0.593667	0.574758	0.580888	0.658412	1.000000

Source: EViews 11

RAGDP and all of the explanatory variables have a positive association, according the report in Table 4.2. In particular, the values for LFP and RAGDP are 0.59, GIH and RAGDP are 0.48, GIA and RAGDP are 0.57, and GIE and RAGDP are 0.48. The overall coefficients of the understudied variables are less than 0.7, suggesting that neither collinearity nor multicollinearity are taken into account by the model.

Stationarity Test

Table 4.3: ADF Unit Root Test Results

Variable	**Level**		**First difference**		
	Test statistic	**p-value**	**Test statistic**	**p-value**	**Order of Integration**
RAGDP	-2.4823	*0.1267* NS	-4.0848	0.0027***	I(1) 1st diff
GIE	-2.9381	***0.0542****	-----	------	I(0) level
GIH	-2.1210	*0.2378* NS	-8.2759	0.0000***	I(1) 1st diff
GIA	-2.3943	0.1495 NS	-9.0899	0.0000***	I(1) 1st diff
LFP	-0.0572	0.9476 NS	-7.1871	0.0000***	I(1) 1st diff

Source: EViews 11

Note: **NS, ***, **,** and * denote non-stationary, statistically significant at 10%, 5%, and 1% significance level respectively.

With a coef. value of -2.9381 and a P.v. of 0.05, Table 4.3 notably demonstrates that GIE achieved stationarity at the 5% significant level, whereas RAGDP, GIH, GIA, and LFP became stationary at the first difference @5% level. This suggests the potential for an ARDL short-term-long association after the lower-upper bound test yielded a mixed result.

Model Selection Criteria

Table 4.4: Model Selection Criteria

Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
30	95.436728	-3.771836	-2.927397	-3.466514	0.999005	ARDL(4, 4, 3, 4, 0)

Source: EViews 11

The specification order for analytical representation is 4. 4, 3, 4, 0 in Table 4.4. This indicates that the short-term model would not take into consideration the value for labour force participation, which is represented by 0.

ARDL Co-integration Test

Table 4.5: Bounds Test Result

F-statistics	Significance level	Lower bound	Upper bound
4.687652	5%	2.56	3.49

Source: EViews 11

The limit test is shown in Table 4.5 with F-st. value of 4.687652, which was significant at 5% and seems to be higher than the bounds for the lower (2.56) and upper (3.49) limits, respectively. As a result, the model shows a long-term link between human capital development and the sustainability of Nigerian agricultural productivity.

Short-run Estimation Results

Table 4.6 Short-run Estimation Result

Variable	Coefficient	Std. Error	T	P>|t|
D (RAGDP (-1))	0.958496	0.099033	9.678501	0.0000
D(RAGDP(-2))	-0.293892	0.096614	-3.041917	0.0064
D(RAGDP(-3))	0.327186	0.085214	3.839578	0.0010
D(GIE)	0.151561	0.050542	2.998678	0.0071
D(GIE(-1))	-0.021748	0.044080	-0.493383	0.6271
D(GIE(-2))	0.071198	0.043627	1.631991	0.1183
D(GIE(-3))	0.175157	0.026141	6.700595	0.0000
D(GIH)	0.190403	0.046083	4.131760	0.0005
D(GIH(-1))	0.242240	0.066146	-3.662203	0.0015
D(GIH(-2))	0.235003	0.054472	4.314193	0.0003
D(GIA)	0.041651	0.020858	2.996885	0.0396
D(GIA(-1))	-0.053618	0.027589	-2.943445	0.0662
D(GIA(-2))	-0.009737	0.026458	-0.368006	0.7167
D(GIA(-3))	0.119072	0.027041	4.403440	0.0003
CointEq (-1) *	-0.554564	0.098955	-5.604230	0.0000
R-squared	0.888870			
Adj. R squared	0.826637			
Durbin Watson	2.158487			
Prob(F-statistic)	0.000000			

Source: EViews 11

Table 4.6 demonstrates that every explanatory factor significantly and favourably affects RAGDP. The corresponding coefficient values on RAGDP are 0.151561 and 0.175157, 0.190403 and 0.235003, 0.041651 and 0.119072, D(GIE) and D (GIE (-3), D(GIH) and D (GIH (-2), and D(GIA) and D (GIA (-3). Based on the relevant percentages, this suggests that any further increase in GIE, GIH, and GIA values equated to about 15.16% and 17.52% for GIE and GIE(-3), 19.04% and 23.50% for GIH and GIH(-2), and 4.16% and 11.91% for GIA and GIA(-3) respectively. This clearly shows that lending money to the private sector for investment objectives, as well as spending on worker skill development, health care, and education, are all beneficial human capital expenditures that have an immediate effect on the agricultural growth of Nigeria. This demonstrates how the Nigerian government's efforts to improve agricultural growth, ensure food security, and supply food have a major impact. In order to increase agricultural productivity and boost national growth, investments in health, education, and agriculture should be maintained. The results support the findings of Akintunde et al. (2025) about the substantial impact of government expenditure in funding agricultural activities on overall national performance, but they differ from those of Omokugbo and Imogiemhe (2020). The delayed error correction term CointEq (-1) (-0.554564) indicated that the rate of recovery from disequilibrium to the long-run equilibrium is 55.45%. As evidenced by the modified R-square of 0.888870, the rise in agricultural production sustainability is attributed to joint huma capital development factors. The P-value of 0.0000 shows that the model is generally accepted. DWT score 2.158487 indicates that autocorrelation problems were not detected in the analysis.

Long-run Estimation Result

Table 4.7: Long-run Estimation Result

Variables	Coefficient	Std. Err.	T	P>|t|
GIE	0.256781	0.184263	1.393553	0.1787
GIH	0.193122	0.154609	1.249096	0.2261
GIA	0.217777	0.095874	2.271498	0.0343
LFP	0.227749	0.076276	2.985852	0.0073
C	1.743175	0.235875	7.390248	0.0000

Source: EViews 11

GIE and GIA have respective coefficients of 0.256781 and 0.193122, as indicated in Table 4.7. The link between the elements is definitely favourable, although the effect is small. As a result, a 1% increase in GIE and GIH over the research period corresponds to a meagre 25.67% and 19.31% improvement in RAGDP, or sustainability of agricultural development. In order to boost and sustain agricultural production, the government makes annual expenditures in the health and education sectors, however this shows that these investments are not real and genuine. Even if the outcome is good, the minor impact is concerning. This is related to the government's promises and failure in the fields of health and education. The opposite is true in Nigeria, where spending is much below the UNESCO-recommended ratio, in contrast to other nations that make significant investments in health and education. The agriculture industry may be greatly revitalised if the government makes sincere financial and infrastructure investments in the fields of health and education. The analysis supports Jerry et al.'s (2025) finding that investment in health and education is positively correlated with Nigeria's agricultural output. Moreover, the coefficients of GIA and LFP are 0.227749 and 0.217777, respectively. Not only do the components have a positive association, but they also have a significant influence on RAGDP. This means that a 1% increase in GIA and LFP, respectively, resulted in rises in RAGDP of 21.77% and 22.77%. Consequently, the country's agricultural development sustainability is greatly influenced by active worker involvement, skill, training, and financial investment. This outcome was anticipated and suggests that government inadequacies and a casual attitude are undermined by labour involvement capacity training and agricultural facility investments. The outcome contradicted the findings of Adediyan and Omorenuwa (2021), but it supported the assertions of

Ibeinmo and Akidi (2023) and Ofem et al. (2023) that labour force participation and agricultural investment had a major impact on Nigerian agricultural production and development.

Post-Estimation Test

Table 4.8 Post-Estimation Test

Statistics	**Chi-square/F-stat/Jarque-bera**	**Prob.**
Normality	3.451662	0.1780
Stability	0.382670	0.5435
Breusch-Godfrey Serial Correlation	0.525817	0.5999
Heteroskedasticity Test: ARCH	3.611925	0.0652

Source: EViews 11

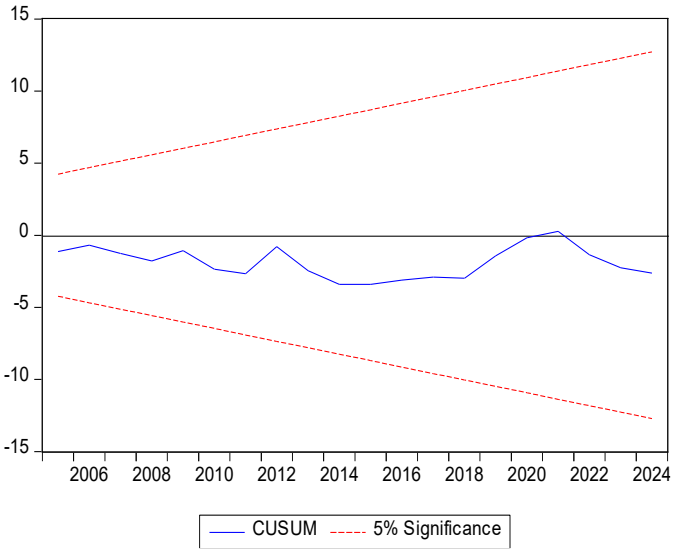

Fig. 1: CUSUM

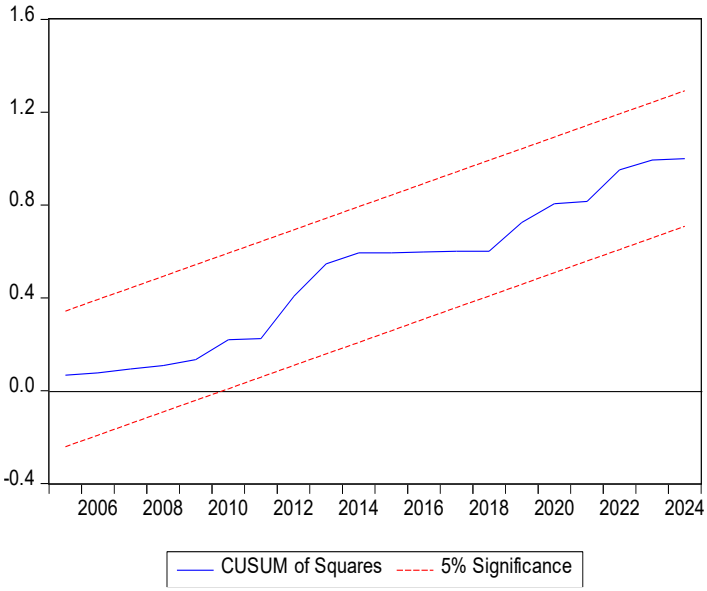

Fig. 2: CUSUM of Squares

Source: EViews 11

According to the general rule of thumb, the model passed the post-estimation test if a significant value of >5% is required (Table 4.8). The study is homoscedastic, stable, normalised, and strongly correlated as a result. Figures 1 and 2 show that the trend movement inside the important boundary lines indicates that the estimated short-run model is both structurally and dynamically stable for policy development.

DISCUSSION OF FINDINGS

The sustainability of agricultural output and the development of human capital were both empirically examined. Utilising an autoregressive distributed lag model, the study discovered a long-term relationship between the understudied variables. This implies a long-standing link between Nigeria's agricultural output sustainability and human capital development. The outcome backs up James's empirical study from 2021. The ECT short-term research also shown that labour force participation, government expenditure on agriculture, health and education had a positive and noteworthy short-term effect on the country's agricultural output. This result validates the claim of Ofem et al. (2023) that human capital development has a significant influence on agricultural development in Nigeria. Nigeria's agricultural output and development are significantly increased by government policies, programs, initiatives, and investments in both the public and private sectors as well as in individuals.

The case had a different long-term effect, where health and education spending has a minor but positive effect on agricultural production sustainability. This implies that although the sector loses over time, the government is primarily focused on the short-term or immediate results. The result is significant in the short run but negligible in the long run, which is likely due to the Nigerian government's implicit lack of regard for its human capital as a way to sustain agricultural productivity. Regarding the long-term, positive, and insignificant correlation between government expenditure on health, education, and agricultural production, this result is consistent with the findings of Jerry et al. (2025). Moreover, this little effect may be related to the meagre funding allotted to the education and health sectors, respectively, which deviates from the recommendations of the World Health Organisation. Therefore, to increase intermittent agricultural output, human capital investment in health and education must be assured.

The insignificant long-run effect of health and education expenditure may reflect structural inefficiencies in Nigeria’s public spending system rather than the irrelevance of human capital investment. Budgetary allocations to health and education have historically fallen below international benchmarks, particularly UNESCO’s recommended 15–20% education budget allocation and WHO standards for health expenditure. Moreover, weak monitoring systems, corruption, and misalignment between educational curricula and agricultural labour market needs may prevent these investments from translating into agricultural productivity gains. This suggests that the issue may not be the quantity of expenditure but its efficiency, targeting, and implementation quality.

Furthermore, the results showed that labour force participation and agricultural investment had a positive and significant effect on long-term agricultural productivity. This result confirms the conclusions of Ofem et al. (2023) and Ibeinmo and Akidi (2023), which indicate that labour force participation and agricultural investment are essential to the output and development of the agricultural sector. Additionally, the government must work with the private sector to expand the amount of credit available to the agriculture sector in order to ensure food security and national progress.

However, labour force participation indicates that the government is investing in human resource development to boost agricultural output and development. However, more financing is required for labour research, training, and development in order to sustain agricultural development.

CONCLUSIONS AND POLICY RECOMMENDATIONS

The study looked at how human capital development affected the sustainability of Nigeria's agricultural output during a 44-year period, from 1981 to 2024. The ARDL study found that government expenditure on agriculture, health, education, as well as labour force participation had a short-term, positive, and significant influence on sustainable agricultural productivity. Long-term sustainable agricultural output is significantly impacted by

government investment on agriculture and human capital involvement, but there is no appreciable effect on government spending on health and education. According to the aforementioned, the study confirms the conclusions of James (2021), Ndibe (2022), and Ofem et al. (2023) that the sustainability of Nigerian agricultural output is positively and significantly impacted by the development of human capital. Accordingly, the study suggests that more funds be allocated to the health and education sectors in order to modify the country's agriculture sector and advance literacy and people's well-being. The government should specifically define goals for expenditure-to-GDP ratios, enhance vocational training for agri-value chains, and rebalance spending towards agricultural R&D, rural health, and extension services. In order to increase agricultural output, the government should also keep funding the industry, especially by working with the private sector.

Furthermore, Nigeria's economy and agricultural production will grow if labour force participation is permitted. The work contributed to knowledge by separating short- and long-term dynamics, estimating LFP and human capital together, and accumulating information spanning 44 years (1981–2024).

In light of the findings and the foregoing discussion, the following actionable strategies are recommended:

1. **Increase Budget Allocation Efficiency:** Government should not only increase funding for health and education but ensure targeted rural spending focused on agricultural communities.

2. **Strengthen Agricultural Extension Services:** Investment in skill acquisition programs tailored to agri-value chains should be expanded.

3. **Promote Public-Private Partnerships (PPP):** Collaboration between government, NGOs, and private agribusiness firms should be strengthened to improve agricultural financing access.

4. **Align Education with Agricultural Innovation:** Agricultural curriculum reform should incorporate climate-smart agriculture and digital farming technologies.

5. **Establish Monitoring Frameworks:** Transparent monitoring mechanisms should be introduced to evaluate the effectiveness of agricultural and human capital expenditure.

6. **Support Youth Participation in Agriculture:** Targeted youth employment programs in agriculture should be introduced to strengthen labour force participation sustainability.

Future Research Direction

Future studies should adopt a mixed-method approach combining econometric modeling with field surveys and case studies to capture micro-level agricultural dynamics. Additionally, incorporating environmental variables such as climate change, land degradation, inflation, and policy instability would provide a more comprehensive understanding of agricultural sustainability in Nigeria.

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