



Department of Economics and Development Studies

Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State, Nigeria.

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DOES PUBLIC AGRICULTURAL EXPENDITURE DRIVE FARM EFFICIENCY? PANEL EVIDENCE FROM WEST AFRICA, 2003-2024

¹Yaqoob Jelili & ²Oke Margaret Adebimpe¹Department of Business Administration & Management, Oyo State College of Agriculture & Technology, Igboora²Department of Economics, Ajayi Crowther University, Oyo, NigeriaEmail: jyaqoob09@gmail.com

ABSTRACT

This study examines the direct impact of public agricultural expenditure (PAE) on total factor productivity (TFP) across selected West African countries over the period 2003-2024, encompassing two decades of post-Maputo Declaration agricultural policy reform. Using the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) estimators, chosen for their robustness to cross-sectional dependence and slope heterogeneity confirmed through prior diagnostic tests, alongside System Generalised Method of Moments (GMM) for robustness, the study establishes a positive and statistically significant elasticity of TFP with respect to PAE in the range of 0.418 to 0.516. Complementary controls for fertiliser consumption, agricultural trade openness, rural infrastructure, and precipitation are incorporated. Pre-estimation diagnostics confirm cross-sectional dependence, mixed integration orders, panel cointegration among I(1) variables, and significant slope heterogeneity. The common factor loading, exceeding 0.70 in both AMG and CCEMG specifications, identifies region-wide shocks, including commodity cycles, climate events, and donor-driven programmes, as major contributors to aggregate productivity variance. Results imply that sustained fiscal commitment to agriculture, directed at productive capital such as irrigation, research and development, and rural infrastructure, constitutes an independent and measurable pathway to closing the agricultural productivity gap in West Africa.

Keywords: Public agricultural expenditure; Total factor productivity; AMG; CCEMG; Panel data

JEL Classification: H54; O13; Q18; C23

1. Introduction

Agriculture remains the economic backbone of West Africa, sustaining livelihoods, absorbing a large share of the labour force, and contributing materially to gross domestic product across Economic Community of West African States (ECOWAS) member countries. Recent regional and continental assessments show that agriculture still accounts for a major share of employment in West Africa, while its contribution to GDP remains lower than its employment weight, indicating a persistent productivity gap that constrains structural transformation (African Development Bank, 2025; ECOWAS, 2023; West African Development Bank, 2024). In several ECOWAS economies, the sector employs more than half of workers, yet its output share remains well below that level, suggesting that the region is still not extracting sufficient value from its agricultural resource base (West African Development Bank, 2024). This imbalance matters because agriculture remains central not only to income generation and rural welfare but also to food security and poverty reduction across the region (ECOWAS, 2023).

The productivity problem is equally evident in long-run output performance. The African Development Bank's 2025 outlook indicates that total factor productivity (TFP) growth in Africa has remained weak relative to other regions, and West Africa continues to lag behind comparator economies in efficiency gains (African Development Bank, 2025). FAO's 2024 assessment of food prospects and situation in West Africa further suggests that cereal production growth has been driven largely by expansion in cultivated area rather than by improvements in yield or input efficiency, leaving the region vulnerable to land constraints, climate volatility, and rising production costs (FAO, 2024). Put differently, agricultural growth has often depended on extensification rather than intensification, which is neither sustainable nor sufficient for a region with growing population pressure and limited arable land.

Policy responses to this challenge have long been shaped by the African Union's CAADP commitments. The Maputo Declaration of 2003 required African Union member states to allocate at least 10% of national budgets to agriculture, and the Malabo Declaration of 2014 reaffirmed that target while also linking it to an agricultural growth objective of at least 6% per year (African Union, 2003, 2014). Yet implementation has remained weak. FAO's review of public expenditure on food and agriculture in sub-Saharan Africa found that governments allocated, on average, only about 6% of national budgets to food and agriculture between 2004 and 2018, with very few countries meeting the 10% threshold (Pernechele *et al.*, 2021). The 2022 CAADP Biennial Review also showed that only Rwanda was fully on track with the Malabo commitments, while only a small number of countries met the spending benchmark or broader performance targets (AKADEMIYA2063, 2022; CAADP, 2022). More recent scorecards and reviews continue to suggest that the number of countries on track remains very limited, despite the continued policy salience of agricultural transformation (Makombe *et al.*, 2025; Matchaya *et al.*, 2024).

Against this backdrop, whether public agricultural expenditure (PAE) actually translates into productivity gains remains an open empirical question. Existing studies generally point to positive fiscal-productivity linkages in African and comparable developing-country settings, including evidence that public agricultural spending can support agricultural output growth, total factor productivity, and food-system resilience (Hodjo *et al.*, 2023; Marson, 2025; Ngepah & Sunge, 2023; Nin-Pratt, 2021). However, the evidence base is still limited in three important ways. First, many country and region-level studies do not adequately account for cross-sectional

dependence among West African economies, even though these economies face shared climatic shocks, similar commodity-price cycles, and regionally coordinated or donor-funded programmes; ignoring these interdependencies can bias estimated elasticities and weaken inference (Espoir *et al.*, 2024). Second, the slope heterogeneity documented across the region, which reflects differences in fiscal systems, agro-ecological zones, infrastructure endowments, and governance quality, is often overlooked when researchers impose homogeneous estimators such as pooled ordinary least squares or standard fixed effects (Mogashoa *et al.*, 2024). Third, relatively few studies extend their analysis to 2024, thereby excluding the COVID-19 pandemic, the Russia-Ukraine grain-price shock, and the recent wave of political instability in parts of the Sahel, all of which altered fiscal space, input prices, and investment conditions for agriculture (African Development Bank, 2025; Marson, 2025).

A parallel literature focused largely on South Africa and Nigeria provides useful but narrower evidence. Studies using vector autoregressive and autoregressive distributed lag frameworks show that government agricultural spending raises output value and productivity in both the short and long run, but these estimates are country-specific and cannot isolate the region-wide common shocks that increasingly shape agricultural performance in an interconnected West African commodity space (Ngobeni & Muchopa, 2022; Ngepah & Sunge, 2023). Broader evidence suggests that improving public spending on agriculture can boost productivity, with productive investments generating stronger returns than recurrent spending and with beneficial effects operating through channels such as technology, knowledge, transaction-cost reduction, and private capital crowd-in (World Bank, 2017). Taken together, these findings are encouraging, but they also show that the size and transmission of the PAE effect depend heavily on model specification, time horizon, and the treatment of unobserved regional shocks.

This study addresses these gaps by employing second-generation panel estimators, namely the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) estimators, alongside System GMM, over a balanced panel of West African countries covering 2003 to 2024. The paper makes three specific contributions. First, it conducts rigorous pre-estimation diagnostics to confirm cross-sectional dependence and slope heterogeneity before estimator selection, directly responding to methodological concerns raised in recent panel-data studies of African agricultural productivity (Espoir *et al.*, 2024; Mogashoa *et al.*, 2024). Second, it isolates the independent contribution of PAE to TFP while controlling for fertiliser intensity, trade openness, infrastructure access, and precipitation, thereby reducing omitted-variable bias and improving identification of the productivity return to public spending. Third, it estimates a common factor loading that captures unobserved regional shocks otherwise conflated with fiscal policy effects, a decomposition that recent studies suggest is essential for avoiding overstated elasticities and for correctly interpreting fiscal-productivity relationships in highly interconnected regional panels (Mogashoa *et al.*, 2024).

Research Questions

The study is guided by the following research questions:

- a) To what extent does public agricultural expenditure affect agricultural total factor productivity in West Africa when estimators robust to cross-sectional dependence and slope heterogeneity are employed?
- b) To what extent do fertiliser consumption, rural infrastructure, precipitation, and agricultural trade openness independently influence agricultural total factor productivity alongside public agricultural expenditure?

- c) How do the diagnostic tests for cross-sectional dependence, unit roots, cointegration, and slope homogeneity support the selection of the estimators used in the study?
- d) What is the magnitude of common regional shocks relative to country-specific fiscal effort in explaining aggregate agricultural productivity performance in West Africa?

Objectives of the Study

The broad objective of the study is to examine the direct impact of public agricultural expenditure on total factor productivity across selected West African countries between 2003 and 2024. Specifically, the study sought to:

- a) Establish the elasticity of agricultural TFP with respect to PAE using estimators robust to cross-sectional dependence and slope heterogeneity.
- b) Assess the independent contribution of fertiliser consumption, rural infrastructure, precipitation, and agricultural trade openness to TFP alongside PAE.
- c) Conduct rigorous pre-estimation diagnostics, including tests for cross-sectional dependence, unit roots, cointegration, and slope homogeneity, to justify estimator selection.
- d) Quantify the magnitude of common regional shocks relative to country-specific fiscal effort in explaining aggregate agricultural productivity performance in West Africa.

2. Literature Review

2.1 Conceptual Literature

Public agricultural expenditure (PAE) refers to government spending directed toward the agriculture sector, including outlays on research and development, extension services, irrigation, rural roads, input support, and other public goods that affect farm production conditions. In the African policy literature, the distinction between capital and recurrent spending is especially important because capital expenditure is more likely to create durable productive assets, whereas recurrent spending often sustains administrative functions without expanding the productive frontier (Fan & Rao, 2003; Pernechele *et al.*, 2021). This distinction is consistent with evidence from agricultural public expenditure reviews in African countries, which repeatedly show that countries spend too little on productivity-enhancing investments and too much on expenditure items with weaker long-run effects on agricultural output (Pernechele *et al.*, 2021; World Bank, 2025).

The dependent variable in this study, total factor productivity (TFP), captures the efficiency with which an economy transforms a bundle of inputs into output after accounting for growth in factor use. Unlike partial productivity indicators such as output per hectare or output per worker, TFP isolates changes in efficiency, technology, and allocative performance, making it the more suitable concept for assessing whether public spending improves agricultural performance beyond simple input expansion (Fuglie & Gao, 2024; Ngepah & Sunge, 2023). In West African agriculture, this is especially important because many observed output gains have historically come from extensification, input intensification, or subsidy-induced expansion rather than sustained efficiency improvements (African Development Bank, 2025; FAO, 2024).

The conceptual linkage between PAE and TFP operates through several channels. First, public spending on agricultural research and extension helps diffuse improved technologies, seed varieties, and management practices across farms, thereby raising the productivity of existing inputs (Fan & Rao, 2003; Romer, 1986). Second, investment in irrigation, roads, storage, and market infrastructure reduces transaction costs, expands market access, and lowers post-harvest losses, all of which strengthen the productivity response of agriculture to fiscal support (World Bank, 2024; West African Development Bank, 2024). Third, complementary inputs such as fertiliser, trade openness, and access to rural infrastructure can amplify the effect of public spending, because the returns to government investment are usually higher when private and market-supporting inputs are available (Zhang & Zhang, 2024). This complementarity is particularly relevant in West Africa, where climatic risk, fragmented markets, and weak logistics often prevent agricultural spending from translating automatically into measurable productivity gains.

A further conceptual distinction relevant to this study is between country-specific fiscal effort and region-wide common shocks. Commodity price cycles, climate variability, donor-funded regional programmes, and shared policy adjustments generate co-movements in agricultural performance across West African countries that are not fully explained by domestic policy choices alone (Espoir *et al.*, 2024). If these common shocks are ignored, the estimated relationship between PAE and TFP may be overstated or understated, depending on whether the omitted regional factor is positively or negatively correlated with public spending. For this reason, second-generation panel estimators that explicitly model common factors are better suited to studying the PAE-TFP relationship in West Africa than standard first-generation estimators.

2.2 Theoretical Literature

The theoretical case for public agricultural expenditure is grounded in public finance theory, endogenous growth theory, and factor-complementarity arguments. Public finance theory explains why governments should invest in agriculture where private markets underprovide socially valuable goods such as agricultural research, extension, irrigation, and rural infrastructure. These are classic public or quasi-public goods because they generate spillovers that cannot be fully captured by individual farmers or firms, leading to chronic underinvestment if left entirely to private markets (Fan & Rao, 2003; World Bank, 2024).

Endogenous growth theory strengthens this argument by showing that knowledge-based investment can generate persistent productivity gains. Romer's (1986) framework demonstrates that growth can be sustained by increasing returns to knowledge and innovation rather than solely by factor accumulation. Applied to agriculture, this implies that public spending on research, technology diffusion, and extension can create self-reinforcing productivity growth over time, especially where learning, experimentation, and adoption are cumulative. Empirical evidence from agricultural productivity studies supports this logic by showing that public research spending has stronger and more durable effects than purely consumption-oriented expenditures (Fuglie & Gao, 2024; Pernechele *et al.*, 2021).

The multiplier perspective also supports public spending on productive agricultural assets. Keynesian public investment theory suggests that government expenditure can stimulate output through demand and supply channels, especially where spending targets infrastructure, logistics, and productive services. In agriculture, investments in roads, irrigation, and storage raise private returns by lowering transport costs, reducing risk, and improving access to markets and inputs. Evidence from African expenditure reviews consistently shows that capital-oriented agricultural spending has stronger growth effects than recurrent spending, and that expenditure

composition matters at least as much as the total budget envelope (Benin, 2016; Fan & Rao, 2003; Pernechele *et al.*, 2021).

Wagner's Law provides a complementary macro-fiscal perspective. It predicts that public expenditure should rise with income as economies structurally transform and the demand for public goods increases. In the context of West Africa, persistent underinvestment in agriculture despite rising policy commitments suggests that budget allocation is not following a simple income-driven path. Instead, the financing gap likely reflects political economy constraints, competing fiscal priorities, and weak accountability structures rather than an absence of economic capacity (Olaoye *et al.*, 2022; Pernechele *et al.*, 2021). This helps explain why many countries continue to fall short of the Maputo and Malabo targets even where agriculture remains central to livelihoods and food security.

The theory of factor complementarity further suggests that the productivity return to PAE depends on the availability of complementary inputs such as fertiliser, trade access, and infrastructure. If these inputs are scarce, the marginal effect of public spending may be muted because farmers cannot fully convert fiscal support into higher output. Conversely, where complementary inputs are available, fiscal support may generate larger productivity gains through input diffusion, market integration, and technology adoption (Zhang & Zhang, 2024). This theoretical point justifies the inclusion of fertiliser consumption, trade openness, infrastructure access, and precipitation as conditioning variables in the empirical model.

2.3 Empirical Literature

The empirical literature on the relationship between public expenditure and agricultural productivity is broad but uneven, spanning global, continental, country-specific, and regional studies. A consistent finding across this literature is that not all agricultural spending generates the same productivity payoff. Fan and Rao (2003) showed that public spending on agriculture in developing countries has strong growth and poverty-reducing effects, but these effects vary substantially by spending category. Their work, together with later expenditure reviews, indicates that research, extension, irrigation, and rural roads usually produce higher returns than broad consumption or subsidy-heavy spending patterns (Fan & Rao, 2003; Pernechele *et al.*, 2021).

Within Africa, agricultural public expenditure reviews provide strong evidence that budget composition matters. Pernechele *et al.* (2021) found that average public spending on food and agriculture in sub-Saharan Africa remained well below the CAADP target over the 2004-2018 period, and that only a small number of countries reached the 10% benchmark. The report also highlighted the dominance of recurrent and subsidy-type spending in many countries, despite the stronger productivity effects associated with capital and research-oriented spending. Similarly, World Bank diagnostic reviews have emphasized that many African countries continue to underinvest in the productivity-enhancing components of agricultural budgets, especially research, irrigation, and rural infrastructure (World Bank, 2025).

Country-level evidence also generally points to a positive relationship between government agricultural expenditure and agricultural performance, though the magnitude and sign of the effect depend on model specification and spending composition. In Nigeria, Alabi and Abu (2020) found that agricultural capital expenditure had a positive effect on productivity, while total and recurrent agricultural expenditure were less consistently significant. In Ghana, Benin *et al.* (2012) reported that public spending on agriculture and rural roads

had substantial productivity effects across agro-ecological zones, with feeder roads and agricultural spending among the strongest contributors to agricultural output gains. In Togo, ARDL-based studies found that public investment improved agricultural total factor productivity, whereas public consumption spending had a negative effect, reinforcing the argument that the composition of expenditure matters (Koffi & Dtorane, 2022; Waibena & Yovo, 2021). Evidence from South Africa likewise indicates that government agricultural expenditure raises the value of agricultural production and supports TFP growth over both short and long horizons (Ngoben & Muchopa, 2022; Ngepah & Sunge, 2023).

At the cross-country level, broader evidence from sub-Saharan Africa also supports a positive link between agricultural public expenditure and agricultural output. At the cross-country level, evidence from sub-Saharan Africa indicates that higher and better-targeted public spending on agriculture is associated with stronger productivity performance, especially when spending is directed toward productive investments rather than recurrent outlays (World Bank, 2017; FAO, 2021). This is important because it suggests that the output effect of public spending is not purely direct; rather, it is mediated by the availability of complementary production assets and the efficiency with which public resources are converted into private productivity gains. Findings from ECOWAS-specific studies similarly indicate that public agricultural investment can improve food security, productivity, and rural welfare, though the evidence remains methodologically limited and often relies on single-country or homogeneous-panel specifications (Kamenya, 2022; Marson, 2025).

A recurring limitation of the literature is the frequent neglect of cross-sectional dependence and slope heterogeneity. Many studies still rely on pooled OLS, fixed effects, or other first-generation estimators that assume independent country trajectories and identical slope coefficients. This is problematic in West Africa because agricultural outcomes are jointly influenced by common shocks, such as climate events, commodity cycles, and regional policy changes, and because countries differ significantly in governance quality, institutional capacity, and agro-ecological endowments (Espoir *et al.*, 2024; Mogashoa *et al.*, 2024). Another limitation is the weak treatment of recent shocks, especially COVID-19, global food-price inflation, and political instability in the Sahel, which altered the fiscal environment for agriculture and likely affected the productivity response to public spending (African Development Bank, 2025; Marson, 2025).

Taken together, the empirical literature converges on the view that public agricultural expenditure can support agricultural productivity, but it leaves three important gaps. Methodologically, few West African-focused studies apply second-generation estimators that are robust to both cross-sectional dependence and slope heterogeneity. Temporally, many panels end before 2024 and therefore fail to capture the most recent global and regional shocks. Substantively, few studies separate common regional shocks from country-specific fiscal effects, despite growing evidence that this distinction is essential for unbiased estimation in highly interconnected panels (Espoir *et al.*, 2024; Mogashoa *et al.*, 2024). This study is positioned directly at the intersection of these three gaps.

3. Methodology

This study employs a panel-data design to examine the relationship between public agricultural expenditure (PAE) and agricultural total factor productivity (TFP) in selected West African countries over the period 2003–2024. Because the countries in the region are exposed to shared climatic shocks, regional commodity-price movements, and policy spillovers, the empirical strategy follows the second-generation panel-data literature and explicitly allows for cross-sectional dependence and slope heterogeneity (Pesaran, 2006; Pesaran & Yamagata, 2008). The methodological framework therefore combines diagnostic testing, long-run heterogeneous estimators,

and a dynamic-panel robustness check to ensure that the estimated PAE-TFP relationship is not driven by unobserved common factors or endogeneity.

Data and Variables

The study uses annual country-level panel data for selected West African economies covering 2003 to 2024. The period begins with the Maputo Declaration, which provides a natural policy baseline for evaluating agricultural spending commitments, and ends in 2024 to capture the post-COVID-19 period, the Russia-Ukraine food-price shock, and recent regional instability. The dependent variable is agricultural TFP, measured using a Törnqvist-Theil or related multifactor productivity index derived from agricultural output and input series, consistent with the approach used in recent productivity studies (Fuglie & Gao, 2024; Ngepah & Sunge, 2023).

The key explanatory variable is public agricultural expenditure, defined as government spending on agriculture, forestry, and fishing. Following the public finance and agricultural investment literature, the variable is treated as a proxy for fiscal commitment to productivity-enhancing agricultural services and infrastructure (Fan & Rao, 2003; Pernechele *et al.*, 2021). The model also includes fertiliser consumption, rural infrastructure access, precipitation, and agricultural trade openness as control variables. These are included because the productivity effect of public spending is likely to depend on complementary inputs, logistical conditions, and climate-related shocks (Espoir *et al.*, 2024; Zhang & Zhang, 2024).

Pre-Estimation Diagnostics

Before estimation, the panel was subjected to a sequence of diagnostic tests. First, cross-sectional dependence was examined using standard dependence tests suitable for macro panels, because the economies of West Africa are likely to share common shocks that violate independence assumptions (Pesaran, 2004; Frees, 1995; Friedman, 1937). Second, the order of integration of each series was assessed using panel unit root procedures that are robust to cross-sectional dependence, since mixed integration orders can bias conventional estimators if not properly detected (Pesaran, 2007). Third, the existence of a long-run equilibrium relationship among the variables was tested using panel cointegration methods that accommodate cross-sectional dependence through bootstrapping (Westerlund, 2007). Finally, slope homogeneity was tested using the Pesaran and Yamagata framework, because the response of TFP to fiscal spending is unlikely to be identical across countries with different agro-ecological and institutional conditions (Pesaran & Yamagata, 2008).

Model Specification

The baseline model is specified in logarithmic form as:

$$\ln \text{TFP}_{it} = \alpha_i + \beta_1 \ln \text{PAE}_{it} + \beta_2 \ln \text{FER}_{it} + \beta_3 \ln \text{INF}_{it} + \beta_4 \ln \text{RAN}_{it} + \beta_5 \ln \text{TRD}_{it} + \varepsilon_{it}$$

where i indexes countries and t indexes time. α_i captures unobserved country-specific effects, and ε_{it} is the idiosyncratic disturbance term. The log-linear form is preferred because it allows the estimated coefficients to be interpreted as elasticities, which is appropriate for policy analysis in fiscal-productivity studies.

Estimation Techniques

Given the likelihood of common shocks and heterogeneous responses, the study estimates the long-run model using the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) estimators. The CCEMG estimator, developed by Pesaran (2006), controls for unobserved common factors by augmenting

each country regression with cross-sectional averages of the dependent and explanatory variables. This approach is especially useful in panels where the number and form of common factors are unknown, but where cross-country co-movement is evident.

The AMG estimator, developed as an alternative heterogeneous-panel approach in the same broad methodological tradition, first extracts a common dynamic process from a first-differenced regression with time dummies and then incorporates that process into country-specific estimations before averaging the slopes. The procedure is well suited to macro panels with slope heterogeneity, non-stationarity, and cross-sectional dependence, because it explicitly captures the common movement that would otherwise be confounded with the coefficient of interest (Bond & Eberhardt, 2009; Eberhardt & Teal, 2010). Using both AMG and CCEMG provides a robustness check across two related but conceptually distinct treatments of common factors.

To address potential endogeneity between public spending and productivity, the study also applies System GMM as a robustness estimator. This is appropriate in a dynamic panel setting because current productivity may influence future budget allocation decisions, and lagged levels and differences can be used as internal instruments when carefully validated (Roodman, 2009). Instrument validity is assessed using the Arellano-Bond serial correlation tests and the Hansen over-identification test. The combined use of AMG, CCEMG, and System GMM provides a methodologically rigorous framework for separating the direct effect of public agricultural expenditure from regional shocks and reverse causality.

Estimation Rationale

The choice of these estimators is driven by the structure of the West African panel. Conventional pooled OLS and fixed-effects models assume slope homogeneity and often ignore cross-sectional dependence, which can produce biased or inconsistent estimates in interconnected regional data. By contrast, second-generation estimators are designed to handle unobserved common factors and heterogeneous slopes, making them more appropriate for a region in which agricultural outcomes are jointly influenced by climate patterns, food-price movements, and shared policy environments (Pesaran, 2006; Pesaran & Yamagata, 2008; Westerlund, 2007). The methodological strategy used here therefore aligns with the growing literature that recommends heterogeneous estimators for agricultural productivity studies in Africa and similar macro panels.

4. Results and Discussion of Findings

4.1 Results Presentation

Table 1 presents the descriptive statistics for the study variables across the 352 country-year observations. Agricultural total factor productivity (TFP) records a mean index value of 97.36, with a standard deviation of 12.42, a minimum of 53.00, and a maximum of 126.00, indicating moderate clustering around the mean but also substantial cross-country variation. Public agricultural expenditure (PAE) is relatively low, with an average of 0.274 US dollars per arable hectare, which is consistent with the long-standing under-prioritisation of agriculture in West African fiscal systems and with evidence that many ECOWAS countries still fall short of the CAADP spending benchmark (Pernechele *et al.*, 2021; Marson, 2025). Trade openness, fertiliser use, rainfall, infrastructure access, and institutional quality also display wide dispersion, indicating that the panel captures substantial structural diversity across the region.

Table 1. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Agricultural TFP (index)	352	97.358	12.421	53.000	126.000
Public agricultural expenditure (US\$/ha)	352	0.274	0.408	0.000	2.700
Trade openness (%)	352	68.182	39.924	4.587	159.313
Fertiliser consumption (kg/ha)	352	11.031	10.420	0.000	64.194
Rainfall (mm)	352	1066.250	708.297	92.000	2526.000
Infrastructure (%)	352	20.593	21.278	0.600	96.900
Institutional quality (index)	352	49.178	20.007	0.000	100.000

Source: Author's computation, 2026.

Table 2 reports the pre-estimation diagnostic results. The Pesaran CD statistic, Friedman statistic, and Frees Q-statistic all reject the null of cross-sectional independence at conventional levels, confirming that West African economies are interdependent rather than isolated units. This is theoretically plausible because the countries are exposed to shared climate shocks, regional market integration, donor programming, and commodity-price movements (Pesaran, 2004; Frees, 1995; Friedman, 1937; Espoir *et al.*, 2024). The Westerlund tests also indicate cointegration, while the Pesaran-Yamagata test rejects slope homogeneity, implying that the response of TFP to public spending is not uniform across countries and that heterogeneous estimators are appropriate (Westerlund, 2007; Pesaran & Yamagata, 2008).

Table 2. Cross-sectional dependence and pre-estimation diagnostics

Test	Statistic	p-value /CV	Decision
Pesaran CD (2004)	3.866	0.014	Reject H_0
Pesaran CD (2004)	3.866	0.014	Reject H_0
Friedman (1937)	17.054	0.026	Reject H_0
Frees Q (1995)	2.105	CV = 0.1537	Reject H_0
Westerlund Gt	-3.649	0.034	Cointegration
Westerlund Ga	-4.488	0.015	Cointegration
Westerlund Pt	-2.168	0.042	Cointegration
Delta slope	7.796	0.000	Heterogeneous
Adjusted delta	9.773	0.000	Heterogeneous

Source: Author's computation, 2026.

Table 3 summarises the AMG, CCEMG, and System GMM estimates. Across all three estimators, PAE is positive and statistically significant, with elasticities ranging from 0.418 to 0.516. The lagged dependent variable in the GMM specification is also positive and significant, showing persistence in productivity growth. Fertiliser

consumption and trade openness are positive and significant in most specifications, while rainfall is negative but insignificant and infrastructure is positive but statistically weak in the contemporaneous model. The common factor coefficient is positive and sizeable in AMG and CCEMG, suggesting that unobserved regional shocks contribute materially to productivity variation in the panel.

Table 3: Pesaran (2007) CIPS Panel Unit Root Test Results

Variable	Level (Constant)	Level (Constant + Trend)	First Diff. (Constant)	First Diff. (Constant + Trend)	Order of Integration
ln TFP	-1.777	-2.801	-4.614***	-4.899***	I(1)
ln PAE	-1.777	-2.820	-5.116***	-5.307***	I(1)
ln TRD	-2.690***	-3.484***	-4.902***	-5.108***	I(0)
ln IQ	-2.234	-2.338	-5.116***	-5.274***	I(1)
ln FER	-2.694***	-2.633	-5.087***	-5.158***	I(1)
ln RAN	-2.610***	-2.787***	-5.617***	-5.934***	I(0)
ln INF	-2.595	-2.664	-4.945***	-5.076***	I(1)

Source: Author's computation, 2026. Note. *** $p < 0.01$. Critical values (Constant): 5% = -2.15, 1% = -2.32. Critical values (Constant + Trend): 5% = -2.67, 1% = -2.83. I(0) = stationary in levels; I(1) = stationary after first differencing.

The CIPS test reveals a mixed order of integration among the study variables. Agricultural total factor productivity (TFP), public agricultural expenditure (PAE), fertiliser consumption (FER), and rural infrastructure (INF) are non-stationary at levels but attain stationarity after first differencing, classifying them as I(1) series. Agricultural trade openness (TRD) and rainfall (RAN) are stationary at levels, qualifying as I(0). This mixed I(0)/I(1) profile confirms that pooled dynamic OLS or fully-modified OLS estimators, which require uniform I(1) integration, are unsuitable for this panel. Accordingly, the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) estimators, both of which accommodate heterogeneous integration orders while remaining robust to cross-sectional dependence, are adopted for subsequent estimation.

Table 4. Panel regression results: dependent variable lnTFP

Variable	AMG β (SE)	CCEMG β (SE)	GMM β (SE)
L.ln TFP	-	-	0.621*** (0.061)
PAE	0.472** (0.176)	0.516*** (0.163)	0.418*** (0.147)
INF	0.002 (0.001)	0.002 (0.001)	0.001 (0.001)
FER	0.039** (0.015)	0.041*** (0.014)	0.031** (0.013)
RAN	-0.009 (0.007)	-0.007 (0.006)	-0.007 (0.006)
TRD	0.059** (0.026)	0.063** (0.032)	0.045** (0.021)
Common factor	0.703** (0.307)	0.746*** (0.259)	-
Constant	4.601*** (0.312)	4.585*** (0.298)	3.982*** (0.341)

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. AMG = Augmented Mean Group; CCEMG = Common Correlated Effects Mean Group; GMM = System Generalised Method of Moments.

Source: Author's computation, 2026.

Table 4; presents the panel regression results for the determinants of agricultural total factor productivity (lnTFP) using three estimation techniques: Augmented Mean Group (AMG), Common Correlated Effects Mean Group (CCEMG), and System Generalised Method of Moments (GMM). The consistency of the results across the three estimators indicates the robustness of the findings. Public Agricultural Expenditure (PAE) has a positive and statistically significant effect on agricultural productivity in all models. The estimated elasticities range from 0.418 to 0.516, implying that a 1% increase in public agricultural expenditure raises agricultural total factor productivity by approximately 0.42–0.52%, holding other factors constant. This confirms that increased public investment in agriculture enhances productivity.

The lagged dependent variable is positive and highly significant in the GMM model ($\beta = 0.621$, $p < 0.01$), indicating strong persistence in agricultural productivity, whereby past productivity levels significantly influence current productivity. Fertiliser use (FER) exerts a positive and significant effect across all estimators, suggesting that greater fertiliser application improves agricultural productivity. Similarly, trade openness (TRD) has a positive and significant coefficient, indicating that increased integration into international markets contributes to higher agricultural productivity.

Inflation (INF) has a positive but statistically insignificant effect, implying that price changes do not have a meaningful independent influence on productivity during the study period. Rainfall (RAN) carries a negative but insignificant coefficient across all models, suggesting that variations in rainfall did not significantly explain differences in agricultural productivity, possibly because of climatic variability or inadequate complementary agricultural infrastructure. The common factor is positive and statistically significant in both the AMG and CCEMG models, confirming the presence of unobserved common shocks affecting all countries and justifying the use of second-generation panel estimators that account for cross-sectional dependence. Overall, the findings consistently demonstrate that public agricultural expenditure, fertiliser use, and trade openness are key drivers of agricultural total factor productivity in the selected West African countries, while inflation and rainfall do not exhibit statistically significant effects.

4.2 Discussion of the Findings

The main finding is that public agricultural expenditure has a positive and statistically significant effect on agricultural TFP in West Africa, regardless of estimator choice. The elasticity range of 0.418 to 0.516 implies that increases in public agricultural spending are associated with meaningful productivity gains, which supports the view that fiscal commitment to agriculture can function as a direct driver of efficiency improvement rather than merely a redistributive or consumption-oriented budget item (Benin, 2016; Fuglie, 2022; Marson, 2025). This result is consistent with the broader African literature, which shows that agricultural public spending can support productivity and output growth when it is channelled toward productive investments such as research, extension, and rural infrastructure rather than recurrent expenditures alone (Goyal & Nash, 2017; FAO, 2021).

The size of the elasticity is also informative. Compared with several prior African studies, the estimated PAE effect in this paper is relatively strong, which may reflect three factors. First, the use of AMG and CCEMG allows the model to net out common regional shocks that would otherwise contaminate the PAE coefficient and attenuate or inflate the estimate (Pesaran, 2006; Espoir *et al.*, 2024). Second, the balanced panel extends through 2024, thereby capturing post-pandemic and food-price-shock conditions that earlier studies missed, and that may have intensified the productivity relevance of public support. Third, the study controls for fertiliser use, trade openness, infrastructure, and precipitation, all of which are important complementary factors in agricultural production and can otherwise bias the estimated fiscal effect (Zhang & Zhang, 2024; World Bank, 2024). In this sense, the result

is not simply that spending matters, but that spending matters when it is evaluated in a framework that accounts for the complexity of agricultural systems.

The positive coefficient on the lagged dependent variable in the GMM model indicates persistence in productivity performance. This suggests that TFP gains accumulate over time, consistent with endogenous growth theory, in which knowledge, innovation, and public investment generate compounding returns rather than one-off level effects (Romer, 1986; Fuglie & Gao, 2024). Practically, this means that interruptions in public agricultural spending can have costs that extend beyond the current fiscal year, because they slow the accumulation of productive capacity and weaken the base from which future gains are generated. For West Africa, where agricultural transformation remains incomplete, this finding underscores the importance of stable and predictable financing rather than episodic spending spikes.

Fertiliser consumption is also positive and significant in the AMG, CCEMG, and GMM specifications, indicating that public spending is more effective where farmers have access to complementary input technologies. This is consistent with the factor-complementarity literature, which argues that the productivity return to any single input depends on the availability of related inputs and enabling conditions (Zhang & Zhang, 2024). Trade openness is likewise positive, suggesting that access to markets, imported inputs, and commercial exchange channels helps translate fiscal support into productivity gains. These findings reinforce the argument that public agricultural expenditure should be coordinated with input-market policy and trade facilitation rather than implemented in isolation.

The rural infrastructure variable is positive but statistically weak in the contemporaneous model. This should not be interpreted as evidence that infrastructure is unimportant. Rather, it may indicate that roads, irrigation, and related assets have longer gestation periods and their productivity effects are realized over time rather than immediately within an annual panel framework. Similar caution applies to rainfall deviation, which is negative but not statistically significant once other conditioning variables are included. This does not imply that climate is irrelevant; instead, it suggests that part of the climate effect is absorbed by the common factor captured in the AMG and CCEMG estimators, which is consistent with the view that shared regional shocks influence agricultural performance across West Africa (Espoir *et al.*, 2024; Mogashoa *et al.*, 2024).

The common factor loading is one of the most important results in the paper. Its magnitude indicates that unobserved regional shocks, such as commodity cycles, shared climate variability, donor funding shifts, and technology diffusion, explain a substantial share of productivity co-movement across the panel. This has a direct methodological implication that first-generation estimators that ignore such dependence are likely to misstate the true fiscal-productivity relationship. It also has a policy implication that national agricultural budgets alone cannot fully insulate West African economies from region-wide disturbances, so coordinated ECOWAS responses, regional early-warning systems, and joint resilience investments remain essential complements to domestic fiscal effort.

The GMM diagnostics also support the credibility of the dynamic specification. The significant AR(1), insignificant AR(2), and acceptable Hansen test suggest that the instrument set is valid and that the system GMM estimates are not driven by serial correlation or over-identification problems. Taken together, the convergence across AMG, CCEMG, and GMM strengthens confidence in the substantive conclusion that public agricultural expenditure contributes positively and economically meaningfully to agricultural productivity in West Africa.

5. Conclusion and Recommendation

5.1 Conclusion

This study examined the effect of public agricultural expenditure (PAE) on agricultural total factor productivity (TFP) across selected West African countries over the period 2003–2024 using second-generation panel econometric techniques. Employing the Augmented Mean Group (AMG), Common Correlated Effects Mean Group (CCEMG), and System Generalised Method of Moments (GMM) estimators, the study found that public agricultural expenditure exerts a positive and statistically significant effect on agricultural productivity. Specifically, the estimated elasticity of TFP with respect to PAE ranges from 0.418 to 0.516, indicating that increased public investment in agriculture is associated with higher productivity across the region. The consistency of these estimates across alternative estimators demonstrates the robustness of the findings to cross-sectional dependence, slope heterogeneity, and potential endogeneity.

The study further shows that fertiliser consumption and agricultural trade openness significantly complement public agricultural expenditure in enhancing agricultural productivity, while rural infrastructure exhibits a positive but statistically weak contemporaneous effect and precipitation remains statistically insignificant. These findings suggest that the productivity effects of public expenditure are strengthened when accompanied by complementary agricultural inputs and enabling market conditions.

Furthermore, the diagnostic results confirm the presence of cross-sectional dependence, panel cointegration, and slope heterogeneity, thereby justifying the adoption of second-generation heterogeneous panel estimators. The estimated common factor loadings, exceeding 70% in both the AMG and CCEMG models, indicate that regional shocks—including commodity price fluctuations, climatic variability, and donor-supported programmes—account for a substantial proportion of productivity co-movements across West African countries. This finding underscores the importance of distinguishing common regional influences from country-specific fiscal efforts when evaluating agricultural productivity performance.

From a policy perspective, the estimated elasticity implies that a 10% increase in public agricultural expenditure is associated with approximately a 4.2% to 5.2% increase in agricultural total factor productivity, holding fertiliser use, rural infrastructure, precipitation, and agricultural trade openness constant. Given that many West African countries continue to spend below the Maputo–Malabo commitment, this finding highlights the considerable productivity gains that could be realised through sustained and well-targeted public investment in agriculture.

Overall, the study concludes that sustained public agricultural expenditure, particularly when directed towards productivity-enhancing investments such as irrigation, agricultural research and development, extension services, and rural infrastructure, represents an economically meaningful strategy for improving agricultural productivity in West Africa. However, because agricultural performance is also shaped by significant region-wide shocks, national agricultural expenditure should be complemented by coordinated regional policies aimed at strengthening resilience, improving market integration, and mitigating common climatic and economic disturbances. This integrated approach offers a more sustainable pathway for narrowing West Africa's persistent agricultural productivity gap.

5.2 Recommendations

Based on the findings, the following recommendations are proposed for policymakers, regional institutions, and future researchers.

First, ECOWAS member governments should treat agricultural budget allocations as productive investments with measurable output consequences rather than as residual spending categories subject to discretionary cuts during fiscal tightening. The persistent failure to meet the Maputo-Malabo 10% budget threshold represents a quantifiable and foregone productivity opportunity, given the elasticities established in this study, and closing even half of the current allocation gap would be expected to generate a measurable rise in regional agricultural TFP over a sustained horizon. Embedding agricultural expenditure targets within binding medium-term fiscal frameworks, rather than treating them as aspirational commitments, would help insulate this spending from short-term political and revenue pressures.

Second, expenditure composition matters more than aggregate volume alone. Consistent with the broader sub-Saharan African literature (Benin, 2016; Alabi, 2020), the evidence favours capital expenditure on irrigation, agricultural research and development, and rural infrastructure over recurrent spending and politically driven input subsidies, whose fiscal cost per unit of yield gain is disproportionately high (Liverpool-Tasie *et al.*, 2021). Governments should therefore rebalance agricultural budgets toward capital items even where overall budget envelopes remain constrained. In practice, this could involve setting a minimum statutory share of the agricultural budget reserved for capital projects, subject to independent audit, so that recurrent and subsidy-driven expenditure cannot be expanded at the expense of productivity-enhancing capital investment during periods of fiscal stress.

Third, given that fertiliser consumption and trade openness significantly complement PAE in driving TFP, agricultural fiscal policy should be designed jointly with input-market and trade-facilitation policy rather than in isolation. Investment in fertiliser distribution networks, seed systems, and agricultural export logistics is likely to amplify, rather than merely add to, the productivity return on direct public expenditure, consistent with the factor-complementarity and mediation evidence identified in the literature section. Coordinating fiscal, input-market, and trade-facilitation policy under a single implementation framework, rather than across disconnected ministries, would help ensure that the complementarities identified in this study are actually realised in practice rather than left to informal or accidental policy alignment.

Fourth, the significant common factor loadings identified in this study imply that ECOWAS-level coordination of agricultural fiscal responses to external shocks, commodity price volatility, transboundary climatic events, and coordinated donor programming would amplify the effectiveness of national expenditure commitments. Regional buffer mechanisms, jointly financed research infrastructure, and shared early-warning systems for climatic shocks would allow member states to internalise, and partially insure against, the substantial share of productivity variance driven by common regional factors rather than domestic policy choices alone. A regional agricultural stabilisation fund, capitalised jointly by member states and development partners, could provide a concrete institutional vehicle for operationalising this recommendation.

Finally, future research should pursue a decomposition of total public agricultural expenditure into its capital and recurrent components, since the literature consistently suggests these carry substantially different productivity elasticities that the aggregated measure used in this study cannot separately identify. Researchers should also

consider exploiting improved sub-national and administrative expenditure data, and should extend the analysis to explicitly model the interaction between fiscal effort and institutional or governance quality as a conditioning variable for productivity returns, building on recent evidence that governance quality materially moderates the trade-productivity relationship in African agriculture (Espoir *et al.*, 2024). Extending the panel beyond 2024 as new data become available, and testing whether the estimated elasticities are stable across sub-periods of differing commodity price regimes, would further strengthen confidence in the robustness of the results reported here.

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