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The Nexus between Agricultural Aid and Poverty Alleviation in Sub-Saharan Africa

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Abstract

This study's main objective is to investigate how effective foreign public aid for agriculture is at reducing poverty in sub-Saharan African countries. Employing a methodological framework encompassing linear panel and simultaneous equations models, we endeavor to assess the hypothesis that such aid contributes to poverty reduction via the enhancement of agricultural productivity. Our analysis yields evidence indicating a positive and statistically significant effect of international aid allocated to the agricultural sector on agricultural productivity. A 1% increase in aid per worker is associated with a 0.198% increase in agricultural productivity, holding other factors constant. Furthermore, our findings elucidate that increases in agricultural productivity exert a mitigating influence on poverty levels within the sub-Saharan African context. A 1% increase in agricultural productivity is associated with a 0.02 percentage point decrease in the poverty headcount ratio, on average, all else being equal. The results indicate that foreign aid affects poverty and agricultural productivity in the selected countries. Therefore, it is suggested that international donors increase their aid to foreign agriculture, focusing on methods that boost productivity. Consequently, our results highlight the imperative of maximizing the productivity-oriented outcomes of agricultural aid, thereby enhancing its effectiveness in efforts to reduce poverty.

Keywords

Agriculture, Official Development Assistance, Poverty Reduction

1. Introduction

The number of people living in poverty in sub-Saharan Africa increased from 278 million in 1990 to 433 million in 2018 (World Bank, 2020). By 2018, most of the global poor resided in this region, a situation likely to worsen due to COVID-19, over-indebtedness, and corruption. Extreme poverty is predominantly rural, with about 80% of the extremely poor living in rural areas (Castañeda et al., 2018), largely dependent on agricultural activities for income.

The United Nations' first two sustainable development goals (SDGs) aim to end hunger and poverty by 2030, necessitating food security and improved nutrition through sustainable agriculture. This involves doubling agricultural productivity and incomes of small-scale food producers, particularly women, indigenous peoples, and family farmers. Between 1984 and 2014, Africa's agricultural labor force grew, but productivity per worker increased by only 1.6 times, compared to 2.5 times in Asia (NEPAD, 2014). Value added per worker in agriculture remains low compared to other sectors. World Bank data indicates that from 2010 to 2019, agricultural value added per worker rose from 6.27% to 8.61%, while in services it increased from 33.37% to 36.52% and in industry it declined from 60.36% to 54.87%.

Reduced public investment in agriculture is a significant factor in sub-Saharan Africa's low agricultural productivity (Islam, 2011). This reduction in investment stems from both foreign aid and domestic agricultural expenditures. Foreign aid can include financial support, technical expertise, or food provision through grants or concessional loans. According to Kalibata (2010), foreign aid can meet essential needs of African farmers, such as improved seeds, better soil, roads for market access, agribusiness credit, private sector investments, and training with technology to address climate change challenges.

Through these means, foreign aid is expected to enhance agricultural productivity, thereby fostering economic growth and raising incomes in sub-Saharan Africa. However, the disparity between the volume of international aid and the limited results is a major concern for governments, international organizations, and policymakers. The OECD (2023) reported that in 2020-2021, sub-Saharan Africa received 40.1% of global ODA, followed by South and Central Asia at 19.3%. Despite this, the region's human development index (HDI) in 2021 was 0.54, below the world average of 0.71 (UNDP, 2023). The UNDP data show sub-Saharan Africa as the least developed region with the lowest life expectancy, highlighting the need to assess aid effectiveness in this area (**Tables 1-2**).

Table 1. Regional distribution of ODA by individual development assistance committee donors and multilateral agencies

Region	2010-2011	2015-2016	2020-2021
Sub-Saharan Africa	40.7	37.2	40.1
South and Central Asia	19.2	19.7	19.3
Other Asia and Oceania	13.1	11.2	10.4
Middle East and North Africa	10.6	14.3	14.8
Europe	7.0	8.0	7.0
Latin America and Caribbean	9.4	9.5	8.4

Source: OECD (2023),
Notes: Data are in percentage of total gross disbursements and are cross-country averages.

Table 2. Comparison of human development index (HDI) by region (2021)

Regions	HDI	Life expectancy at birth (years)	Expected years of schooling (years)	Mean years of schooling (years)	Gross national income (GNI) per capita (2017 PPP in USD)
Arab States	0.708	70.9	12.4	8.0	13.501
East Asia and the Pacific	0.749	75.6	13.8	7.8	15.580
Europe and Central Asia	0.796	72.9	15.4	10.6	19.352
Latin America and the Caribbean	0.754	72.1	14.8	9.0	14.521
South Asia	0.632	67.9	11.6	6.7	6481
Sub-Saharan Africa	0.547	60.1	10.3	6.0	3699

Source: UNDP (2023).

There is a micro-macro paradox regarding the impact of aid on economic development (Radelet, Clemens, & Bhavnani, 2004; Ndikumana, 2012). Positive effects are seen at the micro level, but it is difficult to identify the impact of foreign aid at the macro level. This has led to a growing focus on analyzing aid effectiveness at the sectoral level (Lee & Izama, 2015; Michaelowa & Weber, 2006; Ndikumana, 2012). Studies show that targeted aid interventions can achieve positive results at the micro level (Dreher, Nunnenkamp, & Thiele, 2008; Gyimah-Brempong, 2015; Pickbourn & Ndikumana, 2016; Yogo & Mallaye, 2015).

While substantial literature exists on aid and economic growth, few studies investigate the impact of agricultural aid on agricultural outcomes and poverty alleviation. Norton, Ortiz, and Pardey (1992) examined the impact of aggregate aid on agricultural growth. This study contributes to the literature by focusing on sectoral and micro-level analysis, specifically investigating the effect of agricultural aid on poverty reduction through improved agricultural productivity. Using OECD aid data disaggregated by sector, the econometric analysis employs panel data techniques to control for country-specific effects with fixed-effects estimations. To address potential endogeneity from reverse causation between aid and poverty variables, a simultaneous equations model was also estimated for robustness.

The remainder of the paper is structured as follows: section 2 reviews the literature, section 3 describes the data and econometric methodology, section 4 presents the results, and the final section offers concluding remarks.

2. Literature Review

Agricultural growth can drive national growth and reduce poverty by increasing farm incomes, providing employment, and lowering food prices. The dual-economy models by Lewis (1954) and Ranis & Fei (1961) suggest that increased agricultural productivity releases labor for other sectors without reducing agricultural output. However, this effect depends on several conditions: a significant proportion of the poor must be engaged in farming, and higher output must sufficiently raise incomes. If increased output lowers product prices or raises production costs, gross margins might only slightly rise. Additionally, poor farmers may struggle to adopt new techniques due to market imperfections, lack of access to credit, and limited knowledge (Hazell & Haddad, 2001). Poor farmers are also often more risk-averse, hindering the adoption of productivity-enhancing techniques.

Agricultural output can also reduce poverty through the labor market. Higher agricultural production can increase demand for farm labor, improve nutrition, and allow for investments in health and education (Timmer, 1997). Increased output may lower food prices, benefiting consumers and net food purchasers. The poverty-reducing effects of enhanced farm production depend on the net marketing position of the poor and the price elasticity of food demand. Poor net-food-buying households benefit from lower food prices if the savings on food exceed the loss in wage income. Conversely, poor net-food-selling producers benefit only if productivity grows faster than prices fall (World Bank, 2008). A dynamic farm sector can also foster social capital formation, as increased interactions among farmers, input suppliers, processors, and banks build confidence and trust for new non-agricultural businesses.

Empirical studies support the importance of the agricultural sector in promoting economic development. Research shows that agricultural growth has a greater impact on poverty reduction than general GDP growth due to high rural poverty levels in developing countries (Ravallion & Datt, 1996; Timmer, 1997). The agricultural sector is a crucial source of employment and export earnings in many developing countries (Lucas & Timmer, 2005; Thirtle et al., 2001). Gallup et al. (1997) found that a 1% increase in per capita agricultural output led to a 1.61% increase in the income of the poorest 20% of the population. Thirtle et al. (2001) found that a 1% increase in agricultural yields reduced the number of people living on less than $1 a day by 0.83%. Agricultural productivity growth is vital for developing countries as it increases income, food security, and reduces poverty.

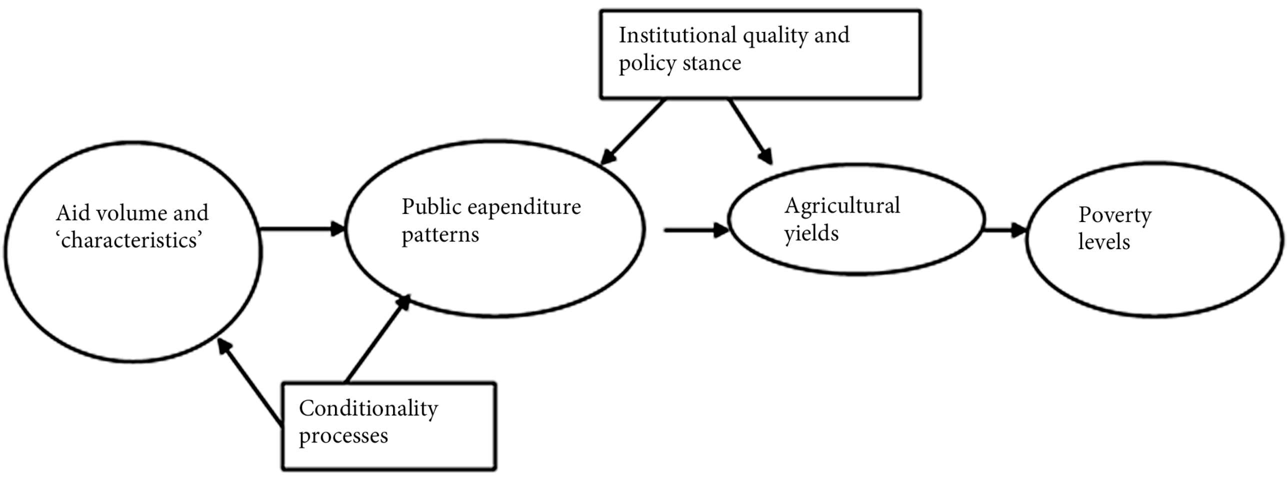
The relationship between international aid and poverty reduction is debated. Some studies suggest aid is effective only under certain conditions, such as sound policy-making (Burnside & Dollar, 2000; Collier & Dollar, 2002; Mosley, Hudson, & Verschoor, 2004), while others find it difficult to reject the hypothesis that aid is effective when proper estimation methods are used. Mosley and Suleiman (2007) argue that aid effectiveness depends on stability and inter-sectoral distribution. Stable aid provision can influence long-term expenditure patterns, and sectoral distribution analyses show aid is effective. For example, Wolf (2007) found positive effects of ODA for education and health sectors using a simultaneous equation model. Dreher et al. (2008) found a robust positive effect of education aid on primary school enrollment. Gyimah-Brempong (2015) found health aid positively impacted health outcomes in African countries, especially with increased domestic health expenditure and better governance.

Few studies have examined the link between aid and agricultural outcomes. Ssozi et al. (2017) argue that African agriculture has been underinvested by governments, donors, and foreign investors, despite research showing higher agricultural productivity can boost economic growth and reduce poverty. Public institutions' quality and economic freedom also enhance agricultural productivity growth and ODA effectiveness. Alabi (2014) found that foreign agricultural aid positively impacts agricultural GDP and productivity in sub-Saharan Africa, and disaster and conflict significantly impact aid receipts.

Mosley and Suleiman (2007) provide a framework explaining how aid affects poverty alleviation through agricultural yield productivity. The distribution of agricultural aid triggers significant transformation when recipient governments promote effective agricultural policies and practices. This commitment leads to better public spending on agricultural infrastructure, research, and extension services, enhancing institutional support and providing farmers with advanced technologies, better seeds, and valuable knowledge. Increased agricultural yields raise farmers' revenues, crucial for poverty reduction.

Kaya et al. (2013) examined the direct impact of agricultural aid on poverty reduction, finding aid effective in reducing poverty directly and indirectly through pro-poor expenditure. However, they did not consider agricultural productivity in the transmission mechanism. Our study aims to empirically assess the relationship between agricultural aid, agricultural productivity, and poverty alleviation.

Ssozi et al. (2017) found a positive relationship between ODA for agriculture and agricultural productivity in sub-Saharan Africa but did not evaluate the impact of agricultural productivity on poverty. Building on this literature, the research hypothesis in this study is that aid increases agricultural productivity, which in turn improves living conditions (**Figure 1**).



Source: Mosley and Suleiman (2007)

Figure 1. Transmission mechanisms from aid to poverty through agricultural yields.

3. Empirical Analysis

3.1. The Model

The aim of this study is to investigate empirically the effect of agricultural aid on poverty levels in countries in sub-Saharan Africa. We test the hypothesis that aid improves agriculture productivity, which in turn contributes to poverty reduction. Two econometrics models are estimated. The first model is a linear panel model. The model is specified as follows:

$$poverty_{i,t} = \alpha_0 + \alpha_1 laidpwo_{i,t-1} + \alpha_2 lagriprod_{i,t} + \alpha_3 lrurpop_{i,t} + \alpha_4 lgovexp_{i,t} + \alpha_5\, polstab_{i,t} + \mu_{i,t} \quad (3.1)$$

where poverty is the dependent variable, measured by the headcount ratio obtained from the Povcalnet database. The explanatory variables are:

- The logarithm of agricultural aid per worker ($laidpwo$), drawn from the OECD's Creditor Reporting System (CRS) database, which covers donors' bilateral and multilateral aid and other resource flows to developing countries and countries in transition. Aid is measured in nominal terms (current prices), and divided by the number of workers in the agricultural sector. The lag of this variable is included in the model because economic shocks, like a flow of capital may take time to play out,
- The logarithm of agricultural productivity ($lagriprod$) , measured by the value added per worker in agriculture. Agriculture comprises value added from forestry, hunting, and fishing as well as the cultivation of crops and livestock production,
- The logarithm of rural population as a percentage of total population ($lrurpop$) , included as a proxy for employment in the agriculture sector (Kaya et al., 2008),
- The logarithm of government expenditures $(lgovexp)$, to capture the effect of government spending in the agriculture sector, which could be an approximation of government spending on agriculture, as we were unable to obtain this data for countries in the sample and,
- An indicator of governance level in the country, namely political stability ($polstab$).

The second model is a simultaneous equations model, expressed as follows:

$$\begin{cases} poverty_{it} = \alpha_1 laidpwo_{i,t-1} + \alpha_2 lagriprod_{i,t} + \theta' X_{it} + \varepsilon_{it} & (3.2) \\ laidpwo_{it} = \gamma_1 lagriprod_{i,t} + \gamma' X_{it} + \delta_{it} & (3.3) \\ lagriprod_{it} = \beta_1 laidpwo_{i,t-1} + \gamma' Z_{it} + \mu_{it} & (3.4) \end{cases}$$

The first equation (3.2) explains poverty levels. The main explanatory variables in this equation are agricultural productivity, measured by the value added per worker in agriculture, and agriculture aid per worker, one-year lagged. Data are in constant 2010 U.S. dollars. The control variables (X_{it}) are the real GDP per capita, to control for the level of economic development among countries in our sample, one-year lagged; the rural population as a percentage of total population, given that the majority of the poor are in rural areas; and also as a proxy of employment levels., government expenditures and political stability, as an indicator of governance. The error term of the first equation is δ_{it}.

The second equation (3.3) attempts to explain the determinant of aid to African countries. The explanatory variables are the real GDP per capita; the indicator of agricultural productivity, infant mortality as a measure of human development levels, political stability. The error term is δ_{it}. The third equation (3.4) explains agricultural productivity. We are interested in assessing the effect of agricultural aid per worker. Z_{it} is a set of control variables, including the real GDP per capita (as in the first equation), government expenditures, rainfall, to capture the effect of climate change on productivity, arable land as a percentage of territory, political stability, as an indicator of governance. The error term in this equation is u_{it}.

3.2. Estimation Strategies

The econometric analysis comprises three steps. A first specification is made through a linear panel model estimated by fixed effects techniques. In this model, an interactive variable between aid and agricultural productivity is introduced to capture their combined effect on poverty levels.

A second estimation is made from a system of equations. In this specification, agricultural productivity, foreign aid, and poverty are considered as endogenous. As a consistent estimation of the parameters requires an estimation method that can deal with the endogeneity problem, we use the three-stage least squares (3SLS) method, which is more efficient than a two-stage least squares (2SLS) estimation (Wooldridge, 2010). The 3SLS estimator decomposes reverse causality, controls for endogeneity, takes the disturbance between residuals in different equations into account and provides the possibility of incorporating other transmission channels within a simultaneous framework. The first two stages of the 3SLS estimation, which are equivalent to a 2SLS estimation, correct the bias in coefficients arising from reverse causality. The third stage improves the estimated standard errors of the coefficients by controlling for the correlation of errors across equations (Kaya et al., 2013). Before considering the method of estimation, the identifiability of the model was checked because estimation methods that are used for SEM are functions of identification criteria. For an equation in a system of equations to be identified, the number of excluded exogenous variables in that equation must be at least as great as the number of included endogenous variables, less one. In our case, each equation is over-identified. In estimating the equations, we control for unobserved time-invariant variables and unobserved time effects by including N − 1 country dummies and T − 1 time dummies.

Furthermore, the Dumitrescu and Hurlin (2011) panel causality analysis is used to analyze the causal relationship between the three main variables, namely the poverty headcount ratio, foreign aid to agriculture and agricultural productivity. This method is well-suited for our panel data structure as it accounts for heterogeneity in causal relationships across countries, improves statistical power by pooling cross-sectional information, and allows us to explore bidirectional causality. Indeed, countries differ in how aid is used, how productive agriculture is, and how poverty responds. The test accounts for these heterogeneous dynamics. The panel fixed effects and simultaneous equations models do not formally test the direction of causality. To complement these approaches, the Dumitrescu and Hurlin (2011) panel causality test is employed to determine whether past values of one variable help predict another. This multi-method strategy ensures robust and nuanced inference on the dynamics between aid, productivity, and poverty reduction. It helps confirm or challenge the assumed direction of causality in the simultaneous system. The simple model (3.5) with two variables constitutes the basic framework for studying Granger causality in a panel data context

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \tag{3.5}$$

With $K \in N^*$ and $\beta_i = \left(\beta_i^1, \cdots, \beta_i^K\right)'$. For simplicity, the individual effects α_i are supposed to be fixed in the time dimension. Initial conditions ($y_{i,-k}, \cdots, y_{i,0}$) and ($x_{i,-k}, \cdots, x_{i,0}$) of both individual processes $y_{i,t}$ and $x_{i,t}$ are given and observable. We assume that lag orders K are identical for all cross-section units of the panel and the panel is balanced. Besides, Dumitrescu and Hurlin (2011) allow the autoregressive parameters $\gamma_i^{(k)}$ and the regression coefficients slopes $\beta_i^{(k)}$ to differ across groups.

The DH test considers the HNC[1] null hypothesis, where no Granger-causal relationships are assumed to exist for any member i of the panel. The DH test is based on an aggregated Wald statistic of individual Granger causality tests defined as:

$$W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T},$$

Where $W_{i,T}$ denotes the individual Wald statistics for the i^{th} cross-section unit corresponding to the individual test $H_0 : \beta_i = 0$.

Using the required stationarity tests, properties like the presence of a unit root in the panel data were verified. Since the panel data contains a large number of cross-sections that are clustered together, a test of cross-sectional dependence was then carried out. When using first-generation unit root tests, an extreme assumption of cross-sectional independence is made. Consequently, a cross-dependency test was conducted using Pesaran's CD test, which is the most often used test. If a cross-section dependence is revealed, second generation unit root tests should then be used to ascertain the stationarity levels of the variables before conducting the causality test.

3.3. Data Description

The data for this study are drawn from various sources and cover the period from 2002 to 2019. The sample comprises 34 countries in sub-Saharan Africa. Although the choice of countries is governed by the availability of data, the included countries broadly cover the whole region. Table 3 shows summary statistics of the var-

[1]Homogeneous Non-Causality (HNC): The null hypothesis of HNC test is that there is no causal relation between the variables for any individual, i.e., for all i it holds that X_i does not Granger-cause Y_i.

iables. The correlation matrix is found in the appendix (**Table A1**). The definition and measurement units can be found in the appendix (**Table A2-A3**).

Table 3. Summary statistics.

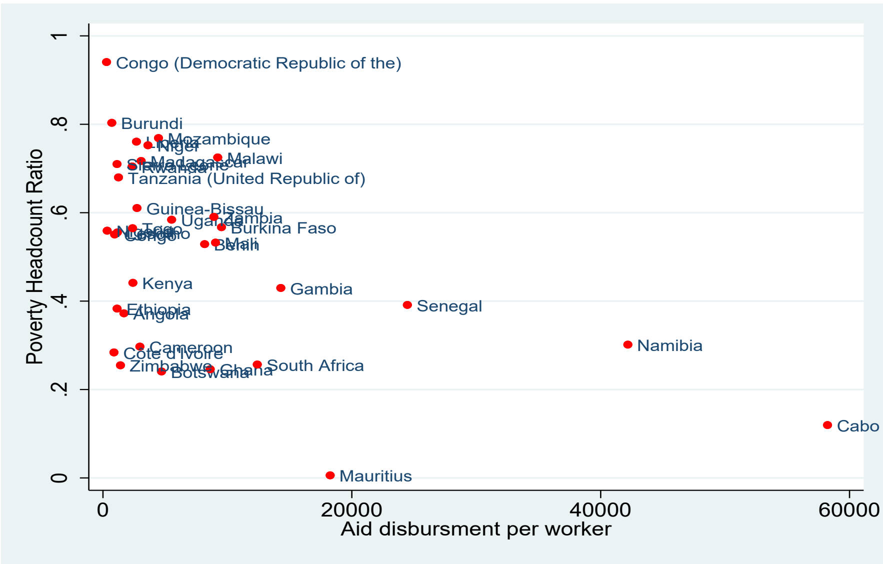
Variable	Obs.	Mean	Std. Dev.	Min	Max
Agriculture value added per worker	611	13.79	1.02	11.19	16.47
Aid per worker	612	14731.38	31424.35	10.57	375899.6
Poverty headcount ratio	612	0.45	0.215	0.0012	0.952
GDP per capita constant	612	1614.56	1845.23	248.16	10610.59
Government expenditures (% of GDP)	612	21.10	1.40	16.94	25.13
Infant mortality	612	57.644	21.99	12.5	132.9
Rural population (% of total pop.)	612	0.61	0.151	0.298	0.913
Rainfall (mm)	612	85.69	48.220	12.1	253.61
Arable land (% of territory)	612	17.06	13.99	0.321	50.40
Political stability	612	−0.45	0.84	−2.52	1.20

Source: Author's computation.

4. Results and Discussion

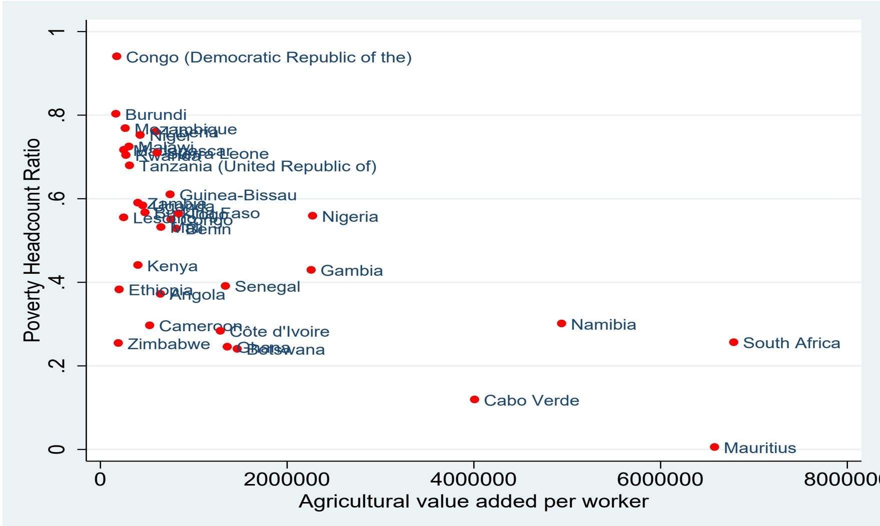
4.1. Descriptive Analysis

Figure 2 illustrates the relationship between agricultural aid and poverty levels in the countries included in the study. An overall negative association is evident across these variables, with significant variances observed among the selected nations. Countries like the Democratic Republic of Congo, Burundi, and Malawi



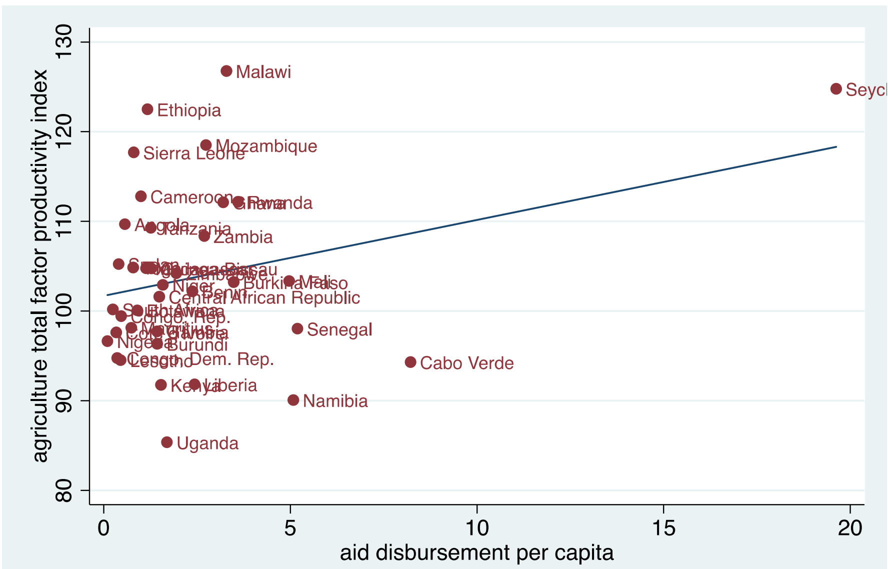
Source: Authors from World Development Indicators, 2020

Figure 2. Agricultural aid disbursement per capita and poverty headcount ratio in selected countries in sub-Saharan Africa (2002-2017).



Source: Authors from World Development Indicators, 2020

Figure 3. Agriculture value added per worker and poverty headcount ratio in selected countries in sub-Saharan Africa (2002-2017).



Source: Authors from World Development Indicators, 2020

Figure 4. Agricultural aid disbursement per capita and the agriculture total factor productivity index.

have high poverty rates and receive low levels of aid per person, which may be due to their large populations. Conversely, Mauritius, Cape Verde, and Seychelles exhibit lower poverty rates. In Seychelles, there is a noticeable correlation between decreased poverty rates and increased agricultural assistance. **Figure 3** shows a negative relationship between agricultural value added per worker, used as a proxy for agricultural productivity, and poverty rates. Prominent examples include the Democratic Republic of Congo and the Central African Republic, known for high poverty rates and reduced agricultural productivity. And, **Figure 4** shows a positive correlation between aid disbursement and agriculture total factor productivity index which can be also used to measure productivity in agriculture. However, these observed associations remain descriptive and do not provide a basis for causal inferences. We will be able to ascertain whether there is a causal relationship between these variables through the econometric study that follows.

4.2. Fixed Effects Estimation Results

Table 4 presents the results of the estimation of a poverty model using the fixed effects techniques on a panel of 32 in sub-Saharan Africa[2].

Table 4. Fixed effects estimates of the relationship between poverty, agricultural aid, and agricultural productivity , 2002-2019.

Variables	(I)	(II)	(III)
Agriculture aid per worker, lagged	-0.006** (0.043)	–0.006* (0.081)	-0.008** (0.022)
Agriculture productivity	-0.039*** (0.000)	-0.0421*** (0.000)	-0.056*** (0.000)
Rural population (as % of pop.)	0.958*** (0.000)	0.859*** (0.000)	0.976*** (0.000)
Government expenditures	-0.021** (0.006)	–0.022** (0.005)	
Political stability	-0.060*** (0.000)		
Constant	0.879*** (0.000)	1.066*** (0.000)	0.735*** (0.000)
Number of observations	544	544	544
Number of countries	32	32	32

Notes: p-values in parentheses; ***p < 0.01, **p < 0.05, *p < 0.1.
All variables except for the political stability index are in the logarithm form.

In the first column, variables are all introduced into the model. The coefficients are all significant with expected signs, showing the reducing effect that aid to agriculture, agricultural productivity, government spending and the quality of institutions could have on poverty rates. In the second column, we remove the governance variable (political stability). This variable has been eliminated from the model due to the possibility that international aid could impact poverty by bolstering recipient nations' institutional frameworks. Therefore, we eliminate it to see if there is a change in the coefficient of international aid in order to quantify the ceteris paribus effect of aid on poverty.

Having done this, we also observe no change in the coefficients of the variables. Similarly, the results obtained in column 4 are without the government spending and political stability variables. Along with a small rise in the aid coefficient, we

[2]Figure 1 reveals the existence of outliers in the sample, namely Cabo Verde and Seychelles, therefore these countries were excluded from the estimations.

also see that the coefficients of the variables that were first introduced maintain their sign and significance. This suggests that development aid has little or no effect on poverty through budgetary contributions and institutional strengthening. This may be explained by the fact that we are using data for aid that has been earmarked for agriculture particularly rather than the entire amount of aid that is distributed across all sectors.

In general, we discover that agricultural aid slightly lowers the poverty rate. According to the results, the effect of aid to agriculture on the poverty rate varies between 0.006% and 0.008%. Specifically, a 1% increase in aid per worker is associated with an approximate 0.006 (column I and II), and 0.008 (column III) percentage point decrease in the poverty headcount ratio, holding other factors constant. An explanation to this small effect could be that agriculture has not been a top priority for ODA spending (Eber et al., 2020). According to FAO data, since 2015, agricultural ODA has consistently comprised the smallest share of total ODA. In 2018, the relative share of ODA allocated to agriculture was 4.3%, the lowest share since 2006. Disbursements for humanitarian aid and health each amounted to more than three times the disbursements for agriculture in 2018, representing 13.9% and 13.3% of total ODA disbursements, respectively (Eber et al., 2020)

4.3. Three Stage Least Square Estimation Results

Continuing our analysis, we address potential endogeneity concerns stemming from the reciprocal relationship between poverty levels and aid allocation within a nation. **Table 5** presents the simultaneous equation model (SEM) estimates using the Three-Stage Least Squares (3SLS) approach. The expected signs are observed for the coefficients of the majority of control variables. According to the poverty equation, agricultural assistance lowers poverty levels; this relationship is statistically significant and has a tiny but negative coefficient. A 1% increase in aid per worker leads to a decline in the poverty headcount ratio by 0.007%. Agricultural productivity measured by the value added per worker in the agricultural sector has a negative and significant coefficient. Also, per capita income is associated with diminished poverty levels. Conversely, a rise in the rural population exacerbates poverty levels across the countries.

In the aid equation, GDP per capita is always significant, indicating a negative relationship with development aid. Aid is generally allocated to developing countries with high levels of poverty and lower GDP per capita (Mahembe & Odhiambo, 2019). Thus, as incomes appear to rise, aid volumes will have to fall. The productivity variable is positively signed and significant indicating that the more value added per worker increases, the more aid will go to the agricultural sector.

In relation to the productivity equation, it is notable that agricultural aid emerges as a contributing factor to the enhancement of productivity. Additionally, there exists a positive correlation between GDP per capita and agricultural productivity showing that when the wealth generated in the economy is equitably distributed, this fosters an improvement in producers' incomes. Consequently, these producers are more inclined to invest substantially in their endeavors, thereby augmenting their agricultural yield. Furthermore, a positive relationship is observed between the proportion of irrigated area and agricultural productivity, indicating that an increased allocation of land for irrigation is associated with higher levels of productivity in the agricultural sector.

Table 5. Three SLS estimation results from the relationship between poverty, agricultural aid, agricultural productivity, 2002-2019.

	Poverty headcount ratio	Aid per worker	Agricultural productivity
Log aid per worker, lagged	−0.007** (0.027)		0.198*** (0.000)
Log per capita GDP, lagged	−0.100*** (0.000)	−0.701*** (0.000)	0.869*** (0.000)
Log agricultural productivity	−0.020* (0.052)	0.647*** (0.000)	
Rural Population (%)	0.775*** (0.000)		
Log government expenditures	−0.010 (0.215)		−0.010 (0.608)
Political stability	−0.010 (0.135)	0.641*** (0.000)	
Infant mortality		−0.021*** (0.000)	
Log rainfall (mm)			0.089** (0.047)
Arable land (% of territory)			0.013*** (0.000)
Constant	0.987*** (0.000)	6.188*** (0.000)	5.477*** (0.000)
Number of observations	512	512	512
Number of countries	32	32	32

Notes: p-values in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Country and time fixed effects are included in the regressions.

An increase in gross domestic product (GDP) per capita, reflecting a higher quality of living is associated with a rise in agricultural production. Higher income levels are linked to a rise in the availability of upgraded agricultural implements and the ability to pay for better working conditions.

The study emphasizes how agricultural production can effectively reduce poverty, albeit in tiny proportions. Many vulnerable populations in sub-Saharan Africa heavily depend on agriculture for their main source of food, which is consistent with existing academic research. The increase in agricultural production can significantly improve living conditions by increasing food supply and reducing food prices. The findings align with Gallup et al.'s (1997) finding that increased agricultural output had a beneficial effect on the income of the poorest twenty percent of the population. Thirtle et al. (2001) found that a 1% increase in agricultural output is associated with a 0.83% decrease in the population living on less than one USD per day. Thus, it can be said that boosting agricultural productivity is essential for developing countries.

4.4. Dumitrescu Hurlin Panel Causality Analysis

In the analysis process, a causality test is also conducted. The cross-section dependence tests show evidence of cross-dependence across countries in the sample (**Table 6**). This is expected, given that the countries in the sample are developing countries, belonging to the same economic region, whose main characteristics are high levels of poverty. Therefore, the cross-sectionally ADF (CADF) of Pesaran (2007) which is a second-generation panel unit root test is undertaken (**Table 7**). The headcount poverty ratio and agricultural aid are stationary at first differenced while the agricultural productivity is stationary at level.

Table 6. Cross section dependence test.

Variables	Test	Statistic	Probability.
Poverty headcount ratio	Breusch-Pagan LM	2758.512	0.000***
Aid per worker Agricultural value added	Pesaran scaled LM	71.83484	0.000***
per worker	Pesaran CD	6.135506	0.000***

Notes: ***, **, *: significance at 1% level, 5% level and 10% level.
Source: Authors' compilations.

Thereafter, the cross-sectionally ADF (CADF) of Pesaran (2007) which is a second-generation panel unit root test is undertaken (**Table 8**). The headcount poverty ratio and agricultural aid are stationary at first differenced while the agricultural productivity is stationary at level.

Table 7. Second generation Pesaran's unit root test.

	PES-CADF	
	Level	First diff.
Headcount poverty ratio	0.973	0.000***
Agricultural aid per worker	0.125	0.000**
Agricultural value added per worker	0.000***	0.000***

Notes: Figures in the table are p values. ***, **, * express significance at 1% level, 5% level and 10% level.
Source: Authors' computations.

Table 8 presents the results of homogeneous non causality hypothesis test between the poverty headcount ratio, foreign aid to agriculture and agricultural productivity in the sample based on three test statistics, namely, the average Wald statistic, W_{HNC}, the asymptotic standardized statistic, Z_{HNC} and the approximated standardized statistic based on finite sample moments, $\tilde{Z}_{HNC}$. The causality tests are conducted with stationary variables, and the optimal lag criteria is the Akaike information *criterion (*AIC).

Table 8. Homogeneous non causality hypothesis tests results.

Test statistics	Agricultural aid does not granger cause poverty (lags:2)	Poverty does not granger cause Agricultural aid (lags:2)
W_{HNC}	4.5506	1.2736
Z_{HNC}	7.2142 (0.0000***)	1.0946 (0.2737)
$\tilde{Z}_{HNC}$	3.5941 (0.0000***)	0.2691 (0.7878)
	Agricultural aid does not granger cause agricultural productivity (lags: 3)	**Agricultural productivity does not granger cause agricultural aid (lags:2)**
W_{HNC}	4.1238	6.5465
Z_{HNC}	2.5952 (0.0095**)	8.1904 (0.0000***)
$\tilde{Z}_{HNC}$	-0.0770 (0.9386)	2.3704 (0.0178***)
	Agricultural productivity does not granger cause poverty (lags:2)	**Poverty does not granger cause agricultural productivity (lags:2)**
W_{HNC}	3.6371	2.0833
Z_{HNC}	10.5484 (0.0000***)	4.3333 (0.0000***)
$\tilde{Z}_{HNC}$	7.1969 (0.0000***)	2.6425 (0.0082***)

Notes: The numbers on parentheses are probability values related to the tests statistics. ***, **, *: significance at 1% level, 5% level and 10% level.
Source: author's computation.

A p-value of less than 1%, 5%, or 10% suggests that there is a causal relationship for at least one country in the sample, contrary to the null hypothesis of the causality test, which states that there is no causal relationship between the variables for any individual. Based on the three causality test statistics, the analysis's findings show that there is a unidirectional relationship between poverty and agricultural aid, with the relationship going in the direction from aid to poverty. This supports the outcomes from the earlier regressions. All three tests demonstrate that agricultural productivity granger causes poverty, and two of the three indicators (W_{HNC} et Z_{HNC}) likewise demonstrate the relationship between agricultural aid and agricultural productivity. Agricultural aid has an effect on labor productivity in the agricultural sector, which in turn has an impact on poverty.

Furthermore, the results suggest a bi-directional relationship between foreign agricultural aid and agricultural productivity, as well as between poverty and agricultural productivity. Aid can provide farmers with access to modern technology, better quality seeds, improved irrigation systems, etc. This can increase their productivity and, consequently, reduce poverty by increasing farm incomes. On the other hand, poverty can also negatively affect agricultural productivity. Poor farmers may have limited access to resources such as land, water and credit, which can hamper their ability to invest in improved farming practices. As a result, their productivity may remain low, maintaining their poverty level.

5. Conclusion

Sub-Saharan African countries mainly rely on agriculture as the foundation of their livelihoods, particularly disadvantaged groups. To address this situation, it is crucial to base poverty reduction efforts in these countries on improving the agricultural sector. This nexus is a focus point in the objectives of this article, which aims to examine the influence of foreign agricultural aid on reducing poverty in sub-Saharan Africa. The study suggests that agricultural productivity has a crucial role in promoting national progress and alleviating poverty, as it was revealed by significant studies conducted by Lewis (1954) and Ranis & Fei (1961). An investigation using a fixed effects techniques and a simultaneous equation model confirms that foreign agricultural aid improves agricultural productivity and reduces poverty levels. This article emphasizes that increasing agricultural productivity is a powerful and effective way of reducing poverty in sub-Saharan Africa. Furthermore, a causality test is conducted to analyze the causal relationship between the poverty headcount ratio, foreign aid to agriculture and agricultural productivity. The results reveal that aid does affect agricultural productivity and poverty in the selected countries. Therefore, it can be advised that foreign agricultural aid be increased by international donors, and to give priority to factors that improve productivity when allocating sectoral foreign agricultural aid. In addition, governments should increase and improve the effectiveness of public spending in agriculture. This would benefit the productivity of agriculture and boost Sub-Saharan Africa's economy.

Availability of Data and Materials' Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Competing Interests

No potential conflict of interest was reported by the authors.

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Appendixes

Table A1. Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Poverty headcount ratio	1.00									
(2) Aid per worker	−0.31*	1.00								
(3) Agriculture value added per worker	−0.50*	0.34*	1.00							
(4) GDP per capita constant 2010US	−0.60*	0.23*	0.68*	1.00						
(5) Rural population (% total population)	0.51*	−0.12*	−0.50*	−0.63*	1.00					
(6) Political stability	−0.27*	0.35*	0.17*	0.36*	−0.25*	1.00				
(7) Government expenditures	−0.30*	−0.01	0.82*	0.58*	−0.36*	−0.03	1.00			
(8) Infant mortality	0.31*	−0.35*	−0.26*	−0.26*	0.01	−0.19*	−0.18*	1.00		
(9) Arable land (% of territory)	0.14*	−0.08	0.05	−0.34*	0.36*	−0.13*	−0.05	−0.05	1.00	
(10) Rainfall	0.33*	−0.31*	−0.27*	−0.36*	−0.12*	−0.24*	−0.21*	0.41*	0.11*	1.00

Notes: *indicates 5% significance level.

Table A2. Source and definition of variables.

	Definition	Source
Agricultural aid per worker	The DAC definition of aid to agriculture includes assistance to "agriculture", "forestry", and "fishing". ODA for agriculture includes agricultural sector policy, agricultural development and inputs, crop and livestock production, and agricultural credit, cooperatives, and research. These figures are divided by the number of employees in the agricultural sector, which is drawn from the ILO database.	OECD (2020)
Agricultural productivity	Agricultural productivity is measured by the agriculture value added per worker. Value added in agricultu re measures the output of the agricultural sector (ISIC divisions 1 - 5) less the value of intermediate inputs. Agriculture comprises value added from forestry, hunting, and fishing as well as cultivation of crops and livestock production. Data are in constant 2010 U.S. dollars.	United Nations Statistics Division and ILOSTAT of the ILO
Poverty headcount ratio	Poverty headcount ration is the percentage of the population living with less than $1.90.	Povcalnet database, 2019
GDP per capita	GDP per capita is gross domestic product divided by midyear population. Data are in constant 2010 U.S. dollars.	United Nations Statistics Division
Rural population (% total population)	The proportion of the population living in rural areas (% of total population)	ILOSTAT database (2018)
Gini coefficient	Gini coefficient measures the level of income inequality	Polcalnet of the World Bank
Government expenditures (% GDP)	Final consumption expenditure as a percentage of GDP	United Nations Statistics Division
Political stability	Index of political stability and absence of violence/terrorism	World Governance Indicators (WGI, 2020) of the World Bank
Inflation	The annual change in the consumer price index for a given basket of consumer goods	IMF World Economic Outlook (WEO)
Infant mortality	Infant mortality rate per thousand births for a given year	World Bank WDI, 2020
Arable land in % of territory	Proportion of arable land in the territory	FAOSTAT of the FAO
Rainfall (mm)	Average precipitation in depth (mm per year)	FAO (2020)

Table A3. The list of countries.

Angola	Cameroon	Ghana	Malawi	Nigeria	Tanzania
Benin	Congo, Dem. Rep.	Guinea-Bissau	Mali	Rwanda	Togo
Botswana	Congo, Rep.	Kenya	Mauritius	Senegal	Uganda
Burkina Faso	Cote d'Ivoire	Lesotho	Mozambique	Sierra Leone	Zambia
Burundi	Ethiopia	Liberia	Namibia	South Africa	Zimbabwe
Cabo Verde	Gambia	Madagascar	Niger		