Foreign Aid and Agricultural Productivity in Senegal

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Abstract

This study examines the relationship between foreign aid and agricultural productivity in Senegal from 1985 to 2020. Using annual time series data and STATA software, the analysis combines the Autoregressive Distributed Lag (ARDL) model with the Error Correction Model (ECM) to capture both short- and long-term dynamics. Findings from the ECM indicate that foreign aid has a positive and statistically significant impact on agricultural productivity at the 1% significance level, but only in the long term. This suggests that an increase in foreign aid allocations leads to higher agricultural productivity over time. Rainfall also positively and significantly affects agricultural productivity in Senegal, both short- and long-term, at a 5% significance level. In contrast, price inflation negatively and significantly impacts agricultural productivity in the short term, with a 5% significance level. The size of the rural population positively and significantly influences agricultural productivity in the short term, at a 10% significance level. Finally, the share of cultivated land relative to the national territory has a negative and significant effect on agricultural productivity in the short term, at the 1% level. Additionally, the lagged share of cultivated land negatively affects agricultural productivity, with significance at the 5% level.

Key words: Foreign aid, agricultural productivity, Senegal, ARDL and ECM.

JEL Classification: O13, Q18, F35, C22

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1. Introduction

Food security remains a major challenge in many parts of the world, especially in developing countries where agriculture is a key source of subsistence and income. In Africa, and Senegal in particular, this vital sector faces persistent structural constraints, including the effects of climate change such as rainfall variability, recurring droughts, and frequent floods, along with demographic pressure and the often-inefficient management of natural resources. These factors combine to exacerbate food insecurity, especially among the most vulnerable segments of the population, particularly rural communities that rely heavily on agriculture for their livelihoods.

In this context, foreign aid has emerged as a strategic tool to support agricultural productivity and strengthen national and local food systems. Since the global food crisis of 2008, which raised widespread concern about rising food prices and access to staple crops, food security has become a top priority for international donors. Multilateral and bilateral partners have significantly increased their funding for agricultural development programs in low-income countries. However, despite this growing commitment, the effectiveness of foreign aid remains a contentious issue within the scientific community and among development practitioners.

While some studies emphasize its positive role in boosting agricultural growth, improving livelihoods, and reducing poverty, others highlight the inefficiencies, dependency risks, and weak institutional absorption capacities that may undermine its impact. For instance, Verter (2017), Sesay et al. (2021), and Guicharu and Kiriti-Nganga (2022) have confirmed the positive effect of aid on agricultural development. Conversely, Sane (2017, 2022) and Toure et al. (2021) argue that aid negatively affects economic growth in Senegal due to donor coordination issues, administrative burdens, inefficient project management, and resource allocation distortions. These divergent findings reflect a partial understanding of the mechanisms through which aid influences food security and agricultural performance, particularly in countries like Senegal, where external funding to the agricultural sector has significantly increased over recent decades.

The existing literature on foreign aid continues to show important limitations. Many studies focus narrowly on macroeconomic growth or poverty alleviation, often neglecting sectoral impacts such as agriculture and food security. Additionally, global or regional analyses often lack the contextual specificity needed to inform

effective, country-level interventions. The specific case of Senegal remains underexplored. This paper fills this gap by providing a comprehensive empirical analysis of how foreign aid affects food security in Senegal, a country where agricultural challenges and climate vulnerabilities remain pressing. This study will not only enrich academic debates but also provide a solid foundation for evidence-based policymaking.

The objective of this paper is to examine the effects of foreign aid on agricultural productivity in Senegal. By integrating a critical review of existing literature with an empirical analysis of national time series data, this research aims to enhance the understanding of aid effectiveness. Additionally, it seeks to provide concrete recommendations for policymakers and development partners dedicated to strengthening food systems and improving agricultural resilience in Senegal.
To highlight this study, the paper first provides a review of relevant literature, followed by the presentation of our methodology and the analysis and discussion of the results obtained.

2. Literature Review

2.1. Debates on the Effectiveness of Foreign Aid

Foreign aid is often seen as a key tool to stimulate economic growth and reduce poverty in developing countries. However, the effectiveness of foreign aid remains a topic of intense debate among scholars and development practitioners. Analyses are divided into two main perspectives: some consider foreign aid ineffective, while others highlight its positive effects.

Many studies highlight the limitations of the effectiveness of foreign aid, particularly in Sub-Saharan Africa, where aid flows have not consistently translated into sustainable development outcomes. Geng and Hernandez (2020) revealed that the relationship between aid, policy, and economic growth is complex. Their results indicate that aid can stimulate growth only when flows are very high, representing more than 7% of the aid-to-GDP ratio. Dörr (2024) supports this perspective, but with caution: according to his findings, reductions in aid negatively affect growth, whereas there is no evidence that increases in aid flows lead to higher growth rates.

In the specific case of Senegal, empirical studies appear to corroborate these broader findings. Sane (2017, 2022) demonstrated that foreign aid had a negative effect on economic growth in Senegal, citing challenges such as the lack of coordination among donors, administrative burdens in the disbursement process, and inefficient

management of aid-funded projects. Moreover, Touré et al. (2021) revealed that a 1% increase in foreign aid, expressed as a share of Gross Domestic Product (GDP), resulted in a 2% decrease in Senegal's economic growth rate, suggesting potential distortions in resource allocation.

The literature highlights several factors contributing to this inefficiency. Raballand (2015) notes that aid investments often lack coherence and fail to target economically viable initiatives. In contrast, countries such as China, Vietnam, and Indonesia have achieved significant poverty reduction through internal reforms and autonomous development strategies, rather than relying on foreign aid.

However, other studies emphasize the positive effects of foreign aid when implemented within appropriate institutional and policy contexts.

Ahmed (2014) underscores the importance of both the nature and duration of aid. He argues that long-term investments in strategic sectors such as infrastructure, education, and healthcare are more likely to yield sustainable and positive outcomes for economic growth. Nevertheless, he acknowledges that corruption remains a major barrier to realizing the full potential of aid, often diverting funds from their intended purposes and weakening development outcomes.

Tang and Bundhoo (2017), in their analysis of 10 Sub-Saharan African countries, found that aid, when evaluated in isolation, does not have a statistically significant impact on economic growth. However, their research demonstrated a positive interaction between aid and indicators measuring the quality of public policies, reinforcing the idea that aid can be effective when integrated within a sound institutional framework.

Similarly, Mahembe and Odhiambo (2021) examined the role of aid in poverty reduction across Sub-Saharan Africa from 1981 to 2013. Their findings revealed that foreign aid can significantly reduce extreme poverty, highlighting its potential to improve living conditions when certain governance and implementation conditions are met.

In sum, while the academic literature remains divided between skeptics and proponents of aid, there is broad consensus that its impact is highly context-dependent. Macroeconomic analyses offer useful insights but remain insufficient to fully grasp the sectoral effects of foreign aid, particularly in crucial domains such as food security and agricultural development.

2.2. Effect of Foreign Aid on Food Security

Improving food security is a critical challenge in developing countries, where agriculture is central to livelihoods, employment, and sustenance. In many of these contexts, particularly in Sub-Saharan Africa, the agricultural sector has suffered from decades of structural underinvestment, limiting its potential to effectively contribute to economic development and poverty reduction. As a result, foreign aid has become a key tool for supporting agricultural productivity and enhancing food systems. This section reviews the effects of agricultural aid, drawing from a range of empirical and theoretical studies to understand its scope and limitations.

Several studies highlight a positive relationship between foreign aid and agricultural growth. For example, the World Bank (2024) reports that countries receiving agricultural loans have experienced significant improvements in productivity. This correlation is largely attributed to foreign aid's ability to stimulate public and private investments in rural infrastructure, modern agricultural technologies, extension services, and access to quality inputs such as fertilizers and seeds.

In the African context, Alabi (2014) demonstrated that agricultural foreign aid positively influences both agricultural productivity and Gross Domestic Product (GDP), with bilateral aid having a more noticeable and targeted impact. Similarly, Verter (2017) identified a comparable effect in Nigeria, where aid contributed to increases in crop yields and rural income levels. Additionally, Guicharu and Kiriti-Nganga (2022) found that the impact of foreign aid in Kenya is both positive and statistically significant, but only in the long term, highlighting the importance of sustained support. Sesay et al. (2021) revealed that foreign aid in Economic Community of West African States (ECOWAS) countries improves food accessibility, although persistent challenges such as armed conflict, poor infrastructure, and weak institutions continue to hinder its impact on food availability and distribution. However, some research offers a more nuanced perspective, emphasizing the variability of aid effectiveness across different contexts. For instance, Griffon (2014) argued that foreign aid played a marginal role in the success of the "Green Revolution" in Asia, where robust state policies and significant technological advancements were the primary catalysts of agricultural transformation. Similarly, studies by Ighodaro and Nwaogwugwu (2013) in Nigeria found no statistically significant correlation between foreign aid and agricultural productivity, suggesting that innovations and endogenous factors may be more decisive than external funding alone.

To maximize the potential impact of aid, Alabi (2014) recommends increased investment in agricultural research and development (R&D). Such investment should be paired with improvements in rural infrastructure, agricultural extension services, and mechanisms for better targeting and allocation of resources according to local needs. Tailoring aid strategies to country-specific challenges is essential for enhancing their effectiveness.

Despite these valuable contributions, the literature on foreign aid and food security presents notable limitations. Firstly, most research focuses on macroeconomic effects such as GDP growth and national poverty rates, often neglecting sectoral impacts, particularly on agriculture and food security. Secondly, many analyses are conducted at a continental or regional level, which, while offering comparative insights, tends to obscure the particularities of individual national contexts.

Moreover, while the literature on foreign aid is extensive, the specific case of Senegal remains underexplored. Comprehensive empirical research is needed to fully understand how foreign aid influences food security in Senegal, where agricultural challenges and climate vulnerabilities are pressing. Such research would enrich academic debates and provide a solid foundation for evidence-based policymaking. Strengthening this knowledge base could guide national policies and international interventions aimed at supporting the most vulnerable populations and building the resilience of Senegal's agricultural systems.

2.3. Stylized Facts

2.3.1. The agricultural situation of Senegal

In Senegal, agriculture remains a cornerstone of the national economy, employing approximately 26.9% of the workforce and contributing around 17.4% to the country's Gross Domestic Product (GDP) in 2023 (ANSD, 2025). Despite numerous agricultural and food policy initiatives implemented between 1960 and 2007, including programs aimed at modernizing farming systems and improving productivity, the country has not succeeded in achieving food self-sufficiency or meaningful agricultural diversification. Rapid population growth (2.9% annual average) and accelerating urbanization (54.7%) have further widened the gap between domestic agricultural production and national food demand, leading to a rising dependence on food imports (USDA, 2024). This situation exposes the country to high volatility in international markets, making it vulnerable to external price shocks and supply disruptions.

The 2008 global food crisis underscored this vulnerability, as international rice prices more than doubled between 2007 and 2008. This sharp increase significantly raised Senegal's food import bill and deepened food insecurity (Doligez & Avezou, 2018). Although cereal yields in Senegal follow a generally upward trend, performance remains modest. Between 1990 and 2019, yields increased from 0.8 to 1.6 tons per hectare, a 100% growth. Nevertheless, the average annual yield during this period hovered around 1 ton per hectare, far below countries like Vietnam, where yields average approximately 4.5 tons per hectare. Cereals constitute the country's main food base, and since the 2008 crisis, boosting production, particularly rice self-sufficiency, has been central to agricultural policy priorities.

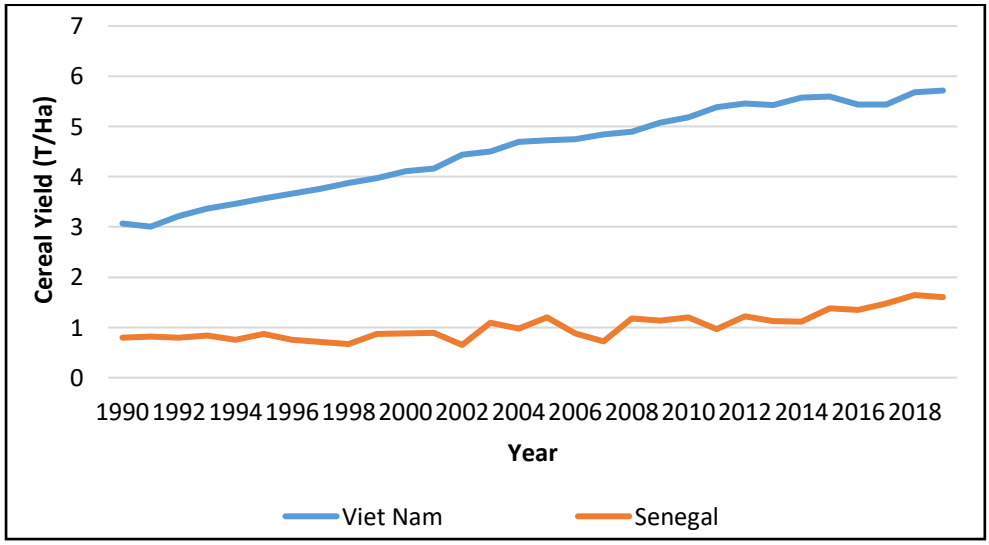

Figure 1: Trends in Cereal Yields in Senegal and in Viet Nam, 1990–2019
Source: World Bank, 2024

2.3.2. Foreign aid in Senegal

The financing of Senegal's agricultural sector heavily depends on foreign aid, which constitutes between 60% and 80% of public agricultural expenditures (Ribier & Baris, 2014). Domestic financial resources are primarily directed toward recurrent expenses, such as salaries and administrative costs, leaving little room for investment in productive agricultural infrastructure, innovation, or capacity building. The global food crisis of 2008 brought agriculture back into focus on international development agendas, leading to renewed commitments from donors. Between 2008 and 2010,

several high-level international summits were convened to mobilize increased funding for food security and agricultural development.

An analysis of foreign aid allocations to Senegal from 2002 to 2019 shows a fluctuating trend. Total aid increased from 680.55 million USD in 2002 to 1,605.3 million USD in 2019, marking a rise of approximately 136%. During this period, the average annual allocation was around 1,170 million USD.

The significant allocation in 2006 represents debt that was cancelled and is recorded as foreign aid. Indeed, that year was marked by Senegal's eligibility for the Multilateral Debt Relief Initiative (MDRI). The G8-led initiative called for the cancellation of debts owed to the World Bank and the International Monetary Fund (IMF) for countries that met the criteria of the Heavily Indebted Poor Countries (HIPC) initiative.

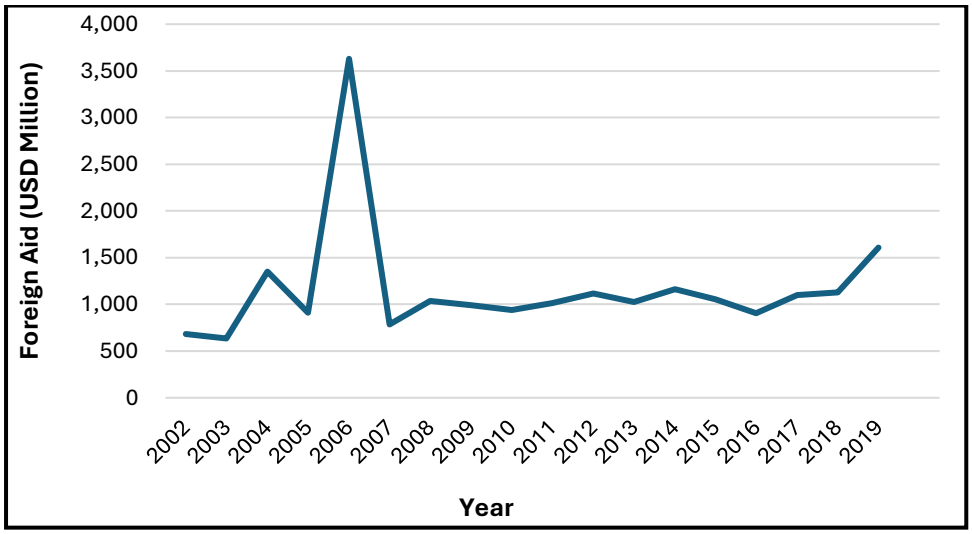

Figure 2: Trend in Foreign Aid Allocations to Senegal from 2002 to 2019
Source: *OECD, 2023*

The main donors of Senegal include the World Bank Group, France, the United States, European Union institutions, and the African Development Bank Group (AfDB) (refer to Figure 3 below).

The chart below illustrates the share of these contributors.

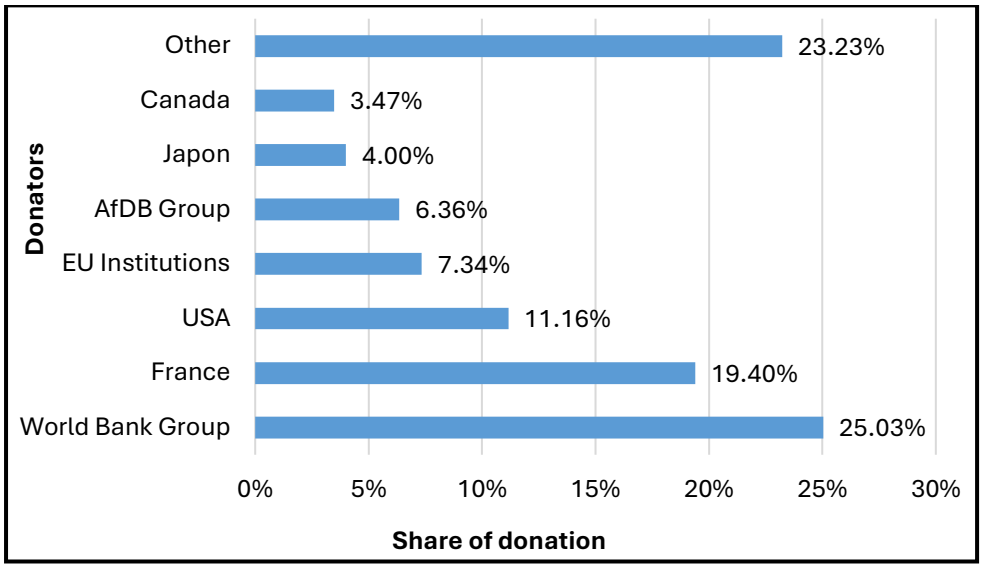

Figure 3: Distribution of Senegal's Key Donors
Source: OECD, 2023

3. Methodology and Data

The methodology used in this study, which analyzes the effect of foreign aid on agricultural productivity from 1985 to 2020, is based on an econometric analysis. For this purpose, the estimations were carried out using STATA version 15.1.

3.1. Data and variables

This study uses time-series data with annual observations for Senegal covering the period 1985–2020. This period was chosen because uniform and consistent data on the relevant variables are available for it. Agricultural productivity is considered the dependent variable, while foreign aid, fertilizer consumption, annual rainfall, rural population, consumer price inflation, and permanently cultivated land area are included as explanatory variables. Data were collected from FAOSTAT, the World Bank, and the OECD databases.

- **Dependent variable**

Agricultural productivity (PA) is used as the dependent variable and is measured by cereal yield, defined as the annual quantity of cereal production per hectare (tons/ha). This indicator reflects the efficiency of agricultural production and is widely used in

empirical studies as a proxy for agricultural productivity. Data on cereal yields were obtained from FAOSTAT.

- **Independent variables**

Foreign aid (APD) represents total financial transfers provided by developed countries to Senegal to support economic development and improve living standards. It is measured in millions of U.S. dollars per year. Foreign aid is expected to positively influence agricultural productivity by supporting investments in agricultural infrastructure, technology, and capacity building. Data were obtained from the OECD database.

Fertilizer consumption (CE) measures the quantity of nutrients applied per unit of arable land, expressed in kilograms per hectare (kg/ha). Fertilizers include nitrogen, potash, and phosphate nutrients. Higher fertilizer use is expected to increase soil fertility and crop yields, implying a positive relationship with agricultural productivity. Data were obtained from the World Bank.

Annual rainfall (Plu) represents the total amount of precipitation received in a year, measured in millimeters (mm). Rainfall is a key determinant of agricultural production in rain-fed farming systems, such as those in Senegal. Therefore, a positive relationship between rainfall and agricultural productivity is expected. Data were obtained from the World Bank.

Rural population (Pop) refers to the number of people residing in rural areas of Senegal. This metric reflects the availability of agricultural labor and is anticipated to positively influence agricultural productivity. Data were obtained from the World Bank.

Consumer price inflation (Inf) measures the annual percentage change in consumer prices. High inflation may increase production costs and reduce farmers' purchasing power, potentially negatively affecting agricultural productivity. Thus, a negative relationship is expected. Data were obtained from the World Bank.

Permanently cultivated land area (Terre) represents the proportion of Senegal's land area that is permanently used for cultivation, expressed as a percentage. The expansion of cultivated land is expected to enhance agricultural production and productivity. Data were obtained from the World Bank.

Several other independent variables are also relevant. For instance, extension services, access to improved agricultural technologies, the use of improved seed

varieties, and pesticide application all contribute to explaining agricultural productivity. However, we encountered challenges in obtaining consistent data for the 1985–2000 period, which is the focus of this study.

3.2. Model Specification

Verter's (2017) model explains the effect of official development assistance (ODA) for agriculture on net agricultural production in Nigeria. Accordingly, the model is specified as follows:

$$NAP = \alpha_0 + \alpha_1 ODAA + \alpha_2 TDCLA + \alpha_3 FER + \alpha_4 CC + \varepsilon \quad \textbf{(1)}$$

Where:

- NAP is Net agricultural production
- ODAA is agricultural official development assistant;
- TDCLA is total domestic commercial loans to agriculture;
- FER is fertilizer consumption.
- CC is Climate change (CO2eq emissions) on agricultural soils
- α_0 is the constant term;
- $\alpha_1, \alpha_2, \alpha_3 \; et \; \alpha_4$ are the coefficients associated with the model's variables;
- ε is the error term.

However, this model presents certain limitations when applied to the Senegalese context. In the specific case of Senegal, where agriculture remains largely extensive, dependent on climatic variability, and poorly mechanized, agricultural productivity appears to be a more relevant dependent variable. It makes it possible to measure yields, which constitute a key indicator of agricultural development (Fall et al., 2013). Therefore, for the case of Senegal, we introduce adjustments based on the synthesis of the models proposed by Alabi (2014) and Hussain (2016) in order to better align them with local specificities. Specifically, our model incorporates variables such as consumer price inflation, rainfall, rural population, and arable land area to assess their impact on improving agricultural productivity.

Function 2 therefore appears to be more relevant and better suited to the Senegalese context.

Accordingly, Equation 1 is reformulated as follows:

$$AP = \alpha_0 + \alpha_1 FAid + \alpha_2 Fer + \alpha_3 RFa + \alpha_4 RPo + \alpha_5 Inf + \alpha_6 PCL + \varepsilon \quad \textbf{(2)}$$

Where:

- AP = Agricultural productivity;
- FAid = Foreign Aid;
- Fer = Fertilizer consumption;
- RFa = Annual rainfall;
- RPo = Rural population;
- Inf = Consumer price inflation;
- PCL = Permanently cultivated land area.
- α_0 is the constant term;
- α_1, α_2, α_3, α_4, α_5, α_6 are the coefficients associated with the model's variables;
- ε is the error term.

To minimize the effects of large-scale economic data and potential heteroskedasticity, we transform Equation 2 into a logarithmic model. The heteroskedasticity test yielded a p-value of 0.4192, indicating that the null hypothesis of homoskedasticity cannot be rejected. This suggests that heteroskedasticity is not a major issue in this model.

Thus, Equation 2 becomes:

$$logAP_t = \alpha_0 + \alpha_{1,} logFAid_t + \alpha_{2,} logFer_t + \alpha_3 logRFa_t + \alpha_4 logRPo_t + \alpha_5 Inf_t + \alpha_6 PCL_t + \varepsilon_t \quad \textbf{(3)}$$

Where *t* is the time.

3.3. Econometric Model

The effect of the explanatory variables on the dependent variable was analyzed using time series data. For this type of data, two main techniques are used: the Autoregressive Distributed Lag (ARDL) model and the Error Correction Model (ECM). These models allow for the estimation of both long-term and short-term relationships, making it necessary to conduct stationarity and cointegration tests to validate the chosen model.

Stationarity test

In the context of our study, all variable data are subjected to unit root tests to determine their order of integration and stationarity. The ADF test is used, with the null hypothesis indicating the presence of a unit root. The results show that the variables Inf, logPop, and logAR are stationary at the 5% level, while the other

variables become stationary after differencing, classifying them as integrated of order 1 (Table 4 in the Appendix).

Cointegration test

Cointegration tests are crucial in time series analysis to identify long-term relationships between variables. The Engle-Granger and Johansen methods are commonly used to detect these relationships in order to avoid misinterpretation and ensure the validity of econometric models.

Table 5 (see Appendix) shows the existence of a cointegration relationship between the variables. These results show that the variables share a long-term relationship, which justifies the use of the error correction model (ECM) to model this relationship. The cointegration test represents the first step of the ECM. All the necessary assumptions are met, confirming the relevance of adopting this method to obtain reliable estimates.

By combining the ARDL approach with the ECM, our study captures both the immediate and lasting effects of foreign aid on agricultural productivity in Senegal, providing a comprehensive understanding of the mechanisms involved.

The ARDL method integrates autoregressive models and distributed lag models, making it particularly effective for small samples like ours, which consists of approximately 34 observations. This technique enables the joint analysis of long-term dynamics and short-term adjustments.

Consequently, we will estimate the short-term and long-term relationships through an econometric equation. This estimation yields the following equation:

$$\Delta logAP_t = a_0 + \gamma logAP_{t-1} + \alpha_1 logFAid_{t-1} + \alpha_2 logFer_{t-1} + \alpha_3 logRFa_{t-1} + \alpha_4 logRPo_{t-1} + \alpha_5 Inf_{t-1} + \alpha_6 PCL_{t-1} + \sum_{i=0}^{n} \beta_{1i} \Delta logAP_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta logFAid_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta logFer_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta logRFa_{t-i} + \sum_{i=0}^{n} \beta_{5i} \Delta RPo_{t-i} + \sum_{i=0}^{n} \beta_{6i} \Delta Inf_{t-i} + \sum_{i=0}^{n} \beta_{7i} \Delta PCL_{t-i} + \varepsilon_t \quad \textbf{(4)}$$

Where:

- α_0 is the constant;
- $\gamma, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ and α_6 are the long-term coefficients;
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ *and* β_7 are the coefficients of the model's dynamics over a short period
- ε is the error term;

- *t* is time;
- *n* represents the number of optimal lags.

The model is estimated using a sample of 34 observations. The coefficient of determination (R^2) is 0.88, indicating that 88% of the variation in agricultural productivity is explained by the selected explanatory variables. The adjusted R^2, approximately 0.82, confirms the good fit of the model, accounting for the number of variables included.

The coefficient associated with the speed of adjustment is -0.77. It is negative and significant at the 1% level, validating the error correction model.

4. Results and Discussion

The table below presents the results of the ARDL/ECM model, illustrating the long-term and short-term relationships between the variables.

Table 1: Results of the long-term and short-term relationships between the variables

Variables	(1) ADJ	(2) LR	(3) SR
logFAid		0.334*** (0.083)	
logRFa		0.627** (0.246)	
logRPo		0.216 (0.679)	
Inf		-0.001 (0.005)	
PCL		2.592 (1.801)	
logFer		0.036 (0.053)	
L.logAPr	-0.778*** (0.169)		
D.logRFa			0.354** (0.144)
D.logRPo			24.97* (12.87)
D.Inf			-0.007** (0.003)
D.PCL			-3.839*** (1.167)
LD.PCL			-3.084** (1.285)
Constant			-3.338 (8.299)
Observations	34	34	34
R-squared	0.884	0.884	0.884

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Computed by the authors.

Our analysis reveals that the variables foreign aid (FAid), rainfall (RFa), rural population (RPo), inflation measured by consumer prices (Inf), and area of cultivated land (PCL) have a significant relationship with agricultural productivity.

The analysis of the significance of the explanatory variables on agricultural productivity is detailed below.

4.1. Foreign Aid

In the long term, foreign aid (FAid) has a positive and statistically significant effect on agricultural productivity in Senegal ($p < 0.01$). Our analysis indicates that a 1% increase in FAid allocations leads to a 0.33% increase in agricultural productivity. These findings are consistent with a substantial body of literature. For example, Alabi (2014) observed a beneficial effect of FAid on agricultural productivity in Sub-Saharan Africa, and Verter (2017) found a similar impact in Nigeria. Ssozi et al. (2019) confirmed that FA contributes to improved food security in the region. Similarly, Makamba (2021) for Zimbabwe, and Guicharu and Kiriti-Nganga (2022) for Kenya, concluded that FAid complements the resources of government and local agricultural actors, thereby enhancing the productive capacity of the agricultural sector.

Several factors account for the positive long-term effect of foreign aid on agricultural productivity in Senegal.

First, agricultural infrastructure, such as irrigation systems and farming equipment, often requires time to become fully operational, justifying the delayed manifestation of investment effects. Second, FAid may indirectly impact food security by improving the macroeconomic environment, providing policymakers with greater flexibility to fund agricultural initiatives. Third, FA can generate positive outcomes through its complementarity with public spending.

However, some studies offer differing results. For instance, Deborah (2015) found that agricultural FAid had a positive but insignificant relationship with agricultural GDP growth in the short term, and a significant negative relationship in the long term. Similarly, Ighodaro and Nwaogwugwu (2013) concluded that FAid had no significant effect on agricultural productivity in Nigeria.

4.2. Rainfall

Rainfall has a positive and significant effect on agricultural productivity in Senegal, both in the short and long term ($p < 0.05$). Specifically, a 1 mm increase in rainfall leads to a 0.62% increase in agricultural productivity in the long term and a 0.35% increase in the short term. This finding aligns with previous studies, such as Alabi (2014) and Massaquoi et al. (2020), which demonstrated that rainfall significantly influences agricultural productivity in Sub-Saharan Africa. These studies emphasize the importance of effective water management for agriculture, particularly in regions like Senegal where inadequate irrigation makes rainfall a critical determinant of crop yields.

4.3. Rural Population

In the short term, the size of the rural population has a positive and significant effect on agricultural productivity at the 10% significance level. A 1% increase in the rural population results in a 0.25% increase in short-term agricultural productivity. This finding is consistent with economic theory, such as Solow's growth model (1956), which suggests that population growth increases the labor supply, thereby boosting agricultural productivity.

4.4. Inflation

In the short term, consumer price inflation (Inf) has a statistically significant negative effect on agricultural productivity at the 5% significance level. Specifically, a 1% increase in consumer price inflation leads to a 0.0069% decrease in agricultural productivity. This result aligns with economic theory, which posits that rising inflation diminishes access to agricultural inputs, thereby constraining investment in optimal agricultural practices and ultimately lowering productivity. Lopes and Costa (2018) support this finding, noting that inflation negatively impacts agricultural productivity by increasing input costs and reducing farmers' profit margins, thus limiting investment in technological innovations.

4.5. Permanently Cultivated Land

The proportion of permanently cultivated land (PCL) relative to the national territory has a statistically significant negative impact on agricultural productivity in the short term ($p < 0.01$). Specifically, a 1% increase in this proportion leads to a 3.84% decrease in agricultural productivity in the short term.

This finding is consistent with Hussain's (2016) observations of a negative correlation between increased agricultural land area and productivity in developing countries, often attributed to poor soil quality limiting agricultural productivity. Furthermore, the FAO (2019) emphasizes that expanding cultivated land can hinder traditional sustainable land management practices, such as fallowing, which are crucial for restoring soil fertility and conserving natural resources.

Additionally, the analysis reveals that the proportion of cultivated land in the previous year (N-1) also has a statistically significant negative effect on agricultural productivity in year N ($p < 0.05$). A 1% increase in the proportion of cultivated land in year N-1 results in a 3.08% reduction in productivity the following year. This result corroborates the arguments of Tittonell and Giller (2013), who suggest that allowing land to lie temporarily fallow or using it for post-harvest grazing enables livestock to deposit organic matter, thereby enhancing soil fertility for future cropping seasons.

5. Conclusions and Recommendations

This empirical study explored the impact of foreign aid on agricultural productivity in Senegal. To achieve this, we employed the combined ARDL-ECM approach to capture both the immediate and long-term effects of foreign aid on agricultural productivity between 1985 and 2020. The econometric analysis was conducted using the STATA 15.1 software.

The findings of our study show that ODA has a positive and significant effect on agricultural productivity only in the long term. Additionally, variables such as rainfall, rural population size, inflation, and the share of cultivated land relative to the national territory had a statistically significant effect in the short term. However, fertilizer consumption did not have a significant effect on agricultural productivity.

The absence of a statistically significant effect of foreign aid on agricultural productivity in Senegal in the short and medium term, despite the increase in foreign aid flows, raises important questions regarding the optimal use of allocated resources. Based on these findings, several recommendations are proposed to enhance the effectiveness of foreign aid in improving agricultural productivity.

First, it is crucial to ensure better coordination and harmonization of interventions among technical and financial partners, as well as between these partners and the governments of recipient countries. Notably, project-based funding instruments accounted for approximately 69% of total ODA allocations between 2009 and 2018.

Therefore, policymakers should adopt a comprehensive governance framework for ODA projects, ensuring coherence and complementarity across interventions. This approach would allow for optimal planning that considers public expenditures, thereby maximizing the impact on agricultural productivity.

Additionally, donors are encouraged to increase the share of aid directed toward the agricultural sector, particularly by investing in agricultural research. Strengthening research efforts is essential to boosting productivity through the development of high-quality, high-yield seed varieties and the promotion of best agricultural practices.

In conclusion, this study highlights the importance of Official Development Assistance (ODA) as a lever for agricultural development in Senegal, while emphasizing the need for better resource allocation and improved data availability to enable more precise and relevant analyses.

Building on this research, several avenues for future investigation deserve exploration:

- Refining the analysis by incorporating the typology of development partners to assess whether certain donors are more effective than others in supporting the agricultural sector.
- Examining the distribution of agricultural foreign aid allocations to better understand how resources are allocated and their specific impacts on productivity.
- Conducting a comparative study on the effect of agricultural aid within a broader regional framework, such as within the West African Economic and Monetary Union (WAEMU) or the Sahel, to provide a wider perspective on aid effectiveness.

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Appendices

Table 2: ADF test results

Variable	A niveau		Différence Première	
	P-Value	Test Statistic (t)	P-Value	Test Statistic (t)
logAP	0.543	-1.480	0.000	-9.699
LogFA	0.135	-2.425	0.000	-8.926
logFe	0.501	-1.566	0.000	-5.483
Inf	0.000	-5.178	-	-
LogPop	0.000	-9.489	-	-
L	0.918	-0.350	0.000	-6.416
logAR	0.000	-5.589	-	-

Source: Computed by the authors.

Table 3: Integration test results

F=5,021

	10 percent	level	5 percent	level	2.5 percent	level	1 percent	level
	(1_0)	(1_1)	(1_0)	(1_1)	(1_0)	(1_1)	(1_0)	(1_1)
K_7	2.12	3.23	2.45	3.61	2.75	3.99	3.15	4.43

Source: Computed by the authors.