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Modeling of the Role of Rice Productivity in the Socio-Economic Development of Households

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Abstract

This study analyzes the role of rice productivity in shaping the socio-economic development of rural households in the Maranga zone of northern Burundi. Using a quantitative approach, primary data were collected from 255 rice-farming households and analyzed through an econometric model based on Ordinary Least Squares (OLS). The study examines key determinants including production levels, access to agricultural inputs, credit, technical support, farmer organizations, infrastructure, climate change, and market access. The results reveal significant variability in rice production, reflecting disparities in farmers' capacities. While the use of combined fertilizers is widespread and contributes positively to soil fertility, access to credit and technical support remains limited. Market access and infrastructure deficiencies are identified as major constraints, while climate change poses an additional risk to productivity. Overall, the findings show that rice productivity has a positive and significant effect on household socio-economic development. However, this effect is conditioned by access to inputs, institutional support, and market integration. The study concludes that improving infrastructure, strengthening extension services, enhancing financial inclusion, and promoting climate-resilient practices are essential for maximizing the developmental impact of rice farming in Burundi.

Keywords: Ordinary Least Squares (OLS), Multicollinearity Tests, Ramsey RESET Test

1. Introduction

Rice production remains a cornerstone of rural livelihoods and food security in Sub-Saharan Africa, where it performs a dual function as both a staple food and a critical source of household income. Over the past two decades, rice has transitioned from a supplementary crop to a central component of food systems in many African countries, driven by urbanization, population growth, and changing dietary preferences. As a result, the demand for rice has increased substantially, often outpacing domestic supply and leading to heightened dependence on imports. This dynamic has raised concerns about food sovereignty and economic vulnerability, particularly in low-income countries [1, 2].

Across developing countries, improvements in rice productivity have been closely associated with enhanced food availability, increased farm income, and significant reductions in poverty levels. Empirical studies conducted in Asia and Africa demonstrate that productivity gains in staple crops, especially rice, have multiplier effects on rural economies, contributing to employment creation, improved nutrition, and enhanced resilience among farming households [3, 4]. In particular, increased rice yields are linked to better household welfare outcomes, including higher per capita income, improved dietary diversity, and reduced food insecurity [5].

In Sub-Saharan Africa, rice has become one of the fastest-growing staple foods. According to recent estimates, rice consumption in the region has grown at an annual rate exceeding that of other major cereals, reflecting both population growth and evolving consumption patterns [6]. However, local production has struggled to keep pace with this demand, largely due to persistent productivity constraints. These constraints include limited access to improved inputs, inadequate infrastructure, weak institutional support, and increasing exposure to climate variability [7].

In countries such as Burundi, agriculture remains the backbone of the economy, employing more than 80% of the population

and contributing significantly to gross domestic product (GDP). Within this context, rice cultivation represents a strategic agricultural activity with considerable potential to drive socio-economic development. Marshland areas, such as those found in the Marangara zone of Kiremba commune in Butanyerera province, are particularly suited for rice production due to favorable agro-ecological conditions, including water availability and fertile soils.

Despite these advantages, rice productivity in Burundi remains relatively low compared to global standards. Smallholder farmers, who dominate the agricultural sector, often face numerous challenges, including limited access to modern inputs, insufficient extension services, poor infrastructure, and restricted market access. Additionally, climate change has introduced new risks, such as irregular rainfall patterns and increased incidence of pests and diseases, further complicating production systems [8].

Consequently, understanding the factors that influence rice productivity and their implications for household socio-economic development is essential for designing effective agricultural policies and interventions. This study situates itself within this broader context by examining the role of rice productivity in improving the livelihoods of rural households in the Marangara zone.

Recent empirical literature (2020–2025) provides substantial insights into the determinants of rice productivity and their socio-economic impacts. These studies emphasize that agricultural productivity is not determined by a single factor but rather by a complex interplay of technical, institutional, socio-economic, and environmental variables.

One of the most consistently identified determinants of rice productivity is access to improved agricultural inputs, including high-yielding seed varieties, fertilizers, and pesticides. Studies conducted in various African contexts have shown that farmers who adopt improved seed varieties and apply appropriate levels of fertilizers achieve significantly higher yields compared to those relying on traditional practices [9]. The adoption of modern technologies not only enhances productivity but also contributes to increased farm income and improved food security outcomes.

In addition to inputs, access to irrigation infrastructure plays a crucial role in stabilizing and increasing rice production. Irrigation reduces dependence on rainfall, thereby mitigating the risks associated with climate variability. Research findings indicate that irrigated rice systems are generally more productive and efficient than rain-fed systems, particularly in regions prone to drought and erratic rainfall [10]. Furthermore, irrigation infrastructure facilitates multiple cropping cycles per year, thereby increasing overall production and income.

Socio-economic factors also play a critical role in shaping agricultural productivity. Access to credit, for instance, enables farmers to invest in inputs and technologies that would otherwise be unaffordable. Several studies have demonstrated a positive relationship between credit access and agricultural productivity, highlighting the importance of financial inclusion in rural development [11]. Similarly, agricultural subsidies can lower the cost of inputs, thereby encouraging their use and enhancing productivity.

Another important determinant is access to extension services and technical training. Extension services provide farmers with essential knowledge and skills related to modern farming practices, pest management, and resource optimization. Empirical evidence suggests that farmers who receive regular extension support are more likely to adopt improved technologies and achieve higher productivity levels [12].

Farmer organizations and cooperatives also contribute significantly to productivity improvements. Membership in such organizations facilitates access to information, inputs, credit, and markets. It also enhances bargaining power and reduces transaction costs, thereby improving overall efficiency and income [13]. In many cases, organized farmers are better positioned to benefit from government programs and development interventions.

Infrastructure development, particularly in transportation and storage, is another critical factor influencing agricultural productivity and income generation. Poor infrastructure can lead to significant post-harvest losses, increased transportation costs, and limited market access. Conversely, improved infrastructure enhances the efficiency of value chains, reduces losses, and increases farmers' access to profitable markets [14].

Market access itself is a key determinant of the economic benefits derived from agricultural production. Farmers who have access to reliable and competitive markets are more likely to invest in productivity-enhancing technologies, as they can expect higher returns on their investments. Market integration also facilitates price transmission and reduces uncertainty, thereby encouraging production [15].

Climate change represents an increasingly important factor affecting agricultural productivity. Changes in temperature, rainfall patterns, and the frequency of extreme weather events have significant implications for crop yields. Studies have shown that climate variability can lead to yield fluctuations, increased production risks, and reduced income stability among farmers [16]. As such, climate resilience has become a central concern in agricultural development strategies.

Overall, the literature suggests that rice productivity is a multidimensional phenomenon influenced by a combination of technical, socio-economic, institutional, and environmental factors. These factors interact in complex ways to determine not only production outcomes but also the broader socio-economic development of farming households.

Despite the extensive body of literature on agricultural productivity and rural development, there remains a significant gap in empirical research focusing specifically on Burundi, and more precisely on the Marangara zone. While existing studies have examined either the determinants of rice productivity or the socio-economic outcomes of agricultural activities, few have attempted to model the direct relationship between these two dimensions.

This lack of integrated analysis limits the ability of policymakers and development practitioners to design interventions that simultaneously address productivity and welfare outcomes. Without a clear understanding of how various factors interact to influence both production and socio-economic development, policy measures may be less effective or even counterproductive.

In the context of the Marangara zone, this gap is particularly relevant. The area possesses considerable potential for rice production but continues to face persistent challenges that hinder productivity and limit its contribution to household welfare. These challenges include limited access to inputs, inadequate infrastructure, weak institutional support, and

increasing climate risks.

Therefore, this study seeks to address the following research question: How does rice productivity, influenced by key production, institutional, and environmental factors, affect the socio-economic development of households in the Marangara zone? To answer this question, the study focuses on the following explanatory variables:

- X1: Level of rice production;
- X2: Access to agricultural inputs
- X3: Access to credit and subsidies
- X4: Technical support and training
- X5: Membership in farmers' organizations
- X6: Access to infrastructure (transport and storage)
- X7: Climate change effects
- X8: Access to output markets

By analyzing these variables within a unified econometric framework, the study aims to provide a comprehensive understanding of the determinants of rice productivity and their implications for socio-economic development.

This article follows the IMRAD structure (Introduction, Methods, Results, and Discussion). The introduction provides the context, literature review, and research problem. The methodology section outlines the research design, data collection procedures, and econometric model used in the analysis. The results section presents the empirical findings, while the discussion and conclusion interpret these findings and offer policy recommendations.

2. Methodology

2.1 Research Design and Study Area

This study adopts a quantitative and analytical research design aimed at modeling the relationship between rice productivity and household socio-economic development. The research is conducted in the Marangara zone of Kiremba commune, located in Butanyerera province in northern Burundi.

The study area is characterized by extensive marshlands that are highly suitable for rice cultivation. Rice farming in this region is predominantly carried out by smallholder farmers using a combination of traditional and modern practices. The area provides an appropriate setting for examining the interactions between productivity determinants and socio-economic outcomes.

2.2 Data Collection

The study relies on both primary and secondary data sources. Primary data are collected through structured household surveys administered to a representative sample of rice farmers. The survey instrument is designed to capture detailed information on:

- Agricultural production (yields, land size, input use);
- Access to inputs (seeds, fertilizers, pesticides);
- Financial services (credit, subsidies);
- Extension services and training;
- Infrastructure (roads, storage facilities);
- Market access (distance, prices, market participation);
- Climate-related factors (rainfall variability, shocks);
- Socio-economic indicators (income, consumption, assets, food security).

Secondary data are obtained from government reports, agricultural statistics, and publications from international organizations. These data provide contextual information and support the interpretation of primary findings.

2.3 Model Specification

To analyze the relationship between rice productivity and socio-economic development, the study employs a multiple regression framework. The general functional form of the model is specified as:

$$Y = X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + +X8 + \varepsilon$$

Where Y represents the socio-economic development of households, X_1–X_8 represent the explanatory variables described above, and ε is the error term capturing unobserved factors.

2.4 Techniques

In this research, the primary estimation technique used is Ordinary Least Squares (OLS), which provides unbiased and efficient estimates under standard assumptions. To ensure the robustness of the results, several diagnostic tests are conducted, including Multicollinearity tests (Variance Inflation Factor), Heteroskedasticity tests (Breusch-Pagan test), and Model specification tests (Ramsey RESET test).

In cases where endogeneity is suspected, particularly for variables such as access to credit or extension services—advanced econometric techniques such as instrumental variable (IV) estimation or propensity score matching (PSM) may be employed.

2.5 Variables Measurement

The dependent variable (Y) is measured using a composite index of socio-economic development, which include indicators such as household income, asset ownership, consumption expenditure, and food security status.

The independent variables (X1–X8) are measured using quantitative and categorical indicators, including:

- Yield per hectare (X1);
- Binary indicators for access to inputs, credit, and training (X2–X4);
- Membership status in farmer organizations (X5);
- Distance to infrastructure and markets (X6, X8);
- Climate shock indices (X7).

This comprehensive measurement approach allows for a nuanced analysis of the factors influencing rice productivity and their impact on household welfare.

3. Results

3.1 Rice Production in Kilos

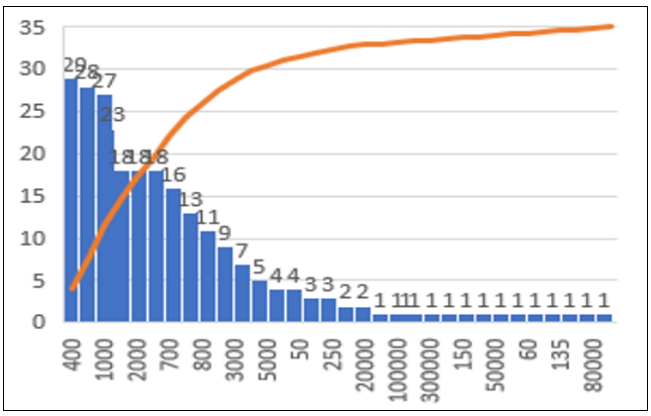

Fig 1: Quantity of kilograms produced on the x-axis and number of producer households on the y-axis

Fig 1 shows that 29 out of 255 respondents (11.4%) harvest 400 kg of rice per year; 28 (11%) harvest 500 kg; 27 (10.6%) obtain 1,000 kg annually from rice farming; and 23 (9%) harvest 600 kg. Similarly, 18 respondents (7.1%) harvest 300 kg, 700 kg, and 2,000 kg respectively. Furthermore, 16 respondents (6.3%) harvest 200 kg; 13 (5.1%) harvest 800 kg; 11 (4.3%) harvest 100 kg; 9 (3.5%) harvest 3,000 kg; 7 (2.7%) harvest 1,500 kg; and 5 (2%) harvest 5,000 kg. In addition, 4 respondents each (1.6%) harvest 50 kg and 900 kg respectively; 3 respondents each (1.2%) harvest 250 kg and 4,000 kg; and 2 respondents (0.8%) harvest 1,200 kg and 20,000 kg respectively. Finally, 1 respondent (0.4%) is recorded in each of the following categories: 60 kg, 130 kg, 135 kg, 150 kg, 535 kg, 1,300 kg, 1,400 kg, 2,500 kg, 10,000 kg, 14,000 kg, 50,000 kg, 80,000 kg, 100,000 kg, 150,000 kg, and 300,000 kg.

These results indicate a high dispersion in the quantities of rice harvested annually. The most frequent production levels range between 300 kg and 1,000 kg, representing several groups between 7% and 11.4%. A notable minority reports higher yields of up to 5,000 kg, while extremely high or very low values remain marginal. This variability reflects significant differences in production capacity among farmers. According to the literature, such disparities highlight the heterogeneity of production conditions and agricultural practices [17, 18].

3.2 Nature of fertilizers used in Rice farming

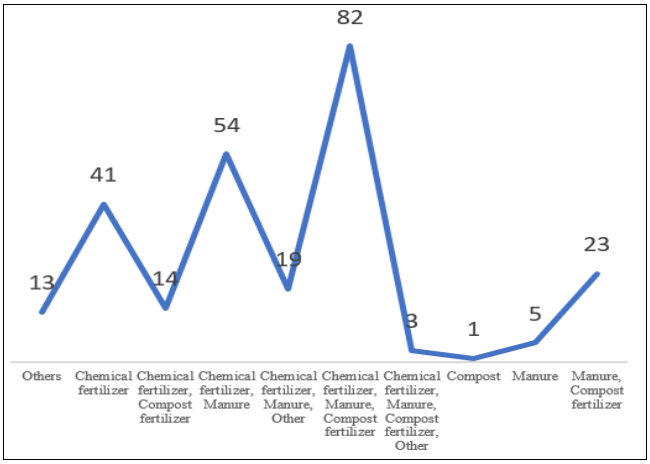

Fig 2: Nature of fertilizer used in X-axis, number of householders using in Y-axis

Fig 2 shows that out of 255 respondents, 82 (67.5%) access fertilizers through a combination of chemical fertilizers, manure, and compost; 54 (21.2%) combine chemical fertilizer with compost manure; 41 (16.1%) use chemical fertilizer alone; 23 (9%) use manure and compost fertilizer; 19 (7.5%) mix chemical fertilizer, manure, and other types; 14 (5.5%) combine chemical fertilizer and compost fertilizer; and 13 (3.9%) do not specify the type used. These results show a predominant and combined use of fertilizers, particularly the integration of chemical fertilizers, manure, and compost, reflecting a search for agronomic efficiency. Other more limited combinations confirm the diversification of practices. This mixed approach contributes to improved soil fertility. According to the literature, the integration of organic and mineral fertilizers sustainably enhances agricultural productivity [19].

3.3 Access to Credit

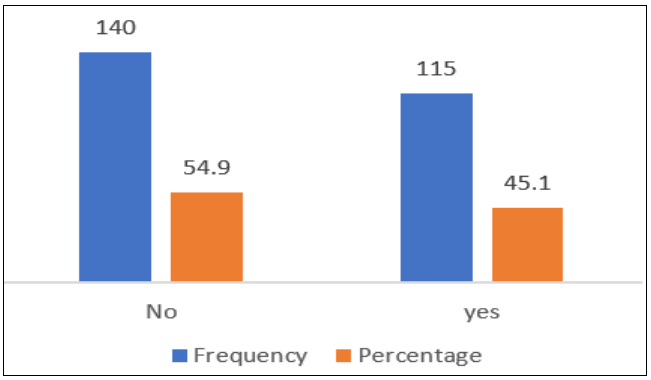

Fig 3: Responses from respondents about access to credit

Fig 3 shows a close distribution between 140 out of 255 respondents (54.9%) who do not perceive access to credit and subsidies as easy, and 115 (45.1%) who report that they do have access to credit and subsidies. These results reveal a divided perception of access to credit: 54.9% consider it difficult, while 45.1% view it as accessible. This contrast reflects inequalities in financial inclusion. According to the literature, access to finance remains a key determinant of agricultural performance and sustainable rural development [20].

3.4 Technical support and training

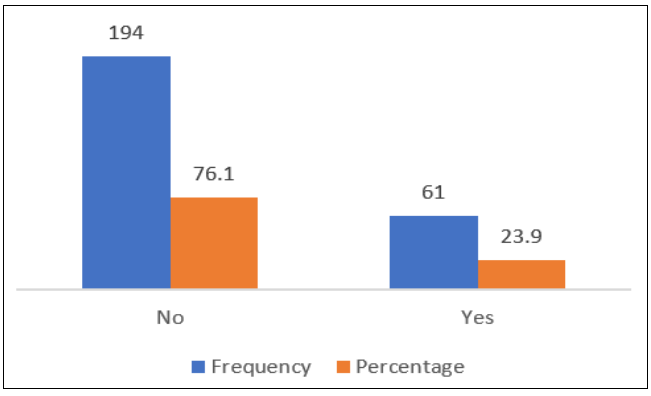

Fig 4: Respondents answers about getting technical support and training

Fig 4 shows that 194 out of 255 respondents (76.1%) have not yet benefited from either technical training or technical support, compared to only 61 (23.9%) who have benefited from such services. The results reveal low coverage of technical training and support, with 76.1% of respondents not having access to these services, compared to only 23.9% who have. This situation reflects a significant capacity-building gap. According to the literature, extension services are essential for improving agricultural productivity, and technical training increases the adoption of agricultural innovations [21].

3.5 Challenges faced by rice farmers

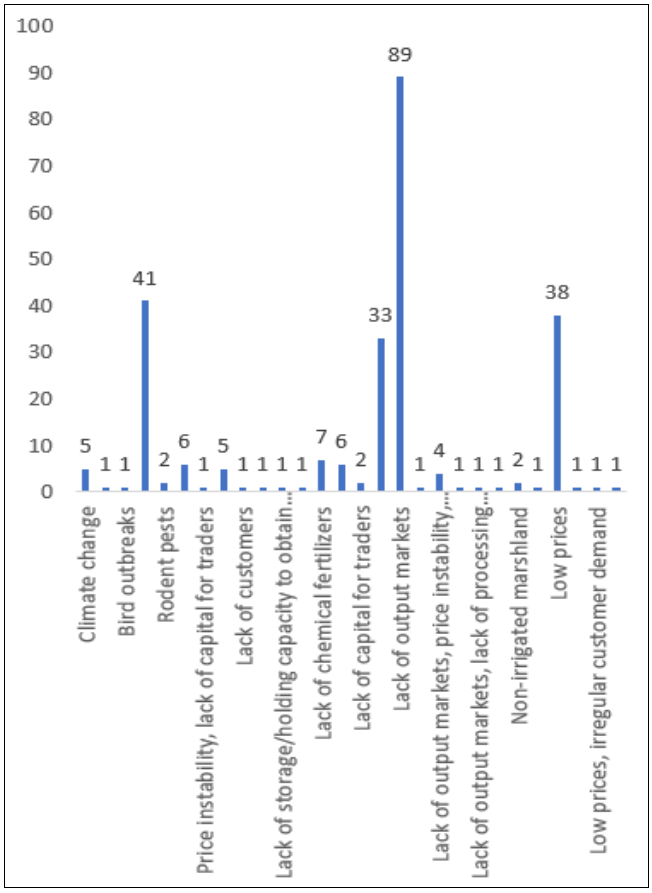

Fig 5: Challenges faced by rice farmers

Fig 5 above shows that out of 255 respondents, 89 (34.9%) identify the lack of output markets as the main challenge faced by rice farmers; 41 (16.1%) cite poorly developed transport infrastructure; 38 mention very low prices; and 33 (12.9%) point to the lack of modern storage facilities for harvests. These results indicate that the primary challenge for rice farmers is the lack of output markets (34.9%), followed by inadequate transport infrastructure (16.1%), low prices, and insufficient modern storage facilities (12.9%). These constraints reflect difficulties in market access and in adding value to production. According to the literature, market failures limit agricultural incomes, and infrastructure strongly influences the commercialization of agricultural products [23]. According to the literature, integrating farmers into markets helps improve their incomes by facilitating the sale of agricultural products and encouraging productive specialization. In the case of rice farming, commercialization involves several stages, including harvesting, storage, transportation, processing, and selling in markets. However, rice farmers often face constraints related to inadequate transport infrastructure, fluctuations in rice prices, the presence of intermediaries, and the weak bargaining power of producers [23].

4. Discussion

4.1 Effet de la production rizicole sur le développement socio-économique des ménages

The results show high variability in production, with yields ranging from low quantities to relatively high levels. Production remains the main driver of rural development. According to the literature, increases in agricultural production are a key factor in poverty reduction [25].
Expected effect: $X_1 > 0$

4.2 Access to agricultural inputs and household socio-economic development

A majority of farmers use combined fertilizers (chemical, compost, and manure). Access to inputs improves soil productivity. According to the literature, integrating organic and mineral fertilizers sustainably increases yields [19].
Expected effect: $X_2 > 0$

4.3 Access to rice credit and household socio-economic development

More than half of the respondents do not have access to credit. Credit is a major limiting factor for agricultural investment. According to the literature, access to finance is crucial for the growth of agricultural activities [20].
Expected effect: $X_3 > 0$

4.4 Technical support and household socio-economic development

More than 76% of respondents have not received technical training. The lack of technical support reduces agricultural innovation. According to the literature, extension services significantly improve agricultural productivity [21].
Expected effect: $X_4 > 0$

4.5 Farmers' organization and household socio-economic development

About 61% of respondents belong to associations, although their effectiveness is considered moderate. Social capital improves coordination and access to resources. According to the literature, social networks enhance economic performance [26].
Expected effect: $X_5 > 0$

4.6 Agricultural infrastructure and household socio-economic development

Infrastructure (transport and storage) is considered insufficient. Poor infrastructure leads to post-harvest losses. According to the literature, rural infrastructure is essential for agricultural development [22].
Expected effect: $X_6 > 0$

4.7 Climate change and household socio-economic development

About 96% of respondents acknowledge the direct impact of climate change on rice farming. Climate change reduces productivity. According to the literature, climate variability directly affects agricultural yields [24].
Expected effect: $\beta_7 < 0$

4.8 Market access and household socio-economic development

Lack of market access is identified as the main challenge (34.9%). Market access determines agricultural profitability. According to the literature, market failures reduce farm income [23].
Expected effect: $\beta_8 > 0$

5. Conclusion

Results conclude the equation $Y = +X_1 + X_2 + X_3 + X_4 + X_5 + X_6 - X_7 + X_8$

They confirm that household socio-economic development strongly depends on a set of interrelated factors. The main positive drivers include production, access to agricultural inputs, membership in farmers' organizations, market access, infrastructure, and technical training. The main limiting factors are climate change and restricted access to credit. Production improves development outcomes when agricultural inputs are accessible, storage and transport infrastructure are available, and strong social capital exists to support farmers. Ultimately, financial and climatic constraints significantly hinder potential gains that could otherwise enhance the socio-economic development of households.

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