Journal of Social Sciences and Economics
Vol. 4(2), 2025, 110-123
ISSN (Online) 2958-1532
https://finessepublishing.com/jsse

Analysis of the Correlation Between Rwanda's Agricultural Growth and Economic Development

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Abstract: Rwanda's economy has historically been based mostly on agriculture, although it remains crucial to the country's economic growth. for most people in this largely rural nation, the agriculture sector continues to be an essential means of occupation, income, and food security. This research took analysis of the relationship between economic development and agricultural growth. Based on data obtained from the Rwanda National Institute of Statistics and the World Bank, the study employed regression analysis to test the correlation coefficient using the ARIMA method model, error correction method, unit root test, and cointegration analysis. The findings show that agricultural growth, defined by the annual increase of the general average output level, positively impacts Rwandan economic development as defined by GDP, GINI index, CPI, and Poverty reduction. Considering the incredibly high R-squared value that is 0.848 for the estimated parameters, where the intercept is equal to 4.338883 and the related slope coefficients are negative, this shows the strong relationship between Rwanda's economic development and agricultural growth. The correlation matrix shows the existence of perfect collinearity with the minimum and maximum value of 0.531 and 0.994, respectively. The ADF test provides a unit root test for specific variables and associated critical values at 1%, 5%, and 10% significance levels associated with negative numbers, and the variables are found stationary since there is no unit root. Thus, consistent efforts are required for agricultural modernization, agricultural mechanization, and transformation as the main drivers of agricultural growth, which boost the economy's output and provide long-term steady growth and development.
Keywords: Agricultural Growth, Correlation Analysis, and Economic Development.

1. Introduction

Rwanda has significantly changed its agricultural environment in recent years through a variety of legislative changes, technical developments, and sustainable practices. The goals of these initiatives have been to raise household incomes, boost productivity, and promote economic stability in general. In Rwanda, there is a complex relationship between the expansion of agriculture and economic development that immediately boosts the GDP, creates many jobs, and is a major factor in the decline of poverty. Understanding the relationship between agricultural expansion and economic development is crucial, particularly in consideration of the nation's emphasis on attaining sustainable development and enhancing the lives of its rural populations.

(Byerlee, De Janvry, & Sadoulet, 2009) argued that agriculture is the primary driver of economic growth and development, serving as the foundation for economic success and poverty alleviation. In addition, (Wambugu, Karugia, & Oluoch-Kosura (2018) gave a shred of clear evidence that it was determined that rising agricultural output and economic expansion were positively correlated. The agricultural sector is frequently promoted as a critical tool and sector for promoting economic growth and combating poverty in several recognized development reports (Alam, Hoque, Khalifa, Siraj, & Ghani, 2009). Regardless of the limited opportunity for trade, modernizing and developing the agricultural industry may be of greater significance for growth in closed, landlocked countries (Fukase & Martin, 2018).

Received 14 November 2024; Accepted 12 June 2025; Published (online) 10 July 2025
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DOI: 10.61363/r41xwq44

Moreover, Los & Gardebroek (2015) illustrated that the growth of the industry is frequently cited as the key engine of economic progress, while agriculture is frequently disregarded. However, the paradigm changed in the 1970s to emphasize economic development from an increasingly agricultural perspective. (Raza, Wu, & Lin, 2023) found that more investments in the agricultural sector, a growing world economy and higher prices for natural resources are the main drivers of this growth process. Therefore, (Pingali, 2012) said that Brazil and India represent two countries that have demonstrated that agricultural development can produce an enormously beneficial effect. India's Green Revolution greatly increased agricultural output, which sped up the country's industrialization and growth in GDP.

(Huang & Rozelle, 2018) Determined that a significant portion of the growth in GDP per capita can be attributed to gains in agricultural production. A nation's capacity to boost agricultural production enabled it to move labor from the traditional agricultural sector to other industries or services. (Ogundari, 2021)observed that development strategies started to suggest a greater emphasis on agriculture, whereas in the past, the domestic policies of developing countries showed a strong bias against the agricultural sector through price, tax and exchange-rate policies that harmed agricultural productivity, the reports and development strategies in the early 1980s suggested more favorable agricultural policies and a greater emphasis on the agricultural sector in the process of economic development.

According to Roemer (1979) demonstrated that the role of agriculture in development is the distinction between open and closed economies, where the nations have abundant resources, such as metals and oil, that they can supply to international commodity markets. In addition, the agricultural sector continues to be the dominant industry in most developing nations, low- and middle-income nations, providing inputs, food, employment opportunities, raw materials for various industries, and foreign profits through the export of agricultural products (Ssozi, Asongu, & Amavilah, 2019). The low productivity and the agricultural industry's slow development are believed to be the primary reasons for emerging countries' low incomes and slow growth in the economy (Alston, 2014).

(Minagri, 2009) reported that Rwanda Government-sponsored initiatives, including the Crop Intensification Program (CIP), have boosted earnings for smallholder farmers and greatly increased yields, which has contributed decrease in poverty. (NISR, 2020) Rwanda's GDP is greatly influenced by agriculture. The National Institute of Statistics of Rwanda (NISR) estimated that during recent years, agriculture generated approximately 24 per cent of Rwanda's GDP. Moreover, (Byiringiro & Re2020) Rwanda stated that the employment Generation for those who live in the countryside, where poverty is greatest, depends on this sector for their living. Therefore, improving agricultural output can be highly significant in mitigating poverty. However, there are other viewpoints regarding the robust and beneficial correlation between agricultural and economic growth. Increases in agricultural development are emphasized in certain literature as a necessary condition for growth in the economy.

The causal relationship between economic development and agricultural expansion noted earlier may account for the recent economic growth observed in the majority of developing African nations. Growth in the agricultural sector requires robust institutional structures with effective government initiatives. Rwanda's frameworks for development and Vision 2020 are instances of strategic plans with considerable value in environmentally friendly farming practices and farmer support systems. The main objective of this research is to understand and analyze Rwanda's agricultural growth and its effect on the determinants of economic development. The study independently analyzes the respective determinants of economic development in depth in response to agricultural growth. The main question of this research aims to address how economic development and agricultural growth are mutually interactive.

Beyond, other empirical research in the field has failed to make use of panel time-series analysis, which enables the use of time-series techniques and combines this with additional data and power gained from panel analysis. Applying these techniques contributes to the existing empirical literature on the relationship between agricultural growth and economic development. In contrast, the experiences of other developing nations demonstrate the variety of ways that agricultural prosperity may contribute to economic advancement. Harnessing the full potential of agriculture to generate comprehensive and sustainable economic development requires sustained investment in technology, policies that encourage it, and sustainable practices. The

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experiences of other African nations demonstrate the importance it is to be implementing supportive policies and technologies to accelerate agricultural growth and economic development.

2. Methodology

The analysis method starts by collecting and sorting out the existing literature on agricultural growth and economic development determinants at home and abroad, and by sorting out relevant documents needed to analyze the current situation of the Rwandan economy. The process of gathering, compiling, evaluating, and interpreting statistical data to draw specific conclusions about the problems it reflects is referred to as a statistical approach. Statistical methods can only be suitable for high-probability events; the more events studied, the more accurate the statistical results obtained. The paper mainly takes data from the Rwanda Bureau of Statistics, the Ministry of Economic Planning and Finance (MINECOFIN), the World Bank, and the International Monetary Fund.

This paper comprehensively uses two analysis methods: qualitative analysis and quantitative analysis, under the guidance of the framework and direction of qualitative analysis, the quantitative analysis means are used to support and verify the conclusions of qualitative analysis, and the two complement each other, to correctly reflect the dynamic relationship between Rwandan economic growth and agricultural development and to provide effective policy recommendations. Comparative analysis consists of quantitative, identical contents, and comparisons of various factors, indicators, and socio-economic phenomena of the same nature, and analyzes the magnitude of changes in each research indicator.

(Baltagi & Kao, 2001) defines empirical analysis as a research method that obtains objective materials through many observations, experiments, and investigations of research subjects and summarizes the essential properties and development laws of things from the individual to the general. Empirical analysis includes many methods, such as static analysis and dynamic analysis, static equilibrium analysis, comparative static equilibrium analysis, dynamic equilibrium analysis, average street analysis and non-equilibrium analysis, qualitative analysis, and quantitative analysis. It concerns foreign theoretical research and successful experience, and corresponding value judgments are put forward, and feasible policy measures are put forward for the optimization and improvement of the Rwandan work system for economic development through agricultural growth.

They argue that the combination of both time series data and cross-sectional data enables the use of relatively accurate data analysis. Panel time-series, or non-stationary panels, aim to use the techniques of time-series and econometric analysis to deal with issues as non-stationarity and combine these with the increased amount of data and power from the different cross-sections. Empirical research in the field of agricultural and economic development that uses these techniques, however, is still very scarce. To study of the causal relation between economic development and agricultural growth estimates a separate time-series equation. This study, therefore, aims to combine time-series techniques with the additional data and power gained from the different panels.

3. Variable description and Model specification

Several empirical studies employing various macroeconomic variables (as suggested by theory) in cross-country analysis regressions have been employed to examine the relationship between agricultural growth (independent variables) and economic development determinants (dependent variable). In this research, we use regression analysis to assess the correlation between the variables of the study. Through the above-mentioned techniques and methods, quantitative data are expected to be assessed with minimum error terms or residuals as small as possible in the findings to properly identify the problem. In this research, the dependent variable and the independent variable are well identified. Based on the conceptual framework and research hypotheses to figure out the links between agricultural growth and economic development, two equations were developed:

$$\Delta \text{Log ECODEVi} = \beta 0 + \beta 1 \Delta \text{LogAGRi} + \text{Ui} \ldots\ldots\ldots\ldots\ldots (1)$$

$$\Delta \text{LogECODE} = \beta 0 + \beta 1 \Delta \text{LogGDPi} + \beta 2 \Delta \text{LogGINIi} + \beta 3 \Delta \text{LogCPIi} + \beta 4 \Delta \text{LogPOVi} + \text{Ui} \ldots\ldots (2)$$

Equation 1 implies that Rwandan economic development is an increasing function of Agricultural growth.
Equation 2 implies that Rwandan economic development is determined by GDP, GINI index, CPI, and Poverty reduction.

The Time Series and Trends Projection took an important place under various circumstances. The research is mainly based on the systematic study of available records. In this study, we used time series annual data from the World Bank and the Rwanda National Institute of Statistics for the period from 2005 to 2024. Both descriptive and econometric techniques were used. Unit Root test, Co-integration test, Error Correction Mechanism, ANOVA, and ARIMA model were used to examine the connection between agricultural rise and determinants of Rwanda's economic development. SPSS and STATA are important software used for the analysis of data.

3. Results and discussion

3.1. Rwanda Agricultural Sector

Rwanda's economy, with limited natural resources, depends mainly on agriculture for subsistence, carried out by local farmers with basic implements. In 2010, farming and agriculture accounted for an estimated 90% of the working population and 42.0% of GDP. The entire country grows potatoes, sorghum, coffee, tea, pyrethrum, bananas, beans, and coffee tea are crucial cash crops for export, with the higher altitudes, steep slopes, and volcanic soils providing favorable conditions. Reliance on agricultural exports makes Rwanda vulnerable to shifts in their prices (Umutoni, 2016).

Coffee is one of Rwanda's major cash crops. In 2012, agriculture accounted for 33% of the economy of Rwanda. Rwanda's economy suffered heavily during the 1994 Genocide, with widespread loss of life, failure to maintain the infrastructure, looting, and neglect of important cash crops. This caused a large drop in GDP and destroyed the country's ability to attract private and external investment. The economy has since strengthened, with per-capita GDP (PPP) estimated at $2,225 in 2018, compared with $416 in 1994. Major export markets include China, Germany, and the United States.

The economy is managed by the central National Bank of Rwanda, and the currency is the Rwandan franc; in June 2010, the exchange rate was 588 francs to the United States dollar. Rwanda joined the East African Community in 2007, and there are plans for a common East African shilling, which is hoped to be in place by 2015. According to (Professionalization, Garrett, Mitchell, & Lintzer, 2010), for US$93 million in 2008, Rwanda's mining sector made an important contribution. The minerals mined comprised coltan, sapphires, wolframite, cassiterite, and gold. These minerals are used to make electronic and communication devices, notably smartphones.

3.2. Rwanda's agricultural production

Historically, agriculture has been an essential part of economic growth, especially in developing nations. This analysis of the literature analyzes whether agriculture contributes to Rwanda's economic growth and makes comparisons with other nations where the sector serves a significant role. The sector provides livelihoods for most of the rural population, where poverty levels are highest. (NISR, 2020). The evaluation looks at the relationship between agricultural growth and GDP, employment, reducing poverty, and general economic stability. The figure 1
below shows the situation of agricultural production of the Rwandan economy in terms of the annual agricultural output situation taken into consideration during this study.

Agricultural development makes a critical contribution to overall economic growth in many developing countries. The Rwandan economy is based on the largely rain-fed agricultural production of small, semi-subsistence, and increasingly fragmented farms. While the production of coffee and tea is well-suited to the small farms, steep slopes, and cool climates of Rwanda, the average family farm size is one-half hectare, unsuitable for most agribusiness purposes. In 2018, agribusiness accounted for approximately 33.6% of Rwanda's GDP and 45% of exports. Rwanda is a country with few natural resources, and the economy is based mostly on subsistence agriculture by local farmers using simple tools. An estimated 90% of the working population farms, and agriculture comprised an estimated 42.1% of GDP.

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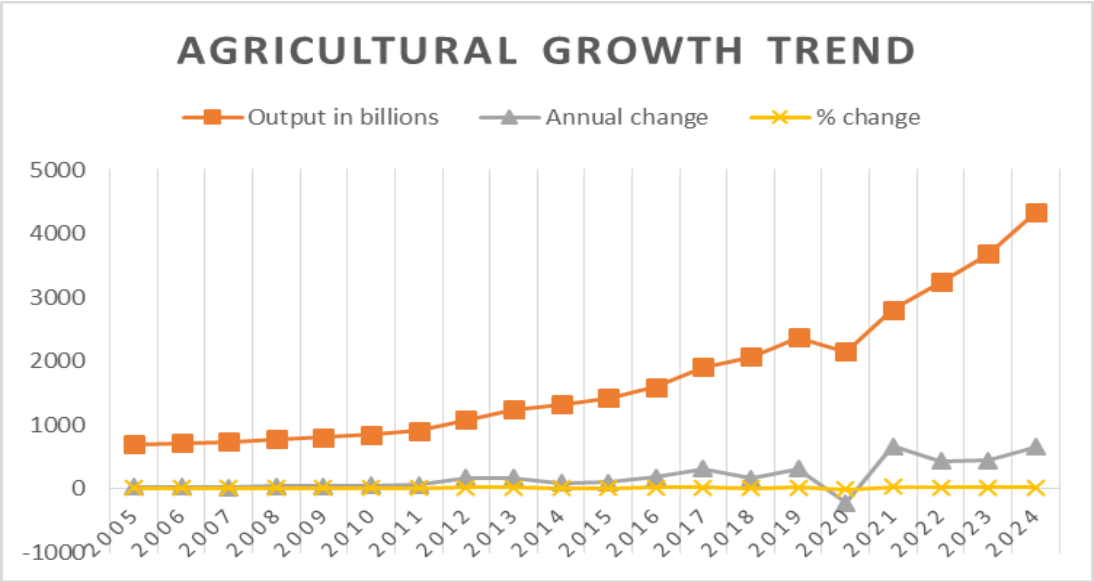

Figure 1. Rwanda agricultural production trend 2005-2024

Despite Rwanda's fertile ecosystem, food production often does not keep pace with population growth, and food imports are required. Crops grown in the country include three types: Firstly, food crops such as cereals (maize, rice, sorghum, wheat, millet), tubers (Irish potatoes, sweet potatoes, cassava); leguminous (beans, peas, soja, banana) and they occupy 92.7 % of the arable land and account for 89% of food supply of rural and urban population. Secondly, traditional cash crops: Coffee, tea, and pyrethrum are the major cash crops for export, with the high altitudes, steep slopes, and volcanic soils providing favorable conditions. They are cultivated on 7.2% of the arable land and account for 45% of the total export in Rwanda. Lastly, new cash crops include vegetables and fruits, flowers, and some spices cultivated on 0.1% (World Bank, 2011). The above figure 1 shows the agricultural production of different periods, which is a consistent increase and a sustainable output trend. The general observation indicates that agriculture maintained its contribution to the economic growth of the country as the primary sector of the Rwandan economy.

3.4. Rwanda agricultural development and its implications for Rwanda's economic development indicators

3.4.1. Rwanda economic growth (GDP)

The gross domestic product at current prices is defined based on the GDP in national currency converted to U.S. dollars using market exchange rates (yearly average). The GDP represents the total value of final goods and services produced during a year. Figure 2 illustrates the situation of Rwandan economy considering Gross domestic product. It provides the trend image of the Rwandan economy in terms of the annual economic growth situation.

Rwanda has enjoyed sustainable variability of economic growth rates in the previous years, as indicated by the figure above. The crucial decline appeared in 2020 due to the general pandemic crisis that negatively affected the world economy. The Government of Rwanda is actively working to develop the economy and reform the financial and business sectors, improving the business climate dramatically, increasing its rank from 139 to 62 on the annual World Bank Doing Business Report. Rwanda’s major foreign exchange earners include mining, tourism, coffee, and tea, and continued growth in these sectors is crucial for economic development.

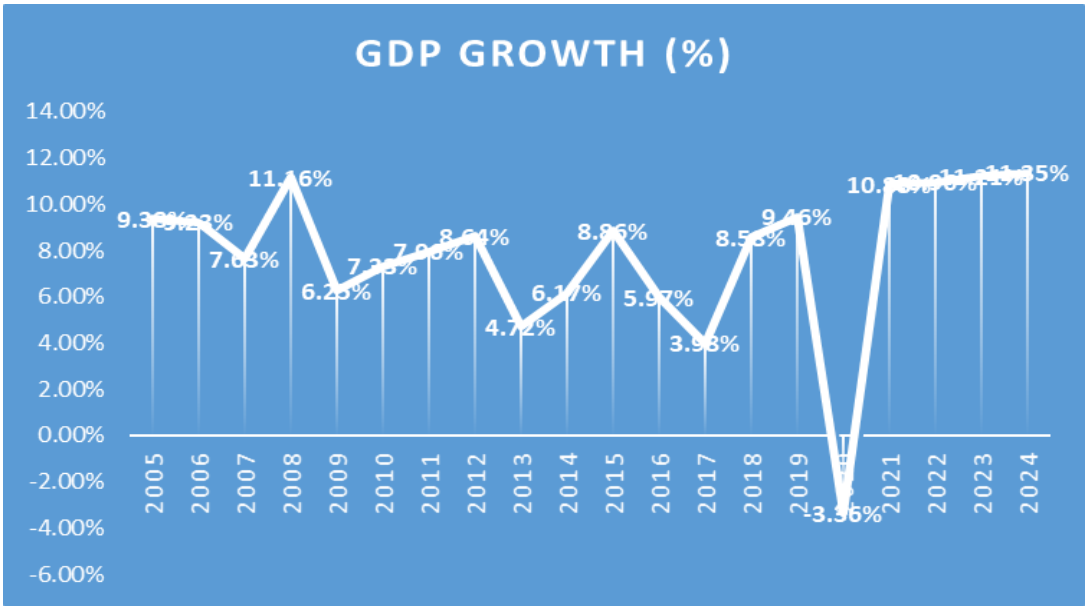

Figure 2. Rwanda economic growth (GDP), 2005-2024

USAID investments focus on enhancing private sector competitiveness with a focus on increasing market access. In the staple crops, dairy, and horticulture sectors, USAID helps farmers expand their markets to increase their products' competitiveness in the region and supports private businesses to grow their supply chain network. USAID also supports the growing role of the private sector along the fertilizer supply chain through facilitation of policy reforms to allow the private sector to take the lead in the fertilizer imports and distribution industry. USAID helped Rwanda benefit from regional trade within the East African Community by improving trade facilitation policies, increasing the competitiveness of Rwandan products, and upgrading infrastructure at border posts. As a landlocked country, efficient and effective trade with neighbors like Uganda, Tanzania, and the Democratic Republic of Congo will be essential if Rwanda is to meet its goal of becoming a middle-income country.

USAID support resulted in a 46% reduction in time for goods to clear customs: a 64% reduction in export release time and a $225 reduction in import cost per truck. As show in the figure above, Rwanda was experienced of mixed both increases and decreases of economic growth rates as measured by a country's GDP especially 2020 due to the general pandemic crisis, where the rate went even below zero, but the general average relies between 8% and 8.5% of annual economic growth increase. Economic growth has been maintained at an increasing rate in the last four years, right after the pandemic crisis.

3.4.2. Rwanda Income distribution (GINI coefficient)

The GINI coefficient measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. Thus, a Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality. The data about income distribution as indicated by the GINI coefficient are illustrated in the figure 3.

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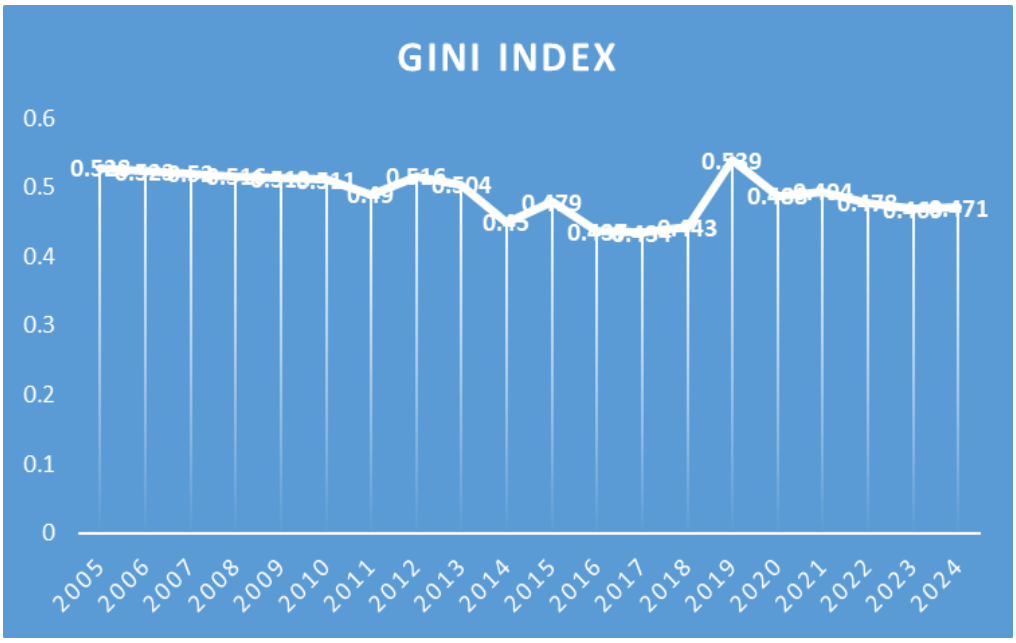

Figure 3. Rwanda GINI coefficient, 2005-2024

For that indicator, we provide data for Rwanda from 2005 to 2024. The average value for Rwanda during that period was 49% index points, with a minimum of 43.4% index points in 2017 and a maximum of 53.9% index points in 2019. Oxfam (2016) uses the share of Gross Domestic National Income (GNI) claimed by the richest 10% of the population divided by that of the poorest 40% to assess income distribution in East Africa. This illustrates that income inequality in Rwanda was highest in the region in 2011, but the next years have declined, as illustrated in the figure above, where it declines by 43% in 2017 and 2018.

3.4.3. Rwanda inflation rate as defined by the consumer price index (CPI)

Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The following figure 4 shows the situation of inflation rates.

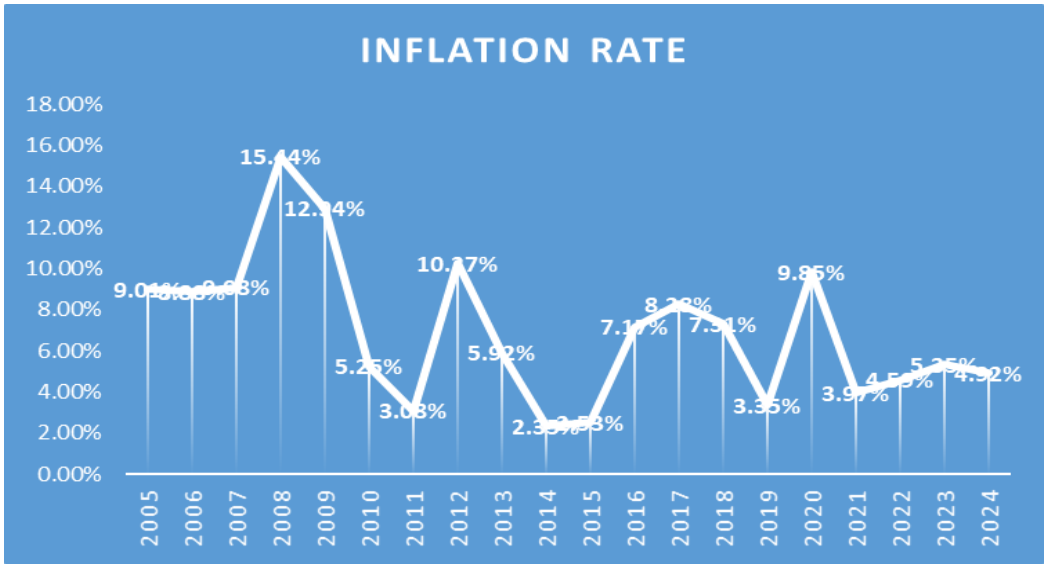

Figure 4. Rwanda inflation rate, 2005-2024

In only a few countries negative inflation rates are achieved. This means that the general price level is declining, and consumer prices are getting cheaper. This is called deflation. In comparison to most other countries, the drastic price increases are no longer average. Usually, this is a sign of political and economic turmoil. Rwanda is one of the African countries that is experiencing price instability, but due to the government's economic development strategies, inflation has decreased in 2011, 2014, 2015, 2019 up to 2024 as indicated by the Rwanda Institute of National Statistics (Figure 4). The general average is 6.98% within 20 years under the study period and indicates that Rwanda maintained an economic growth rate through an increased agricultural growth sector where is high potential for the development of the sector with the introduction of modern methods of farming increased both productivity and quality of products, the development of value added production and initiatives to increase exports so that the agricultural sector makes its full potential contribution to the economy and reducing the consumer prices.

3.4.4. Poverty and Its Dimension in Rwanda

Since independence, the Government of Rwanda has endeavored to improve the quality of life of the people through planned development efforts and has implemented various Economic Development and Poverty reduction Plans. The goals of these plans were to accelerate economic growth and poverty reduction through employment creation. However, the trends in poverty incidence and inequality are based on the lower and upper poverty lines estimated with the cost of basic needs method and the direct calorie intake method. The level of poverty decreased significantly within the period under study, 2005-2024. The drop in poverty in recent years was larger in urban areas than in rural areas. Thus, rural poverty remained much higher than urban poverty in both the lower and upper poverty lines.

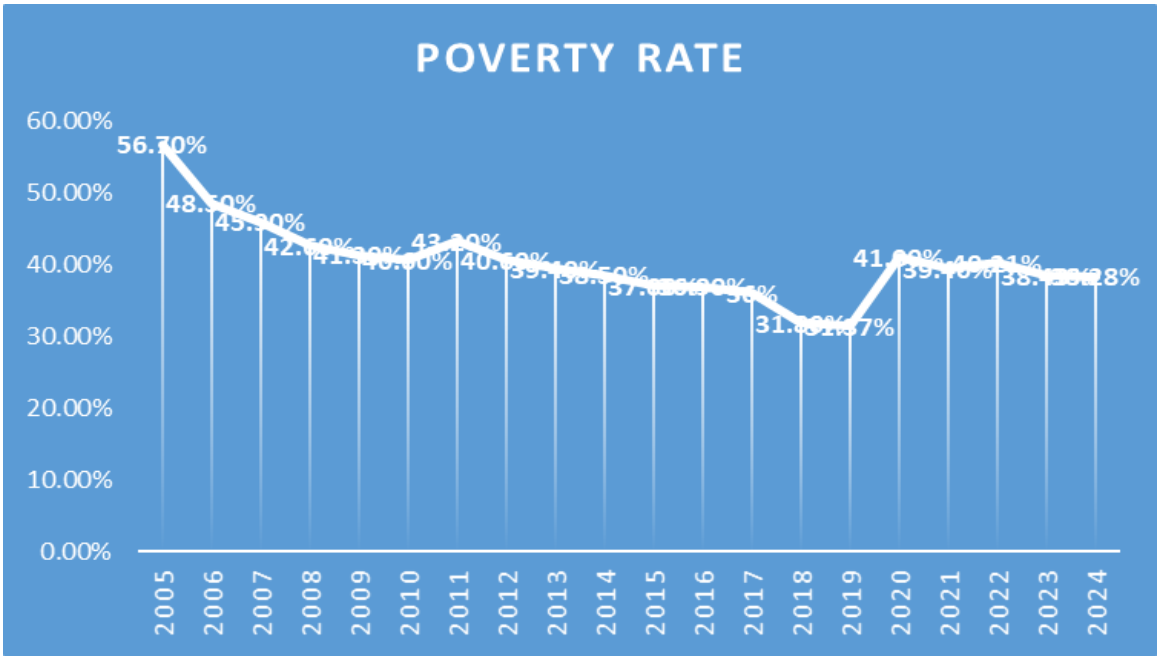

Figure 5. Poverty situation between 2005- 2024

Rwanda is now increasingly seen as a model for economic growth and a stable country in Africa. Real GDP has multiplied by more than 7 in the last 20 years; the growth is coupled with its high stability, which makes the country part of Africa's Stable growers, a growth that is mainly explained by the service sector, especially in the last decade. This growth and good trends in poverty reduction have incited several policies and research questions both nationally and worldwide. One important question is to demonstrate the extent to which ongoing economic growth policies, programmers, and home-grown initiatives have translated into poverty reduction in Rwanda. The contribution of this research is to establish knowledge of how and whether the observed economic growth in the past has been pro-poor and identify what are the enablers and constraints of poverty reduction in Rwanda.

Poverty has reduced linearly from 2005 and 2024 (Figure 5). This implies that, although achieving zero poverty is ambitious, reducing poverty and ensuring sustainable growth is possible in the mid-to-long term. We also

Journal of Social Sciences and Economics
Vol. 4(2), 2025, 110-123
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learn from the findings that poverty reduction interventions will need to concentrate further efforts in rural areas. The results have associated poverty prevalence within the population in rural areas than in urban areas. The ongoing urbanization and secondary cities policy in Rwanda is expected to contribute further to poverty reduction, especially in creating the infrastructure needed for efficient economic transactions. These results show stable, high, and pro-poor economic growth. There is substantial poverty reduction resulting mainly from an inclusive model of economic growth, as the general average of 20 years indicates 40.38%. Even though the agricultural sector is the first determinant of poverty reduction in Rwanda, as revealed by several studies, further investigation is needed to better understand what the sustaining factors in future growth by will be, focusing on the role of economic productivity, public investment, and their interaction in Rwanda.

3.5. Econometric analysis

A collection of statistical methods termed regression analysis is used to estimate the link between a dependent variable and one or more independent variables. In this section, the researcher took time to analyze the correlations between variables, estimation of parameters as results of coefficients, and analysis of variances.

3.5.1. Cointegration Regression Results

The cointegration regression of time series data considers only a long-run equilibrium relationship among them. However, a good time series model should jointly describe the long-run equilibrium and the short-run dynamics. For this, an economic variable's short- and long-term behaviors can be reconciled using the Engle-Granger error-correcting mechanism (ECM). In the study, both for the long-run dynamics analysis and unrestricted error correction mechanisms are used.

Table 1. Summary of regression analysis results

Variable entered	Coefficient	Std. error	t-statistics	P value
Constant	4.338883	0.5060189	8.57 0.000	3.194189
Gross Domestic Product	-.1833253	0.1852814	-0.99	0.348
GINI Index	-.2086578	0.0318492	-3.202	0.007
Consumer Price Index	-.1107763	0.0929046	-1.19	0.264
Poverty reduction	-2.113251	0.4162019	-5.08	0.001
R-squared	0.848		Adjusted R-squared	0.7988
S. E	1.9552			

Source: Authors' calculation based on NISR& World Bank data, 2024

The results derived from the error correction analysis suggest that in the long run, agricultural growth and economic development have a strong positive correlation as revealed by the multiple correlation coefficient, which is 0.848, adjusted at 0.7988. However, the result derived from ECM is also like the result of OLS regression because of the stationary and non-co-integrated time series data. This concurrently delivers long-run equilibrium and short-run dynamics.

3.5.2. Correlation between Variables

The general objective of this research is to find out the influence of agricultural growth and economic development on the Rwandan economy, but one of the specific objectives is to test the interconnectivity between the study variables of the model. The table below illustrates well the correlation between regression variables.

Table 2. Correlation matrix

Variables entered	Agriculture	GDP	GINI	CPI	Poverty reduction
Agriculture	1.000	0.531	0.864	0.931	0.898
GDP	0.761	1.000	0.974	0.871	0.795
GINI	0.682	0.719	1.000	0.675	0.722
CPI	0.943	0.605	0.836	1.000	0.994
Poverty reduction	0.898	0.924	0.882	0.790	1.000

Source: Authors' calculation based on NISR& World Bank data, 2024

The correlation coefficient, which illustrates the relationship between the study variables, is displayed in the above table. As the results presented above show, the findings demonstrated that each of the variables showed a beneficial relationship. The findings facilitate the detection of the partial regression analysis where agricultural growth reacts against GDP at 0.761which implies a positive relationship between the two variables. Agricultural growth reacts positively to income distribution as revealed by a correlation coefficient equal to 0.682 with the GINI coefficient. Furthermore, agricultural growth has a strong correlation coefficient with inflation rates, as indicated by 0.943 with CPI, which measures the consumer price index. Lastly, it was detected that agricultural growth reacts positively to the reduction of poverty in Rwanda, as the correlation coefficient is equal to 0.898. The analysis found the serial correlation between economic development determinants, which implies the existence of multi-collinearity in the regression model, and its implications in this research

3.5.3 Augmented Dickey-Fuller (ADF) Unit Root Test

The underlying time series is assumed to be stationary in regression analysis based on time series data. We applied the Augmented Dickey-Fuller (ADF) test to figure out whether the data was stationary.

Table 3. Unit root test results

Variable	Significance level	Critical values	ADF Statistics
Agricultural production	1%	-2.718	-2.485
	5%	-1.796	
	10%	-1.363	
Gross Domestic Product	1%	-2.660	-5.602
	5%	-1950	
	10%	-1.600	
GINI Coefficient	1%	-2.660	-3.229
	5%	-1.950	
	10%	-1.600	
Consumer Price Index	1%	-2.660	-5.170
	5%	-1.950	
	10%	-1.600	
Poverty reduction	1%	-2.660	-2.940
	5%	-1.950	
	10%	-1.600	

Source: Authors' calculation based on NISR& World Bank data, 2024

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An augmented Dickey-Fuller test (ADF) in statistics and econometrics tests the hypothesis that a unit root is present in a time series sample. Depending on the test version used, the alternative hypothesis varies, although it typically involves stationarity or trend-stationarity. It is an improved Dickey-Fuller model for a more comprehensive and intricate collection of time series models. The test's enhanced Dickey-Fuller (ADF) statistic has a negative value. At a given level of confidence, the hypothesis that there is a unit root is strongly rejected the more negative it is. In general, you can rule out the null hypothesis that there is a unit root when the p-value is less than 5%. Computed DFT statistics plus a tabular value of significance can also be compared. A time series is stationary if its statistical characteristics or, more accurately, the process that produces it, do not vary with time.

Although many helpful analytical methods, including statistical tests and models, depend on significant stationarity. Tests for stationarity in a time series are commonly referred to as unit root tests. If an adjustment in time is not reflected in an alteration in the form of the distribution, a time series is said to be stationary; non-stationarity might have several reasons. One example is unit roots. Low statistical power is a recognized characteristic of these tests. From the analysis, the ADF test provides a unit root test for specific variables and associated critical values at 1%, 5%, and 10% significance levels. Here, all the variables are found stationary because the ADF statistic value is greater than the critical value at 1%, 5%, and 10% significance levels, and thus there exists no unit root as indicated by the consistency of negative numbers detected in the analysis.

3.5.4. Analysis of Variance Results

The collection of statistical models and the associated method for estimation is referred to as analysis of variance, which is used to examine differences in means.

Table 4. Analysis of Variance Results

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	44.019	1	44.019	40.883	0.000[a]
	Residual	7.537	7	1.077		
	Total	51.556	8			

Source: Authors' calculation based on NISR& World Bank data, 2024

The ANOVA test enables a concurrent comparison of more than one group to ascertain whether a relationship between them exists. The F statistics, referred to as the F-ratio, which is the outcome of the ANOVA formula, enables the study of several data sets to determine the variability both within and across samples. The null hypothesis states that there is no significant distinction between the tested groups, which is represented by an F-ratio statistic for the ANOVA that is close to 1. Testing three or more variables is made simpler by ANOVA. ANOVA involves distributing the variation among several sources and group differences by comparing the means of each group. It is used with test groups, subjects, groups within categories, and groupings among groups. The results revealed that ANOVA enabled us to test for the significance of the model. From the F tables, we find F 0.01 = 40.883 where the mean square is equal to 44.19 and the total sum of squares equals 51.556 and F v > Ft so it is evident that the explanatory variable (agricultural growth) has a significant correlation with economic development determinants, and the regression model indicates the goodness of fit.

3.5.5. Autoregressive Integrated Moving Average (ARIMA)

The fundamental AR model for forecasting is expanded into ARIMA (autoregressive integrated moving average) models, which employ three methods to clarify the serial correlation in the disturbance term. The study analysis considers the ARIMA process (1, 0, 1) means a purely AR (1) and M (1) stationary process.

Table 5. ARIMA analysis results

Var	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
GDP	0.076161	0 .097632	0.78	0.435	-0.115195 .2675181
GINI	0.017081	0 .030572	0.56	0.576	-0.042840 .0770024
CPI	-0.399135	0 .359445	-1.11	0.267	-1.103635 .3053643
POV	-0.033667	0.032796	-1.03	0.305	-0.097946 .0306118
ARI 1	0.913716	0 .226321	4.04	0.000	0.470133 1.357299
MA1	0.999907	6152.732	0.00	1.000	-12058.13 12060.13
Sigma	0.0220344	67.78667	0.00	0.500	0 132.8815

Source: Author's calculation based on NISR& World Bank data, 2024

Autoregressive integrated moving average (ARIMA) models are employed in time series analysis to determine which time sequence model best fits historical data. An autoregressive integrated moving average (ARIMA) model is an extension of an autoregressive moving average (ARMA) model in statistics and econometrics, specifically in longitudinal analysis. Each of these models is applied with time series data to forecast future points in the series or to gain an improved comprehension of the data. The developing variable of interest is regressed on its own delayed (i.e., prior) values, as shown by the AR component of ARIMA. The MA component indicates that regression error is a linear mixture of error terms having contemporaneous or progressively occurring values in the past.

The "integrated" indicator (I) denotes that the data values have been substituted with the difference between their current values and their historical values. This method of differentiating could have been carried out once or more. Getting the model as close to the data as feasible is the aim of each of these features. Here, the results derived from the analysis suggest that GINI and GDP are more positive and Poverty and CPI are more consecutive to negative but positive at different lag periods. This implies that economic development is positively increasing after the lags and indicates a long-run positive relationship with agricultural growth.

4. Conclusion

Rwanda is an impoverished country where the primary means of economic growth and overall development is agriculture. Considerable interdependence between the agricultural and economic sectors is revealed by analyzing the correlation between Rwanda's progress in agriculture and its economic development. Rwanda's overall economic expansion has been primarily fueled by agricultural growth, which has boosted GDP, GINI index, CPI, employment, and rural development. Food security has increased because of increased agricultural productivity brought about by government initiatives, advances in technology, and improvements to infrastructure. This increase has also had a knock-on effect on other economic sectors. This expansion has made it easier to reduce poverty and raise living standards, underscoring the significance of agriculture in Rwanda's economic transition. Nevertheless, sustaining this development requires regular investments in innovative farming methods, effective supply networks, and supportive legislation that handles issues like market access and climate change. All things considered, Rwanda's experience shows how important the agricultural industry is to the promotion of all-encompassing and sustainable economic development.

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