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RESEARCH ARTICLE

EXPLORING THE INTERCONNECTIONS OF GREEN FINANCING, FINANCIAL DEVELOPMENT, TECHNOLOGICAL INNOVATION, AND AGRICULTURAL PRODUCTION: EVIDENCE FROM TANZANIA

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ABSTRACT

This study explores the interconnections between green financing, financial development, technological innovation, and agricultural production in Tanzania, guided by Keynesian and endogenous growth theories. Using annual data from 1990 to 2023, the research employs the Phillips-Perron unit root test and the Bound cointegration test and the ARDL model evaluate the stationarity, cointegration and long-run equilibrium relationships respectively. The Phillips-Perron unit root test and the Bound cointegration test results reveal that variables have different order of integrations and exhibits long run relationship. Further, the ARDL results indicate that green financing, financial development, technology, and human capital have varying effects on agricultural production in long run. While in the short run, green financing, technological innovation, and human capital positively influence agricultural output, but financial development exerts a negative impact. The error correction term confirms a stable relationship between the variables. The findings suggest that policymakers should prioritise investment in green financing, technological advancements, and human capital development and directing more credit to the agricultural sector to boost agricultural productivity.

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INTRODUCTION

The agricultural sector plays a critical role in Tanzania's economy, serving as a key factor of growth of economy, a major source of employment, and a significant contributor to food security. Approximately 65% of Tanzania's population relies on agriculture, either directly or indirectly, for their livelihoods. In 2023, the sector contributed 28% to the country's GDP and accounted for 24% of total exports (Cowling, 2024; JICA, 2024). Despite its importance, agricultural productivity in Tanzania faces challenges that can be addressed through innovations in green financing, financial development, and technological advancement. Green financing has emerged as a vital tool in promoting sustainable agricultural practices. By advocating for environmentally friendly investments and reducing carbon emissions, green financing supports the shift towards a green economy. Financial development also plays a critical role by facilitating access to domestic credit, which is essential for purchasing agricultural inputs, storage, and transportation infrastructure. Technological advancements, particularly in mobile connectivity and internet access, have expanded market opportunities for agricultural products both locally and internationally (Qin et.al 2024; Li et.al 2023; Mo et.al, 2023; Gao et.al, 2022). The Tanzanian government has made significant strides in liberalizing the financial and communication sectors since the 1990s to stimulate economic growth. These efforts align with the theory of endogenous growth, which emphasizes the importance of internal factors such as capital, technology, and human capital in influencing long-term economic development(Adabor and Essah, 2024; Magazzino and Santeramo, 2023). Furthermore, the Keynesian economic framework underscores the role of government spending in stimulating growth. Recent government expenditure has increasingly focused on green financing initiatives and investments in renewable energy, reinforcing the drive towards sustainable growth. Given the importance of these factors, this study examines the interconnections between green financing, financial development, technological innovation, and agricultural productivity in Tanzania. By employing Keynesian and endogenous growth theories as the theoretical foundation, the research examinesboth the short- and long-run relationships betwixt these variables.

Study utilizes modern econometric techniques, specifically the ARDL model, to capture these dynamics over the period from 1990 to 2023. This research contributes to both academic literature and policy discussions in several ways. First, it provides new understanding into the role of green financing, financial development, and technological innovation in strengthening agricultural productivity in Tanzania. Second, the findings provide a valuable framework for policymakers aiming to integrate sustainable financial strategies and technological innovations into the agricultural sector. Lastly, the study gives an address to a critical gap in the literature by examining the under-researched nexus betwixt green financing, financial development, and technological advancement in agriculture. These insights are essential for shaping future policies that aim to balance economic growth with environmental sustainability. The remainder of this study is organized as follows: Section Onepresents the relevant literature; whereas Section Two details the research data and methodology; while Section Three presents the empirical results; and the final section offers conclusions and policy recommendations.

LITERATURE REVIEW

Theoretical Literature Review: This study draws on both Keynesian theory and endogenous growth theory to explore the association ship betwixt green financing, financial development, technological innovation, human capital, and agricultural productivity in Tanzania. According to Keynesian economics, government spending plays a crucial role in stimulating growth. In the context of sustainable development, such spending often takes the form of green financing—investment in environmentally friendly projects designed to reduce carbon emissions while driving growth (Mulandi&Mwania, 2022). This linkage between green financing and agriculture is pivotal for Tanzania, where the sector contributes in economic development.

However, Keynesian theory has been criticised for its limited focus on external government interventions without considering internal economic drivers. In contrast, endogenous growth theory focuses on factors such as financial development, technological innovation, and human capital, which are key factors for long-term economic growth from within the economy (Mapanjen *et al*., 2023). In the Tanzanian agricultural sector, these internal factors are essential for improving productivity. For example, access to domestic credit can help farmers invest in better inputs, storage facilities, and transportation, while advancements in technology such as mobile banking and internet connectivity can expand market access for agricultural goods. Human capital, via education and development of skill, also plays a significant role in enhancing agricultural productivity.

By integrating these two theoretical frameworks, the study provides a broad picture in understanding agricultural productivity in Tanzania. The Keynesian emphasis on government spending is relevant in the context of green financing, while endogenous growth theory helps explain the importance of internal factors such as financial development and technological innovation. This combined approach allows for a nuanced grasp of how various economic forces interact to influence agricultural productivity in Tanzania.

Empirical Literature Review: The relationship betwixt green financing, financial development, technology, human capital, and agricultural productivity has been the subject of much debate, with mixed findings across different contexts. Several studies highlight the positive role of financial development in agricultural productivity (Chandio, 2022; Tursoy& Simbarashe, 2021), while others suggest that financial development may have negative or limited impacts, depending on the institutional context (Likius, 2024). These conflicting findings underscore the need for further research, particularly in the Tanzanian context, where agriculture is a cornerstone of the economy. Green financing has been shown to positively influence agricultural productivity in China, where government investments in sustainable agriculture have led to significant gains (Qin *et al*., 2024; Li *et al*., 2023). However, Ye *et al*. (2022) found that the impact of green financing on agricultural productivity can vary widely between regions, suggesting that local institutional frameworks play a crucial role in determining outcomes. This finding raises questions about the potential applicability of these results to Tanzania, where institutional capacities and regulatory environments differ from those in China and other industrialized nations.

Similarly, studies on the role of technological innovation in agriculture have produced varying results. In Ghana and Sub-Saharan Africa, technological advancements such as mobile banking and internet access have been shown to enhance agricultural productivity by improving market access and facilitating better financial management (Mapanjen *et al*., 2023; Ye *et al*., 2022). However, the extent to which these technologies can be leveraged in Tanzania remains underexplored. In terms of human capital, studies have generally found a positive influence between education and agricultural productivity. For instance, Zakaria *et al*. (2019) demonstrated that public investment in education significantly boosted agricultural output in South Asia, a finding that is supported by similar studies in Uganda (Owuor, 2022). These findings suggest that human capital development could play a similarly important role in Tanzania's agricultural sector.

METHODS

This study employs a time series analysis using the Autoregressive Distributed Lag (ARDL) model to analyze both long-run and short-run relationships betwixt green financing, financial development, technology, human capital, and agricultural production in Tanzania. The ARDL model is well-suited for this study as it allows a concurrently analysis of both short-run and long-run dynamics of the variables. The data utilizedin this study spans from 1990 to 2023 and is gathered from the World Bank database. The selection of this period is grounded in the availability and completeness of relevant data, as well as the significant economic reforms undertaken during this time, particularly the liberalisation of financial and communication sectors in Tanzania. The dependent variable is agricultural production, while the independent variables are green financing, financial development, technology, and human capital. Table 1depicts a detailed description of the study variables, including their operational definitions and measurement criteria. This ensures transparency in the analysis and allows for replication of the study.

The choice of these variables is informed by the theoretical frameworks of Keynesian economics and endogenous growth theory, which assert that government spending on green financing, technological innovations, and human capital investment can enhance sustainable agricultural development.

Model Specification: This study builds its analytical framework using a combination of Keynesian theory and endogenous growth theory. Keynesian theory argues that government spending, an external factor, can stimulate economic production by driving demand and investment in key sectors such as agriculture. In contrast, endogenous growth theory highlights the role of internal factors—specifically technological innovation, human capital development, and financial capital—as drivers of sustained economic growth. Accordingly, the model incorporates green financing (as an aspect of government spending), financial development, technological innovation, and human capital as key explanatory variables that influence agricultural production in Tanzania. The methodological approach follows the work of Adabor and Essah (2024) and Chandio (2022), ensuring a rigorous examination of the relationships between the variables. Pre-estimation tests, including unit root and cointegration tests, are conducted to avoid spurious regression results and ensure that the relationships between variables are reliable over time. These tests are critical for determining the stationarity properties of the time series data and whether long-term equilibrium association ship exist in the variables.

Phillips-PerronUnit Root Test: To determine the stationarity, the Phillips-Perron (PP) unit root test was utilized, which is effective in addressing heteroscedasticity and serial correlation that may exist in the data. The PP test improves upon other unit root tests by allowing for more flexibility in handling potential issues with the data, such as time-dependent variance. Testing for stationarity is crucial as it helps to avoid spurious regression results that may arise when variables are integrated in different orders. The stationarity properties of the variables are assessed using the following model:

$$\Delta Y_t = \beta D_t + \alpha Y_{t-1} + u_t \qquad 1$$

Where Y_t is the regressand D_t and Y_{t-1} are regressors while β and α are coefficients of change. $u_t$is error term and Δ first difference operator.

Bound Cointegration Test: This study employs the Bound cointegration test as a key diagnostic within the ARDL model. The Bound test is particularly suited to datasets where the variables express different orders of integration, such as I(0) and I(1), making it an appropriate alternative to the Johansen cointegration test, which requires variables to be integrated of the same order. The ARDL technique is beneficial because it can accommodate a mix of I(0) and I(1) variables in the study. Furthermore, the Bound cointegration test is ideal for small sample sizes, which is often the case in studies like this one, ensuring robust results when assessing the long-run equilibrium relationships among green financing, financial development, technological innovation, and agricultural productivity. The Bound test identifies whether a long-run equilibrium association ship exists betwixt the variables. Once F-statistic exceeds the critical upper bound, a cointegrating relationship is confirmedunder study. The study employ equation 2.

$$y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{p} \Phi_i y_{t-i} + \sum_{i=0}^{q} \beta_1 X_{t-i} + \mu_t \qquad 2$$

Where p as well as q are optimal lag

Autoregressive Distributed Lag (ARDL) Model: Once the Bound cointegration test asserts the presence of a long-run association ship, the ARDL model is employed to investigate both the long-run and short-run dynamics. The ARDL technique is particularly advantageous as it permits estimation of both long-run and short-run coefficients in a single equation, providing a comprehensive view of how green financing, financial development, technological innovation, and agricultural productivity interact over time. Prior to the formulation of ARDL model the study formulated the time series model as shown below:

$$AP_t = C + \gamma_1 GF_t + \gamma_2 FD_t + \gamma_3 TE_t + \gamma_4 CV_t + \mu_t \qquad 3$$

Where AP is agriculture production, GF is green financing, FD is financial development, TE stands for technology while CV is control variable. This study includes human capital as control variable. C is constant term, γ_1 to γ_4 are coefficients of changes of variables and error term is present by μ. Thereafter the ARDL model was formulated incorporating the (ECT_{t-1}). In this model, the error correction term (ECT_{t-1}) is incorporated to capture the speed of adjustment towards long-run association ship. The ECT represents how much of the disequilibrium in one period is corrected in the subsequent period. A statistically significant and negative ECT indicates that the variables adjust back towards equilibrium following a shock, the coefficient's magnitude reflecting the speed of this adjustment. Equation 4 presents the ARDL model with the error correction term:

$$AP_t = \Phi_0 + \gamma_1 AP_{t-1} + \gamma_2 GF_t + \gamma_3 FD_t + \gamma_4 TE_t + \gamma_5 HC_t + \sum_{i=1}^{p} \alpha_1 \Delta AP_{t-i} + \sum_{i=1}^{q} \alpha_2 \Delta GF_{t-i} + \sum_{i=0}^{q} \alpha_3 \Delta FD_{t-i} + \sum_{i=0}^{q} \alpha_4 \Delta TE_{t-i} + \sum_{i=0}^{q} \alpha_5 \Delta HC_{t-i} + \lambda ECT_{t-1} + \mu_{t-i} \qquad 4$$

The dependent variable is presented by agriculture production (AP) and measurement as shown in Table 1 while independent variables are expressed as follows: GF stands for green financing, FD is financial development, TE is technology and HC is human capital. ECTt-1 is the error correction term and μ is the error term. Further, Φ_0 is the constant term, γ_1 to γ_5 stands for coefficients of changes in the long-run while α_1 to α_5 are coefficientsof changes in the short run. Again, λ is error correction term's coefficient but Δ is a first difference operator. Independent variables measurements are well shown in table 1.

RESULTS AND DISCUSSION

Descriptive Statistics Results: Table 2 provide important understanding into the variability and central tendencies of the key variables under study. Agricultural production (AP) has a mean value of 26.70, indicating a moderately high level of agricultural output in Tanzania. The standard deviation of 2.17 suggests moderate variability in agricultural productivity across observations, with a minimum of 23.25 and a maximum of 30.87.

Table 1. VariableDescriptions

Variables	Measurements	Sources
Agriculture Production (AP)	"Agriculture, forestry, and fishing, value added (% of GDP)"	WDI (2024)
Green Financing (GF)	"Renewable energy consumption (% of total final energy consumption)"	WDI (2024)
Financial Development (FD)	"Domestic credit to private sector by banks (% of GDP)"	WDI (2024)
Technology (TE)	"Mobile cellular subscriptions (per 100 people)"	WDI (2024)
Human Capital (HC)	"Government expenditure on education, total (% of government expenditure)"	WDI (2024)

Source: Researcher's compilation, 2024: Data were sourced from "World Development Indicators" (WDI)

Table 2. DescriptiveStatistics

	AP	GF	FD	TE	HC
Mean	26.69956	87.67059	9.253307	33.03167	15.31995
Median	26.32933	90.45000	10.33369	16.80467	13.99800
Maximum	30.86767	95.20000	16.27681	91.89985	24.39654
Minimum	23.24549	52.55000	2.130345	0.001253	11.79397
Std. Dev.	2.165516	8.093405	4.181741	34.84887	3.324815
Observations	34	34	34	34	34

Source: Researcher's computation, 2024.

Table 3. Correlation Results

	AP	GF	FD	TE	HC
AP	1.000000	0.379709	-0.356113	-0.364728	-0.249420
GF	0.379709	1.000000	-0.721012	-0.812133	-0.234301
FD	-0.356113	-0.721012	1.000000	0.880795	0.566090
TE	-0.364728	-0.812133	0.880795	1.000000	0.470910
HC	-0.249420	-0.234301	0.566090	0.470910	1.000000

Source: Researcher's computation, 2024.

Table 4. Phillips-Perron Unit Results

Variable		With Intercept no Trend		With Intercept and Trend	
Variables		Level	1st Difference	Level	1st Difference
Agricultural Productivity	AP	0.6027	0.0004	0.7153	0.0024
Green Finance	GF	0.9999	0.0875	0.9997	0.2880
Financial Development	FD	0.9129	0.0101	0.3427	0.0160
Technology	TE	0.9882	0.0144	0.5550	0.0607
Human Capital	HC	0.1826	0.0000	0.3571	0.0000

Note: Intercept no trend: 1%, 5%, 10%; Intercept and linear trend 1%, 5%, 10%.

Table 5. Bound Cointegration Results

Test Statistic	Value	Signif	I(0)-Lower Bound	I(1)-Upper Bound
F-statistic k	5.2057084	10%	2.45	3.52
		5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06

Source: Researcher's computation, 2024.

Table 6. Long Run Results Model: ARDL(2, 3, 2, 3, 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
AP(-1)	0.083974	0.189196	0.443848	0.6645
AP(-2)	0.329744	0.165404	1.993569	0.0676
GF	0.084252	0.045306	1.859606	0.0857
GF(-1)	-0.015942	0.154788	-0.102995	0.9195
GF(-2)	-0.083931	0.226587	-0.370415	0.7170
GF(-3)	0.242240	0.169933	1.425502	0.1776
FD	-0.626411	0.176757	-3.543902	0.0036
FD(-1)	0.174556	0.239316	0.729392	0.4787
FD(-2)	0.725268	0.178843	4.055335	0.0014
TE	-0.051365	0.053848	-0.953875	0.3575
TE(-1)	0.179069	0.082803	2.162579	0.0498
TE(-2)	-0.216826	0.085452	-2.537392	0.0248
TE(-3)	0.111309	0.058710	1.895889	0.0804
HC	0.176449	0.071039	2.483833	0.0274
HC(-1)	-0.084564	0.067612	-1.250727	0.2331
HC(-2)	-0.104035	0.068077	-1.528207	0.1504
HC(-3)	-0.181785	0.068253	-2.663400	0.0195
C	-4.562569	12.44881	-0.366506	0.7199
"R-squared"	0.960200			
"Adjusted R-squared"	0.908154			
"F-statistic"	18.44905			
"Prob(F-statistic)"	0.000002			

Source: Researcher's computation, 2024.

Table 7. ShortRun Results

ECM Results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	-4.562569	0.642239	-7.104162	0.0000
D(AP(-1))	-0.329744	0.140750	-2.342753	0.0357
D(GF)	0.084252	0.034897	2.414295	0.0312
D(GF(-1))	-0.158309	0.119669	-1.322897	0.2087
D(GF(-2))	-0.242240	0.125576	-1.929036	0.0758
D(FD)	-0.626411	0.129787	-4.826446	0.0003
D(FD(-1))	-0.725268	0.145892	-4.971265	0.0003
D(TE)	-0.051365	0.040979	-1.253442	0.2321
D(TE(-1))	0.105517	0.045576	2.315184	0.0376
D(TE(-2))	-0.111309	0.043446	-2.561975	0.0237
D(HC)	0.176449	0.052613	3.353695	0.0052
D(HC(-1))	0.285820	0.056924	5.021075	0.0002
D(HC(-2))	0.181785	0.044117	4.120541	0.0012
ECT_{t-1}	-0.586282	0.100491	-5.834151	0.0001
"R-squared"	0.857379			
"Adjusted R-squared"	0.748316			
"F-statistic"	7.861307			
"Prob(F-statistic)"	0.000078			

Source: Researcher's computation, 2024.

This shows that while there are fluctuations, they are not extreme, implying relative stability in agricultural productivity over time. Green financing (GF) exhibits significant variability, with a mean of 87.67 and a standard deviation of 8.09, reflecting substantial shifts in green financing over time. Again, variation suggests that the availability of green finance has fluctuated widely, potentially impacting agricultural productivity.

Technological innovation (TE) and human capital (HC) both have relatively high mean values of 33.03 and 15.32, respectively, showing their potential contributions to agricultural productivity. However, the large standard deviation in technological innovation (34.85) indicates that technological advancements have been uneven across the sample period. In contrast, financial development (FD) has the lowest mean of 9.25 and a standard deviation of 4.18, suggesting lower levels of financial sector development relative to the other variables.

CorrelationsAnalysis Results: The correlation analysis, as presented in Table 3, provides key insights into the relationships between the study's variables. There is a positive correlation (0.3797) betwixt agricultural production (AP) and green financing (GF), suggesting that an increase in green financing is associated with improvements in agricultural productivity. This finding is concurred with the Keynesian growth theory, which postulate that financial interventions can enhance economic productivity. Conversely, financial development (FD), technological innovation (TE), and human capital (HC) show weaker, negative correlations with AP, implying that these variables have limited direct influence on agricultural productivity in the current context. For instance, FD has a correlation coefficient of -0.3561, indicating that financial development may not yet be sufficiently advanced to positively influence agricultural productivity. These findings underscore the call for further investigation into how these variables interact in the Tanzanian economy, where institutional capacity may limit the benefits of financial and technological advancements.

Unit Root Results: The PP results, as shown in Table 4, reveal that the variables have mixed orders of integration. Agricultural production (AP), green financing (GF), financial development (FD), technological innovation (TE), and human capital (HC) are integrated at both I(1) and I(0), confirming that they follow a mixed integration pattern. Specifically, AP and HC are stationary at the first difference, while GF and TE show stationarity at both levels. Given these mixed integration orders, the application of the ARDL model is appropriate to avoid spurious regression results. This approach aligns with previous studies (Likius, 2024; Tursoy& Simbarashe, 2021), which also employed ARDL to address similar data characteristics in their respective analyses of agricultural productivity in the USA and Namibia.

Bound Cointegration Results: The Bound cointegration test results, presented in Table 5, confirm a significant long-term association between agricultural production (AP), green financing (GF), financial development (FD), technological innovation (TE), and human capital (HC). The computed F-statistic exceeds the critical upper bound values at all conventional significance levels (1%, 2.5%, 5%, and 10%), hence null hypothesis of no cointegration is rejected. This indicates the presence of a long-term equilibrium relationship, supporting the notion that green financing, financial development, technological innovation, and human capital can drive improvements in agricultural productivity in Tanzania. The findings are in line with those of Zakaria *et al.* (2019), Tursoy and Simbarashe (2021), and Chandio (2022), who also identified similar cointegrating relationships in studies conducted in South Asia, the USA, and China. The empirical evidence underscores the importance of enhancing green financing, developing financial sectors, and fostering innovation and human capital to achieve sustained agricultural growth in Tanzania.

Long Run Results: Table 6 presents the long-run coefficients, demonstrating the impact of green financing, financial development, technology, and human capital on agricultural production in Tanzania. In the long run, agriculture production in the previous year, current green financing, past financial development, previous year technology, and current human capital positively impact agricultural productivity, with coefficients of 0.083974%, 0.084252%, 0.174556%, 0.179069%, and 0.176449%, respectively. This suggests that investments in these areas yield gradual but significant improvements in agricultural output over time. Interestingly, financial development in the current year has a negative influence on agricultural production, reducing it by 0.626411%, which is statistically significant at the 5% level. Similarly, current technological innovation negatively affects productivity by 0.051365%, though this result is statistically insignificant. These findings imply that the benefits of financial development and technological improvements are not immediately apparent in agricultural productivity and might require longer adjustment periods or complementary policy measures to be fully realized.

Short Run Results: In the short run, green financing, technology from the previous year, and human capital significantly and positively influence agricultural production. These results are statistically significant at the 5% level. However, the impact of agriculture in the previous year and financial development on current agricultural production is negative, with both showing statistically significant effects. The error correction term (ECT) is also statistically significant at the 5% level, suggesting that 58.6% of the disequilibrium from any short-term shock adjusts toward long-term equilibrium annually. This supports the cointegration results from Table 5, indicating that the variables under study tend to converge towards long-run equilibrium after economic shocks. These findings underscore the importance of government prioritizing investment in green financing, financial development, technological innovations, and human capital to enhance agricultural productivity in Tanzania.

DISCUSSION

The empirical results reveal a multiplex relationship between green financing, financial development, technological innovation, and human capital on agricultural productivity in Tanzania. Green financing contributes significantly to agricultural production, giving back the positive influencein environmentally sustainable investments on economic activities within the sector. This finding is consistent with prior studies conducted in various economies, including China (Qin *et al*., 2024; Li *et al*., 2023; Mo *et al*., 2023; Gao *et al*., 2022). In Tanzania, government investments in green financing not only support environmentally responsible initiatives but also drive agricultural output by enabling access to sustainable technologies and practices. Similarly, financial development plays a critical role in influencing growth of economy, particularly in the agricultural sector. This finding aligns with previous research (Adabor & Essah, 2024; Magazzino & Santeramo, 2023; Chandio, 2022; Hong *et al*., 2022), which demonstrates a positive effect of financial development on agricultural productivity in countries such as China, Ghana, and the USA. However, in the Tanzanian context, financial development negatively impacts agricultural production in the short run. This counterintuitive result may be imputed to the limited access to affordable credit for smallholder farmers, the dominant actors in Tanzania's agricultural sector. Inadequate financial inclusion may hinder their ability to invest in necessary inputs and innovations, thus suppressing productivity. Technological innovation and human capital are crucial drivers of agricultural productivity, as demonstrated by the findings of Owuor (2022) and Zakaria *et al*. (2019), who found that technological advancement and skilled labor positively influence agricultural outputs in Uganda and South Asia, respectively. In Tanzania, similar dynamics are observed, where technological adoption and improved human capital boost productivity by enhancing efficiency, crop yields, and resource management. These findings support the Keynesian and endogenous growth theories, emphasizing the importance of government investment in green financing, financial development, technological innovation, and human capital to stimulate agricultural growth and overall economic performance.

In the short run, green financing, technological innovation, and human capital significantly and positively effect agricultural productivity. These results mirror the findings of Mapanje *et al*. (2023), Ye *et al*. (2022), and Zakaria *et al*. (2019), who demonstrated similar effects in China and South Asia. Conversely, financial development exhibits a negative short-term impact on agricultural production, suggesting the need for more targeted financial policies to ensure credit accessibility for the agricultural sector. The error correction term further confirms the long-term equilibrium association ship, underscoring the importance of sustained policy interventions to enhance agricultural productivity.

CONCLUSION AND RECOMMENDATIONS

This study examined the interplay between green financing, financial development, technological innovation, human capital, and agricultural production in Tanzania from 1990 to 2023, employing time series analysis and ARDL technique. The analysis revealed a mix of short- and long-run relationships among the variables. While green financing, technological innovation, and human capital positively influence agricultural production in both the short and long term, financial development adversely affects agricultural productivity in the short run but shows potential for positive long-term impact as access to credit improves. The findings suggest that policymakers should prioritize fiscal policies that increase government spending on green financing, technology, and human capital development to enhance agricultural productivity. Likewise, monetary policies should focus on enhancing access to domestic credit for agricultural enterprises, especially for smallholder farmers, to unlock the sector's full potential.Additionally, financial sector reforms should focus on directing more credit to the agricultural sector to improve input availability and promote sustainable agricultural growth in Tanzania. The current study suggest that future research should examine the impact of green financing and financial development on other economic sectors beyond agriculture to provide a more comprehensive understanding of these variables' role in Tanzania's broader economic growth. Cross-sectional analyses across different regions and industries could offer deeper insights for policymakers and practitioners seeking to optimize sustainable economic development strategies.

Conflict of interest declaration: None

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GLOSSARY OF ABBRIAVITIONS

AP: Agricultural Product
ARDL: Autoregressive Distributed Lag
ECT: Error Correction Term

FD: Financial Development
GDP: Gross Domestic Product
GF: Green Financing
HC: Human Capital
JICA: Japan International Cooperation Agency
PP: Phillips-Perron
TE: Technological Innovations

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