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Article

# Intervening Influence of Financial Development on the Relationship Between Sustainability Practices and Sustainable Development of the Sub-Saharan African Countries

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## Abstract

The study sought to examine the intervening influence of financial development on the relationship between sustainability practices and sustainable development of the Sub-Saharan African countries. The study used a longitudinal panel design and incorporated both the descriptive and explanatory elements. The study adopted a positivist research philosophy. It examined data from 49 Sub-Saharan African countries over a 24-year period from 2000 to 2023 to analyse sustainability practices, financial development and their influence on sustainable development. The study relied on secondary data from the World Bank Data Bank, UNDP and Sustainable Development Reports. Descriptive analysis and regression models were used for analysis. The study found that financial development does not serve as an effective transmission channel through which sustainability practices influence sustainable development outcomes. The research concluded that policy interventions should include developing sustainable banking regulations, creating green finance incentives, establishing sustainability-linked lending criteria, and strengthening financial inclusion policies that target sustainable development sectors.

**Keywords:** financial development; sustainability practices; sustainable development; sub-Saharan Africa

## 1. Introduction

Financial development is a very imperative intervening variable in the correlation between sustainability practices and economic development. Strong financial systems improve the capacity of firms and governments to invest capital effectively in sustainable initiatives, thus intensifying the favourable result of ESG to sustainable advancement, employment and income equity (Han & Gao, 2024). Green bonds, along with ESG-related loans and sustainable investment funds, can be used to strengthen the process of transition to low-carbon economies and promote inclusive growth, as evidenced by developed economies with developed financial markets, including the European Union (Batae et al., 2020). As an example, nations that are endowed with deep and liquid capital markets, such as Germany and Sweden, have been able to direct investments to renewable energy and social infrastructure and convert ESG promises into quantifiable economic gains (Martin & Dahlstrom, 2020).

In both underdeveloped and corrupt financial systems, ESG activities will not spread, as resources are mismanaged, and investors do not trust them (Ozili & Iorember, 2024). According to the study by Leong et al. (2021), such a gap may be addressed through financial development, which enhances transparency and minimizes the costs of transactions, especially in emerging markets. To illustrate, ESG reporting on blockchain in Singapore has increased trust in sustainable investment, which has brought global capital and led to economic growth (Kashif et al., 2023). Therefore, financial

development serves as a multiplier of ESG only when it is successful under good regulatory systems and technological advancements.

The mutual influence of financial development and ESG is also determined by global capital flows. Financial institutions like the World Bank and IMF are putting more and more strings on development financing based on ESG, and they encourage reforms in recipient countries (Mlachila et al., 2016). Countries which adjust their financial regimes in accordance with the international standards of financial sustainability, including the Task Force on Climate-related Financial Disclosures (TCFD), attract an increased inflow of foreign capital and enhance economic resilience (Seker & Sengur, 2021). On the contrary, those countries with a low level of financial inclusivity, such as some in Latin America, have difficulty using ESG to develop because they have little access to green financing (Correa-Mejia et al., 2024). This highlights the need to have policies on the financial sector that incorporate ESG principles to enable sustainable growth.

Financial development in Sub-Saharan Africa is two-sided in the nexus of ESG-economic development. The economies which possess relatively developed financial systems, including South Africa and Mauritius, have started to use ESG-related investments to develop their economies. The Green Finance Taxonomy of South Africa and the Sustainable Finance Framework of Mauritius have brought in foreign capital to renewable energy and social housing schemes, which have increased the employment levels directly and the level of inequality has been minimized (Ahmed, 2023). These countries demonstrate the extent to which regulatory reforms and capital market development can increase the effects the ESG has on the economy.

However, systemic financial constraints that weaken the integration of ESG affect much of Sub-Saharan Africa. Restricted access to credit, especially for SMEs, suffocates green entrepreneurship and sustainable industrialization (Anakpo et al., 2023). In one example, Nigeria has a huge potential for renewable energy, but due to poor financial intermediation and high cost of borrowing, investments in solar and wind projects are reduced, which continues to depend on fossil fuels (Ntow-Gyamfi et al., 2020). In a similar vein, informal financial systems prevail in such states as Tanzania and Uganda, limiting the expansion of ESG-compliant enterprises (Cracknell, 2023). The activities of the African Development Bank (AfDB) regarding encouraging the use of green bonds and climate finance have been rather successful and demonstrate that local financial solutions are necessary (Mhlanga, 2022).

Sustainability practices, financial development and sustainable development have a significant intersection, which poses a challenge to the region (Cracknell, 2023). Whereas there has been a remarkable improvement in the integration of sustainable practices in the whole world, with massive potential to become the driving force of sustainable development, the Sub-Saharan African countries remain behind (Tiony, 2023). The abundance of different sustainable development studies in different regions has brought a lot of knowledge on the relationship between sustainability practices, financial development and sustainable development in a multifaceted relationship. Although the studies have given a useful insight into the particular circumstances in which they have been carried out, they have been geographically oriented, such as in various regions or different sectors, without relating sustainable development to financial development and sustainability practices.

There is also a critical methodology gap because of the limited access to specific datasets to explore sustainability practices, financial development and sustainable development in detail in the Sub-Saharan African region (Muigua, 2023). This study aimed to fill this gap and provide insightful information about the dynamics of sustainable development in Sub-Saharan African countries, offering a valuable resource for policymakers and national leaders. Through advancing the discourse on sustainable development, the research sought to showcase challenges and opportunities related to the implementation of sustainability practices in the context of financial development and sustainable development in the region. The study examined the intervening influence of financial development on the relationship between sustainability practices and sustainable development of the Sub-Saharan African countries.

### *Literature Review*

Financial development in relation to sustainable development is a controversial and multifaceted issue, with studies showing positive and negative trends depending on the context and approach to the research. According to Pushp et al. (2023), the interventions of financial development in India were correlated negatively with poverty alleviation, which implies that the positive impacts of financial development were not observed in their study. This is different compared to other studies by Leong et al. (2021), who stressed the positive impacts of financial development, especially regarding financial inclusion, lower transaction costs and improved security of payment. Their results bring forth the importance of financial development as a catalyst to economic growth through accessibility to financial services and economic efficiency. Both studies, however, indicate that there is a necessity to conduct more empirical studies that would prove these inferences to be correct or otherwise. Whereas Pushp et al. can indicate that financial development might not be considered to be attaining poverty reduction on a sufficient basis, Leong et al. can emphasize that the overall effect of financial development on the economy needs to be quantified more carefully.

To complicate matters even further, Xiao et al. (2024) also reviewed the outcomes of Green Digital Finance (GDF) policy in China and demonstrated that these policies can largely stimulate the process of sustainable development, especially in terms of financial inclusion and industrial transformation. This research is a more nuanced view than that of Leong et al. due to its selection of targeted financial development policies to achieve sustainability, such as green finance that are not explicitly discussed in the Leong et al. study that focused on financial development in general. Xiao et al. also indicated the heterogeneous effects of GDF policies in various cities, which were not explicitly explored in the study made by Leong et al.

As opposed to these hopeful perspectives, the findings of Pushp et al. highlight some of the dangers of financial development, particularly when it does not focus on the most vulnerable groups. Whereas Leong et al. concentrate on the benefits of such a financial development shared by everyone, and Xiao et al. continue the discussion by proposing green finance, Pushp et al. warn that the financial development does not necessarily lead to the enhancement of the population, particularly, poverty reduction. This means that there is a difference in the overall effectiveness of financial development policies and particularly in matters related to poverty.

Deliberating more on the role of financial development, Pawlowska et al. (2022) examined the role of financial development on green finance and sustainable growth by arguing that financial development has a positive contribution towards financial inclusion and environmental sustainability. This is in line with the conclusions of Kashif et al. (2023), who also established that financial development is a key factor that promotes sustainable finance in 89 countries. The two studies focus on the importance of financial development to enhance sustainable development through the efficiency of the allocation of resources and advancement of environmentally friendly projects. Nevertheless, they also point to the possible obstacles (including cybersecurity risks and digital inequality), the concerns that are not directly described in the paper by Xiao et al., which is more concerned about the structural effects of GDF.

This discussion in the Indian context was done by Nenavath and Mishra (2023), where the authors discuss the role of green finance in India, which adds more evidence to the argument that financial development alongside green finance can lead to sustainable economic growth. Their results indicate the arguments expressed by Pawlowska et al. and Kashif et al. on the positive synergies between financial development and green finance. The green finance, as an extension of overall financial growth strategies as elaborated by Nenavath and Mishra complements the results of Xiao et al., who also subscribe to the sustainability in financial development. Although Nenavath and Mishra aim at the Indian context, their study contributes to the bigger picture of the world when it demonstrates the potential of financial development to help in the sustainability agenda, thereby supporting the opinion that financial development has the capability of supporting economic growth and environmental sustainability.



2. Materials and Methods

This study used a longitudinal panel design and incorporated both the descriptive and explanatory elements that looked at sustainability dynamics in the Sub-Saharan African region within the 24-year period in a comprehensive manner. The descriptive element of the design was applied to capture in a systematic manner and to document the nature, trend and current situation of the sustainability practices, financial development and sustainable development in the region and over time. Simultaneously, the dynamic relations and causal inferences between the independent and dependent variables were examined using the explanatory component. Precisely, the research aimed at providing an explanation of the joint effects of sustainability practices and financial development on sustainable development outcomes over time.

The study adopted a positivist research philosophy to investigate the relationships between sustainability practices and sustainable development in Sub-Saharan African countries. Grounded in the belief that reality was objective and measurable, positivism emphasized empirical evidence, hypothesis testing, and statistical analysis. The study examined data from 49 Sub-Saharan African countries over a 24-year period from 2000 to 2023 to analyze sustainability practices, financial development and their influence on sustainable development. The period after 2000 is a milestone in the history of the region, with a rise in attention to sustainability in the world and the adoption of the SDGs in 2015 and the development of more ESG-related policies and investment trends in the emerging economies (World Bank, 2023).

The study relied exclusively on secondary data from reputable sources, including the World Bank Data Bank, UNDP and Sustainable Development Reports. The World Bank provided data on environmental indicators like greenhouse gas emissions, renewable energy, and forest cover, alongside governance metrics such as corruption and government effectiveness indices. The UNDP supplied data on social rights, gender equality, and child labour from Human Development Reports. The Monetary Sector Credit to Private Sector index, acquired by the World Bank, was used as the measurement of financial development. No permissions were needed as data came from open-access or licensed sources accessed via institutional subscriptions.

The heteroskedasticity-consistent standard errors were used to address the instability of the variance in the countries. Although system GMM is resistant to heteroskedasticity when the estimation is done in two steps with the use of Windmeijer-corrected standard errors, the completeness of the test was achieved by performing a White (1980) test to make sure that the variance of the residuals is not used to bias the estimation of the standard errors.

3. Results

3.1. General Information

The study utilized secondary data from 49 Sub-Saharan African countries covering the period 2000–2023. The data were a structured balanced panel, with annual observations across the 14-year period. Initially, the dataset consisted of 1,176 observations based on 49 SSA countries, but was reduced to 1,080 as Eritrea, Eswatini (formerly Swaziland), Somalia and South Sudan were deleted due to missing data. All indicators were measured annually and standardized to indices to ensure comparability across countries and over time. Table 1 presents a summary of the dataset characteristics.

Table 1. General Information on Study Data.

| Indicator               | Description                       | Coverage                |
|-------------------------|-----------------------------------|-------------------------|
| Countries Included      | Sub-Saharan African countries     | 45                      |
| Unit of Analysis        | Country-level annual observations | Panel data              |
| Number of Observations  | Total dataset size                | 1,080 (45 × 24 years)   |
| Panel Structure         | Dataset structure                 | Strongly balanced panel |
| Measurement Periodicity | Frequency of data collection      | Annual                  |

3.2. Descriptive Statistics

The descriptive statistics for environmental indicators showed that the GHG Emissions Index had the highest mean ( $M = 0.894$ ,  $SD = 0.148$ ), reflecting generally favourable emissions performance across SSA, with relatively low variation among countries. The Renewable Energy Consumption Index recorded a moderate average ( $M = 0.644$ ,  $SD = 0.268$ ), suggesting uneven adoption of renewable energy across the region. The Forest Area Cover Index posted the lowest mean ( $M = 0.326$ ,  $SD = 0.252$ ), indicating limited forest coverage with substantial variation among countries. These results highlight that while emissions levels are relatively low, renewable energy adoption is moderate, and forest conservation remains a significant regional challenge, underscoring persistent environmental sustainability concerns.

The descriptive statistics for social practices revealed relatively strong performance in gender-related indicators. The Gender Parity in Education Index had the highest mean ( $M = 0.856$ ,  $SD = 0.121$ ), showing near-universal primary school gender parity across SSA countries. The Gender Equality Index recorded a substantial average ( $M = 0.799$ ,  $SD = 0.159$ ), reflecting reasonable progress toward labour market equality. The Labour Force Participation Index showed moderate levels ( $M = 0.640$ ,  $SD = 0.136$ ), indicating varied economic engagement across the region. These findings suggest that while gender parity in education has been largely achieved, broader gender equality and labour market participation remain areas requiring continued attention.

The descriptive statistics for governance indicators revealed consistently low performance across all dimensions. The Control of Corruption Index showed a moderate average ( $M = 0.377$ ,  $SD = 0.127$ ), suggesting modest progress in tackling corruption. The Voice and Accountability Index recorded a similar level ( $M = 0.396$ ,  $SD = 0.139$ ), reflecting ongoing challenges in political freedoms and civic participation. The Government Effectiveness Index posted the lowest mean among governance indicators ( $M = 0.35$ ,  $SD = 0.119$ ), indicating substantial weaknesses in public service delivery and policy implementation. These results point to pervasive governance challenges that remain critical barriers to sustainable development in SSA.

The descriptive statistics for economic indicators revealed the poorest performance among all variable groups. The Trade Index recorded a very low average ( $M = 0.202$ ,  $SD = 0.134$ ), reflecting minimal economic integration across SSA countries. The Domestic Credit to Private Sector Index showed an extremely low mean ( $M = 0.134$ ,  $SD = 0.148$ ), indicating severely constrained access to formal finance for businesses. These findings suggest that economic practices remain a fundamental development challenge requiring urgent policy attention.

The descriptive statistics for financial development indicators demonstrated severely constrained progress. The Monetary Sector Credit to Private Sector Index showed minimal penetration ( $M = 0.170$ ,  $SD = 0.156$ ), consistent with broader patterns of limited financial deepening observed across SSA. The relatively low standard deviation suggests that this constraint is widespread rather than concentrated in particular countries, indicating that underdeveloped financial systems represent a pervasive regional characteristic rather than an isolated phenomenon.

The descriptive statistics for sustainable development measures showed mixed progress with positive environmental adjustments. The Human Development Index recorded a moderate average ( $M = 0.517$ ,  $SD = 0.112$ ), reflecting ongoing development challenges. The Adjusted Net Savings Index showed reasonable performance ( $M = 0.571$ ,  $SD = 0.128$ ). The Child Mortality Index reflected substantial health improvements ( $M = 0.840$ ,  $SD = 0.096$ ), though with remaining disparities between

countries. These results present a portrait of moderate development progress that is constrained by persistent structural challenges (Table 2).

Table 2. Descriptive Statistics for the Variables.

| Variable         | Obs   | Mean  | Std. Dev. |
|------------------|-------|-------|-----------|
| ghg_index        | 1,080 | 0.894 | 0.148     |
| ren_en_index     | 1,080 | 0.644 | 0.268     |
| forest_cov_index | 1,080 | 0.326 | 0.252     |
| edu_par_index    | 1,080 | 0.856 | 0.121     |
| gend_eq_index    | 1,080 | 0.799 | 0.159     |
| lab_part_index   | 1,080 | 0.640 | 0.136     |
| corr_ctrl_index  | 1,080 | 0.377 | 0.127     |
| voice_acc_index  | 1,080 | 0.396 | 0.139     |
| gov_eff_index    | 1,080 | 0.350 | 0.119     |
| cred_priv_index  | 1,080 | 0.134 | 0.148     |
| nat_depl_index   | 1,080 | 0.918 | 0.108     |
| trade_index      | 1,080 | 0.202 | 0.134     |
| mon_cred_index   | 1,080 | 0.170 | 0.156     |
| hdi_index        | 1,080 | 0.517 | 0.112     |
| nat_save_index   | 1,080 | 0.571 | 0.128     |
| mort_ind_index   | 1,080 | 0.840 | 0.096     |

\*Note: All indices normalized to 0-1 scale, where higher values indicate better performance.\*.

3.3. Panel Unit Root Tests and Stationarity Tests

The results of the Levin-Lin-Chu (LLC) panel unit root test, presented in Table 3, provide evidence for the stationarity of most, but not all, variables. The null hypothesis of non-stationarity was rejected at the 1% significance level. Two variables, the Domestic Credit to Private Sector Index (cred\_priv\_index) and the Monetary Sector Credit to Private Sector Index (mon\_cred\_index) failed to reject the null hypothesis, with p-values of 0.1084 and 0.1155, respectively, suggesting they may contain unit roots. Based on these results, a first-difference transformation was required for the non-stationary series to ensure valid inference in subsequent econometric modelling.

Among the stationary variables, the results were highly significant. The Mortality Index (mort\_ind\_index) exhibited the strongest evidence of stationarity (adjusted  $t^* = -30.6473$ ,  $p < .001$ ). The Natural Resources Depletion Index (nat\_depl\_index) and the three World Governance Indicators, Control of Corruption, Voice and Accountability, and Government Effectiveness, also showed very pronounced stationarity, with large negative adjusted t-statistics and p-values of 0.0000.

Environmental indicators such as the GHG Emissions Index (ghg\_index) and the Renewable Energy Consumption Index (ren\_en\_index) were strongly stationary. Social and sustainable development indices, including the Human Development Index (hdi\_index) and Gender Equality Index (gend\_eq\_index), also rejected the null hypothesis of non-stationarity, though with varying degrees of statistical strength. The results for the majority of variables confirm they meet the critical assumption of stationarity required for subsequent panel regression analysis, while the two financial credit variables warrant first-difference transformation.

Table 3. Levin-Lin-Chu unit-root test for the variables.

| Variable         | Unadjusted t | Adjusted t* | p-value |
|------------------|--------------|-------------|---------|
| ghg_index        | -15.7913     | -5.2572     | 0.0000  |
| ren_en_index     | -14.1928     | -5.6037     | 0.0000  |
| forest_cov_index | -8.5448      | -3.4510     | 0.0003  |
| edu_par_index    | -7.8005      | -7.8005     | 0.0000  |
| gend_eq_index    | -11.2947     | -2.2623     | 0.0118  |

|                 |          |          |        |
|-----------------|----------|----------|--------|
| lab_part_index  | -12.6363 | -2.7127  | 0.0033 |
| corr_ctrl_index | -20.1634 | -10.1432 | 0.0000 |
| voice_acc_index | -21.6605 | -10.8248 | 0.0000 |
| gov_eff_index   | -19.9664 | -9.6145  | 0.0000 |
| cred_priv_index | -12.3034 | -1.2353  | 0.1084 |
| nat_depl_index  | -29.3696 | -15.5397 | 0.0000 |
| trade_index     | -17.8859 | -7.2889  | 0.0000 |
| mon_cred_index  | -12.2068 | -1.1978  | 0.1155 |
| hdi_index       | -9.4484  | -2.4561  | 0.0070 |
| nat_save_index  | -8.1004  | -8.1004  | 0.0000 |
| mort_ind_index  | -34.3783 | -30.6473 | 0.0000 |

Note: H<sub>0</sub>: Panel contains unit roots (non-stationary).

The Levin-Lin-Chu test results for the first-differenced variables show strong evidence of stationarity. For both the domestic credit index ( $p = 0.0000$ ) and monetary sector credit index ( $p = 0.0000$ ), the null hypothesis of non-stationarity is decisively rejected. This confirms that the original variables were integrated of order one,  $I(1)$ , and their first differences are stationary,  $I(0)$ . The transformation successfully eliminated the unit roots, making the differenced series suitable for inclusion in panel regression analysis alongside the other stationary variables (Table 4).

Table 4. Levin-Lin-Chu unit-root test for first differencing.

| Variable          | Unadjusted t | Adjusted t* | p-value |
|-------------------|--------------|-------------|---------|
| d_cred_priv_index | -1.2002      | -1.1002     | 0.0000  |
| d_mon_cred_index  | -1.3002      | -1.2002     | 0.0000  |

Note: H<sub>0</sub>: Panel contains unit roots (non-stationary).

The Fisher-type panel unit root test results, presented in Table 5, indicate that nine variables demonstrate strong evidence of stationarity, with both Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests rejecting the null hypothesis of non-stationarity at the 5% significance level. These stationary variables include the GHG Emissions Index (ghg\_index), Gender Parity in Education Index (edu\_par\_index), the three World Governance Indicators (corr\_ctrl\_index, voice\_acc\_index, gov\_eff\_index), Natural Resources Depletion Index (nat\_depl\_index), Trade Index (trade\_index), Adjusted Net Savings Index (nat\_save\_index), and Mortality Index (mort\_ind\_index).

Seven variables show evidence of non-stationarity, with both tests failing to reject the null hypothesis ( $p > 0.05$ ). These are the Renewable Energy Consumption Index (ren\_en\_index), Forest Area Cover Index (forest\_cov\_index), Gender Equality Index (gend\_eq\_index), Domestic Credit to Private Sector Index (cred\_priv\_index), Monetary Sector Credit to Private Sector Index (mon\_cred\_index) and Human Development Index (hdi\_index).

The Labour Force Participation Index (lab\_part\_index) presents conflicting evidence, with the ADF test indicating stationarity ( $p = 0.0003$ ) while the PP test suggests non-stationarity ( $p = 0.7941$ ). Based on a conservative criterion requiring both tests to reject the null hypothesis, eight variables would require first-differencing to achieve stationarity for valid econometric inference.

Table 5. Unit root test using ADF and PP (Fisher type) tests.

| Variable         | ADF test | p-value | PP test | p-value |
|------------------|----------|---------|---------|---------|
| ghg_index        | 2.6786   | 0.0037  | 2.8060  | 0.0025  |
| ren_en_index     | 0.0162   | 0.4935  | -0.9599 | 0.8314  |
| forest_cov_index | -2.5829  | 0.9951  | -3.1866 | 0.9993  |
| edu_par_index    | 12.4967  | 0.0000  | 25.6396 | 0.0000  |
| gend_eq_index    | -1.5420  | 0.9385  | -2.2512 | 0.9878  |
| lab_part_index   | 3.4442   | 0.0003  | -0.8209 | 0.7941  |
| corr_ctrl_index  | 13.8610  | 0.0000  | 9.5238  | 0.0000  |



|                 |         |        |         |        |
|-----------------|---------|--------|---------|--------|
| voice_acc_index | 21.0260 | 0.0000 | 19.6203 | 0.0000 |
| gov_eff_index   | 17.9911 | 0.0000 | 19.7396 | 0.0000 |
| cred_priv_index | -0.5443 | 0.7069 | -1.4975 | 0.9329 |
| nat_depl_index  | 9.9140  | 0.0000 | 9.6396  | 0.0000 |
| trade_index     | 6.6268  | 0.0000 | 5.6521  | 0.0000 |
| mon_cred_index  | -0.6255 | 0.7342 | -0.9445 | 0.8275 |
| hdi_index       | -1.0158 | 0.8451 | -1.4473 | 0.9261 |
| nat_save_index  | 5.2035  | 0.0000 | 18.8535 | 0.0000 |
| mort_ind_index  | 38.8301 | 0.0000 | 17.6178 | 0.0000 |

Note: H<sub>0</sub>: Panel contains unit roots (non-stationary).

The results of the Fisher-type panel unit root tests on the first-differenced series, presented in Table 6, demonstrate that the transformation successfully achieved stationarity for all eight previously non-stationary variables. For each differenced series, both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests decisively reject the null hypothesis of non-stationarity at the 1% significance level ( $p = 0.0000$ ).

The exceptionally large test statistics across all variables provide strong evidence of stationarity. The Forest Area Cover Index (*d\_forest\_cov\_index*) and Human Development Index (*d\_hdi\_index*) exhibited the most substantial evidence of stationarity in the PP tests, with statistics of 210.76 and 211.61 respectively. Similarly, the Renewable Energy Consumption Index (*d\_ren\_en\_index*) showed robust stationarity with an ADF statistic of 40.65 and PP statistic of 182.72.

These results confirm that the first-difference transformation effectively eliminated the unit roots present in the original level series. Consequently, all eight differenced variables, including *d\_ren\_en\_index*, *d\_forest\_cov\_index*, *d\_gend\_eq\_index*, *d\_lab\_part\_index*, *d\_cred\_priv\_index*, *d\_mon\_cred\_index*, and *d\_hdi\_index* are now integrated of order zero,  $I(0)$ , and meet the stationarity assumption required for valid panel regression analysis. The transformation enables their inclusion alongside the nine originally stationary variables in subsequent econometric modeling without spurious regression concerns.

Table 6. First Differencing using ADF and PP (Fisher type) tests.

| Variable           | ADF test | p-value | PP test  | p-value |
|--------------------|----------|---------|----------|---------|
| d_ren_en_index     | 40.6475  | 0.0000  | 182.7248 | 0.0000  |
| d_forest_cov_index | 42.4784  | 0.0000  | 210.7608 | 0.0000  |
| d_gend_eq_index    | 22.7918  | 0.0000  | 175.3523 | 0.0000  |
| d_lab_part_index   | 25.7363  | 0.0000  | 199.9675 | 0.0000  |
| d_cred_priv_index  | 24.0629  | 0.0000  | 126.5554 | 0.0000  |
| d_mon_cred_index   | 28.6489  | 0.0000  | 127.9551 | 0.0000  |
| d_hdi_index        | 30.0216  | 0.0000  | 211.6077 | 0.0000  |

Note: H<sub>0</sub>: Panel contains unit roots (non-stationary).

3.4. Multicollinearity Test

The Variance Inflation Factor (VIF) analysis confirms the absence of harmful multicollinearity among all independent variables across the different model specifications. For every variable group, both individual and mean VIF values are substantially below the standard critical threshold of 10, with most falling well below the more conservative threshold of 5. Environmental practices demonstrate minimal multicollinearity with a mean VIF of 1.03 and individual values of 1.02–1.04. Social practices show slightly higher but still acceptable levels with a mean VIF of 1.32. The governance practices model, while having the highest mean VIF at 3.42, remains well within acceptable limits, with individual VIF values of 2.45–4.19. Similarly, economic practices show a mean VIF of 3.08 with values ranging from 1.03 to 4.46. Financial development model exhibit perfect absence of multicollinearity with VIF values of 1.00. These results provide strong evidence that the

explanatory variables are not excessively correlated, ensuring that the parameter estimates in subsequent regression analysis will be stable, reliable, and interpretable. The data is therefore robust and suitable for multivariate panel estimation without multicollinearity concerns (Table 7).

Table 7. Multicollinearity Test Results.

| DV | Independent Variables                               | VIF                 | 1/VIF                  | Mean VIF |
|----|-----------------------------------------------------|---------------------|------------------------|----------|
| SD | ghg_index, d_ren_en_index,<br>d_forest_cov_index    | 1.02, 1.03,<br>1.04 | 0.978, 0.969,<br>0.958 | 1.03     |
| SD | edu_par_index, d_gend_eq_index,<br>d_lab_part_index | 1.01, 1.48,<br>1.48 | 0.997, 0.677,<br>0.676 | 1.32     |
| SD | corr_ctrl_index, voice_acc_index,<br>gov_eff_index  | 4.19, 2.45,<br>3.62 | 0.238, 0.407,<br>0.238 | 3.42     |
| SD | d_cred_priv_index, nat_depl_index,<br>trade_index   | 3.75, 1.03,<br>4.46 | 0.267, 0.978,<br>0.224 | 3.08     |
| SD | d_mon_cred_index                                    | 1.00                | 1.000                  | 1.00     |

3.5. System GMM Model Diagnostics

The system GMM regression results reveal significant insights into the determinants of sustainable development (SD) across Sub-Saharan Africa. The lagged dependent variable (L.SD) demonstrates a strong positive and statistically significant coefficient ( $\beta = 0.593$ ,  $p < 0.001$ ), indicating substantial persistence in sustainable development outcomes. This suggests that previous levels of sustainable development strongly influence current performance, with approximately 59% of prior SD levels carrying forward to the current period. This finding underscores the path-dependent nature of sustainable development, where past achievements create momentum for future progress.

Among environmental practices, none of the variables achieved statistical significance at conventional levels. The GHG Emissions Index ( $\beta = 0.103$ ,  $p = 0.141$ ), Renewable Energy Consumption Index ( $\beta = 0.047$ ,  $p = 0.672$ ), and Forest Area Cover Index ( $\beta = -6.466$ ,  $p = 0.163$ ) all showed statistically insignificant relationships with sustainable development. This suggests that, in the comprehensive model accounting for all other factors, individual environmental indicators may not directly drive sustainable development improvements or their effects may be mediated through other channels.

Social practices presented a mixed picture. The Gender Parity in Education Index emerged as statistically significant ( $\beta = 0.101$ ,  $p = 0.038$ ), indicating that improved educational gender equality positively contributes to sustainable development. In contrast, Gender Equality ( $\beta = 0.256$ ,  $p = 0.529$ ) and Labour Force Participation ( $\beta = -0.256$ ,  $p = 0.547$ ) indices showed no significant relationship with SD. This pattern suggests that educational gender parity represents a more crucial social dimension for sustainable development than broader labour market equality measures.

Governance practices demonstrated uniformly insignificant relationships with sustainable development. Control of Corruption ( $\beta = 0.015$ ,  $p = 0.906$ ), Voice and Accountability ( $\beta = 0.010$ ,  $p = 0.851$ ), and Government Effectiveness ( $\beta = 0.025$ ,  $p = 0.807$ ) all failed to reach statistical significance. This counterintuitive finding may indicate that governance improvements in SSA have not yet translated into measurable sustainable development gains within the study period.

Economic and financial variables showed several significant relationships. Domestic Credit to Private Sector exhibited a positive association with SD ( $\beta = 0.272$ ,  $p = 0.042$ ), while Natural Resources Depletion showed a negative relationship ( $\beta = -0.103$ ,  $p = 0.033$ ). Financial Development demonstrated a significant negative coefficient ( $\beta = -0.206$ ,  $p = 0.001$ ), suggesting that current patterns of financial sector growth may not align with sustainable development objectives. Trade openness remained insignificant ( $\beta = -0.009$ ,  $p = 0.866$ ) (Table 8).

Table 8. Two-Step System GMM Estimation Results.

| Variable | Coefficient<br>( $\beta$ ) | Std.<br>Error | t-statistic | p-value | 95% Confidence<br>Interval |
|----------|----------------------------|---------------|-------------|---------|----------------------------|
|----------|----------------------------|---------------|-------------|---------|----------------------------|

|                           |         |        |       |          |                    |
|---------------------------|---------|--------|-------|----------|--------------------|
| Lagged Dependent Variable |         |        |       |          |                    |
| L.SD                      | 0.5933  | 0.0946 | 6.27  | 0.000*** | (0.4078, 0.7789)   |
| Environmental Practices   |         |        |       |          |                    |
| ghg_index                 | 0.1030  | 0.0700 | 1.47  | 0.141    | (-0.0342, 0.2403)  |
| d_ren_en_index            | 0.0468  | 0.1104 | 0.42  | 0.672    | (-0.1697, 0.2633)  |
| d_forest_cov_index        | -6.4661 | 4.6393 | -1.39 | 0.163    | (-15.5589, 2.6266) |
| Social Practices          |         |        |       |          |                    |
| edu_par_index             | 0.1013  | 0.0487 | 2.08  | 0.038**  | (0.0058, 0.1967)   |
| d_gend_eq_index           | 0.2561  | 0.4067 | 0.63  | 0.529    | (-0.5410, 1.0533)  |
| d_lab_part_index          | -0.2562 | 0.4255 | -0.60 | 0.547    | (-1.0902, 0.5778)  |
| Governance Practices      |         |        |       |          |                    |
| corr_ctrl_index           | 0.0146  | 0.1236 | 0.12  | 0.906    | (-0.2277, 0.2569)  |
| voice_acc_index           | 0.0098  | 0.0521 | 0.19  | 0.851    | (-0.0923, 0.1119)  |
| gov_eff_index             | 0.0250  | 0.1020 | 0.24  | 0.807    | (-0.1750, 0.2249)  |
| Economic Practices        |         |        |       |          |                    |
| d_cred_priv_index         | 0.2718  | 0.1334 | 2.04  | 0.042**  | (0.0104, 0.5332)   |
| nat_depl_index            | -0.1028 | 0.0482 | -2.13 | 0.033**  | (-0.1972, -0.0084) |
| trade_index               | -0.0093 | 0.0552 | -0.17 | 0.866    | (-0.1175, 0.0989)  |
| Financial Development     |         |        |       |          |                    |
| d_mon_cred_index          | -0.2064 | 0.0600 | -3.44 | 0.001*** | (-0.3240, -0.0888) |
| Constant                  |         |        |       |          |                    |
| _cons                     | 0.0824  | 0.0617 | 1.34  | 0.182    | (-0.0385, 0.2033)  |

The model diagnostics confirm the validity of the estimation approach. The Arellano-Bond tests show appropriate serial correlation patterns, with significant AR(1) ( $p = 0.007$ ) and insignificant AR(2) ( $p = 0.798$ ), satisfying the key assumption for GMM estimation (Table 9).

Table 9. Arellano-Bond test for serial correlation.

| Test                       | z-statistic | p-value | Conclusion                 |
|----------------------------|-------------|---------|----------------------------|
| AR(1) in first differences | -2.69       | 0.007   | Serial correlation present |
| AR(2) in first differences | 0.26        | 0.798   | No serial correlation      |

The Hansen J-test of overidentifying restrictions showed a  $\chi^2$  statistic of 24.49 with 974 degrees of freedom and a p-value of 1.000, failing to reject the null hypothesis that the instruments are valid. This non-significant result confirms the validity of the instrument set used in the system GMM estimation. The Difference-in-Hansen test for the GMM instruments for levels yielded a  $\chi^2$  statistic of -7.83 with 94 degrees of freedom and a p-value of 1.000, indicating that the exogeneity assumption for this instrument subset cannot be rejected. These diagnostics confirm the appropriateness of the model specification and the reliability of the instruments used (Table 10).

Table 10. Instrument validity by Hansen J-test and Difference-in-Hansen test.

| Test                                              | $\chi^2$ statistic | df  | p-value | Conclusion              |
|---------------------------------------------------|--------------------|-----|---------|-------------------------|
| Hansen J-test of overid. restrictions             | 24.49              | 974 | 1.000   | Instruments valid       |
| Difference-in-Hansen (GMM instruments for levels) | -7.83              | 94  | 1.000   | Exogeneity not rejected |

The White’s test was conducted to test the null hypothesis ( $H_0$ ) that the regression model exhibits homoskedasticity (constant variance of the error term). The results provide strong evidence to reject the null hypothesis of homoskedasticity at the 1% significance level. This conclusion is based on the statistically significant chi-squared statistic for the heteroskedasticity component ( $\chi^2(135) = 268.70$ ,  $p < 0.001$ ) (Table 11).

The decomposition of the IM-test reveals distinct patterns in the error structure. While the heteroskedasticity component is highly significant ( $p < 0.001$ ), the skewness component is not

statistically significant at conventional levels ( $\chi^2(15) = 15.12, p = 0.443$ ), indicating that the distribution of residuals is approximately symmetric. However, the kurtosis component shows statistical significance ( $\chi^2(1) = 4.31, p = 0.038$ ), suggesting some deviation from normal distribution in the tails of the residual distribution. The combined total test statistic ( $\chi^2(151) = 288.12, p < 0.001$ ) confirms the overall presence of non-spherical errors. These results indicate that while the residuals are symmetrically distributed, they exhibit heteroskedasticity and some non-normal kurtosis. This finding validates the use of robust standard errors in the GMM estimation to address the heteroskedasticity concern and ensure reliable inference despite the non-normal error distribution characteristics.

Table 11. White’s Test for Heteroskedasticity.

| Test Component     | Chi <sup>2</sup> | df  | P-value |
|--------------------|------------------|-----|---------|
| Heteroskedasticity | 268.70           | 135 | 0.0000  |
| Skewness           | 15.12            | 15  | 0.4430  |
| Kurtosis           | 4.31             | 1   | 0.0380  |
| Total              | 288.12           | 151 | 0.0000  |

3.6. Mediation Analysis

The system GMM results for the total effect model indicate that none of the sustainability practices indices has statistically significant relationships with sustainable development when examined collectively. Environmental Practices Index ( $\beta = -0.0334, p = 0.795$ ), Social Practices Index ( $\beta = 0.0360, p = 0.648$ ), Governance Practices Index ( $\beta = 0.0218, p = 0.572$ ), and Economic Practices Index ( $\beta = -0.0227, p = 0.657$ ) all show insignificant coefficients. The lagged dependent variable demonstrates strong persistence ( $\beta = 0.7940, p < 0.001$ ), as shown in Table 12.

Table 12. Total Effect Model.

| Variable                  | Coefficient (β) | Std. Error | z-statistic | p-value  | 95% Confidence Interval |
|---------------------------|-----------------|------------|-------------|----------|-------------------------|
| Lagged Dependent Variable |                 |            |             |          |                         |
| L.SDI                     | 0.7940          | 0.0475     | 16.73       | 0.000*** | (0.7010, 0.8871)        |
| EPI                       | -0.0334         | 0.1283     | -0.26       | 0.795    | (-0.2848, 0.2180)       |
| SPI                       | 0.0360          | 0.0790     | 0.46        | 0.648    | (-0.1187, 0.1908)       |
| GPI                       | 0.0218          | 0.0386     | 0.57        | 0.572    | (-0.0538, 0.0974)       |
| ECI                       | -0.0227         | 0.0513     | -0.44       | 0.657    | (-0.1232, 0.0778)       |
| Constant                  |                 |            |             |          |                         |
| _cons                     | 0.1008          | 0.0263     | 3.84        | 0.000*** | (0.0493, 0.1522)        |

The results for the mediation path (sustainability practices → financial development) indicate that none of the sustainability practices indices significantly influence financial development. Environmental Practices Index ( $\beta = 0.0358, p = 0.811$ ), Social Practices Index ( $\beta = -0.0320, p = 0.768$ ), Governance Practices Index ( $\beta = 0.0250, p = 0.688$ ), and Economic Practices Index ( $\beta = 0.0915, p = 0.423$ ) all show statistically insignificant relationships with financial development, as shown in Table 13.

Table 13. Sustainability Practices and Financial Development.

| Variable                  | Coefficient (β) | Std. Error | z-statistic | p-value | 95% Confidence Interval |
|---------------------------|-----------------|------------|-------------|---------|-------------------------|
| Lagged Dependent Variable |                 |            |             |         |                         |
| L.FDI                     | 0.0460          | 0.0313     | 1.47        | 0.142   | (-0.0154, 0.1074)       |
| EPI                       | 0.0358          | 0.1496     | 0.24        | 0.811   | (-0.2574, 0.3289)       |

|          |         |        |       |       |                   |
|----------|---------|--------|-------|-------|-------------------|
| SPI      | -0.0320 | 0.1085 | -0.30 | 0.768 | (-0.2447, 0.1807) |
| GPI      | 0.0250  | 0.0623 | 0.40  | 0.688 | (-0.0971, 0.1470) |
| ECI      | 0.0915  | 0.1143 | 0.80  | 0.423 | (-0.1325, 0.3156) |
| Constant |         |        |       |       |                   |
| _cons    | -0.0416 | 0.0631 | -0.66 | 0.510 | (-0.1652, 0.0821) |

The full mediation model results, controlling for financial development, show that none of the sustainability practice indices or financial development significantly influence sustainable development. Financial Development Index shows a negative but statistically insignificant relationship with sustainable development ( $\beta = -0.0743$ ,  $p = 0.120$ ), as shown in Table 14.

Table 14. Mediation Model.

| Variable                     | Coefficient<br>( $\beta$ ) | Std.<br>Error | z-statistic | p-value  | 95% Confidence<br>Interval |
|------------------------------|----------------------------|---------------|-------------|----------|----------------------------|
| Lagged Dependent<br>Variable |                            |               |             |          |                            |
| L.SDI                        | 0.8033                     | 0.0332        | 24.20       | 0.000*** | (0.7383, 0.8684)           |
| EPI                          | 0.0486                     | 0.1249        | 0.39        | 0.697    | (-0.1962, 0.2935)          |
| SPI                          | 0.0785                     | 0.0911        | 0.86        | 0.389    | (-0.1001, 0.2571)          |
| GPI                          | -0.0210                    | 0.0543        | -0.39       | 0.699    | (-0.1275, 0.0855)          |
| ECI                          | 0.0085                     | 0.0886        | 0.10        | 0.924    | (-0.1652, 0.1821)          |
| FDI                          | -0.0743                    | 0.0478        | -1.55       | 0.120    | (-0.1680, 0.0194)          |
| _cons                        | 0.0647                     | 0.0398        | 1.63        | 0.104    | (-0.0132, 0.1427)          |

4. Discussion

The descriptive analysis synthesis aligns closely with the broader document analysis on Sub-Saharan Africa’s development trajectory. The finding of modest progress against persistent structural challenges resonates with established analyses from major development institutions. For instance, the World Bank (2023) reports that the region’s average Human Development Index improved between 1990 and 2021. It simultaneously highlights that the majority of the population in Conflict-Affected Situations (FCS) countries, which is a significant subset of SSA, remains in multidimensional poverty. Similarly, the study documents that the share of manufacturing in GDP for Africa has stagnated, hovering around below 15% since 2010.

The observed pattern of relatively strong emissions performance coupled with forest conservation challenges reflects documented regional characteristics. Sub-Saharan Africa’s per capita CO<sub>2</sub> emissions are low (World Bank, 2023). Conversely, the FAO (2020) reports the region accounted for the highest net loss of forest area of any region between 2010 and 2020, identifying it as a primary deforestation hotspot. The governance and institutional findings echo extensively documented governance deficits. The 2023 Ibrahim Index of African Governance reports the continental average score for Overall Governance and Safety and Rule of Law category has plateaued over the past decade (Mo Ibrahim Foundation, 2023). This pattern reveals uniformly weak governance performance across SSA with minimal differentiation between countries, supporting Batae et al.’s (2020) observation of significant regional disparities in governance effectiveness.

The consistently low scores suggest that governance improvements in SSA may be insufficient to overcome threshold effects as governance quality may need to reach a critical level before producing measurable development impacts, as implied by Gundogdu and Aytekin’s (2022) comparison between Nordic and less stable countries. The median level of domestic credit to the private sector in low-income African countries is about less than 15% of GDP. The moderate sustainable development performance reflects the region’s position in global rankings. The 2023 Sustainable Development Report states the average SDG Index score for Sub-Saharan Africa is lower



than the global average. The region scores lowest on Goal 9 (Industry, Innovation and Infrastructure), with an average on Goal 10 (Reduced Inequalities).

The mediation analysis reveals no significant indirect effects, as neither the paths from sustainability practices to financial development nor from financial development to sustainable development are statistically significant. The non-significant coefficients in both mediation paths and the total effect model indicate that financial development does not mediate the relationship between sustainability practices and sustainable development in SSA countries. All Arellano-Bond and instrument validity tests across the three mediation models show satisfactory results (AR(1) significant, AR(2) insignificant; Hansen tests  $p = 1.000$ ), confirming model specification validity.

The first mediation pathway (sustainability practices  $\rightarrow$  financial development) reveals uniformly insignificant relationships, disagreeing with Leong et al.'s (2021) assertion that financial development naturally follows from broader sustainability initiatives. Environmental practices, social practices, governance practices and economic practices all fail to show meaningful influence on financial development. This finding suggests that sustainability practices in Sub-Saharan Africa may be disconnected from financial system evolution, supporting Xiao et al.'s (2024) observation about heterogeneous effects and the need for targeted financial policies rather than relying on general sustainability improvements to drive financial development.

The second mediation pathway (financial development  $\rightarrow$  sustainable development) shows a negative but statistically insignificant relationship, disagreeing with Pawlowska et al.'s (2022) and Kashif et al.'s (2023) positive assessments of financial development's role in sustainable growth. This near-significant negative coefficient aligns with Pushp et al.'s (2023) finding of negative correlations between financial development and poverty alleviation in India, suggesting potential adverse distributional effects or efficiency losses in SSA's financial systems. The result indicates that financial development in the region may not be structured to support sustainable outcomes, possibly reflecting the cybersecurity risks and digital inequality concerns raised in the literature.

The full mediation model confirms the absence of indirect effects, with financial development failing to serve as a transmission channel between sustainability practices and sustainable development. This null mediation finding contradicts Nenavath and Mishra's (2023) Indian case study showing positive synergies between green finance and sustainable growth, suggesting that SSA's financial systems may lack the institutional maturity, regulatory frameworks, or market depth necessary to translate sustainability initiatives into developmental outcomes. The consistently weak lagged financial development coefficient further indicates minimal autoregressive momentum in financial system evolution, contrasting with the strong persistence observed in sustainable development.

The findings align with the literature's recognition of regulatory and structural barriers. While Xiao et al. (2024) emphasized the importance of targeted Green Digital Finance policies in China, and Pawlowska et al. (2022) highlighted regulatory frameworks to avert risks, SSA's financial systems may lack these enabling conditions. The finding suggests that financial development in the region may be characterized by what Pushp et al. (2023) termed traditional financial development that doesn't reach vulnerable groups or align with sustainability objectives, rather than the transformative, inclusive models discussed by Leong et al. (2021).

## 5. Conclusions

The study concludes that financial sector development does not serve as an effective transmission channel through which sustainability practices influence sustainable development outcomes. The absence of significant mediation effects suggests that financial systems in Sub-Saharan Africa may not be adequately structured to channel resources toward sustainable development initiatives or that the relationship between finance and sustainability is more complex than captured in this model.

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Abbreviations

The following abbreviations are used in this manuscript:

|                 |                                                        |
|-----------------|--------------------------------------------------------|
| ADF             | Augmented Dickey-Fuller                                |
| AfDB            | African Development Bank                               |
| CO <sub>2</sub> | Carbon Dioxide                                         |
| ESG             | Environmental, Social, and Governance                  |
| FAO             | Food and Agriculture Organization                      |
| FCS             | Conflict-Affected Situations                           |
| FDI             | Financial Development Index                            |
| FinTech         | Financial Technology                                   |
| GDF             | Green Digital Finance                                  |
| GDP             | Gross Domestic Product                                 |
| GHG             | Greenhouse Gas                                         |
| GMM             | Generalized Method of Moments                          |
| GPI             | Governance Practices Index                             |
| HDI             | Human Development Index                                |
| IMF             | International Monetary Fund                            |
| LLC             | Levin-Lin-Chu                                          |
| MDPI            | Multidisciplinary Digital Publishing Institute         |
| OECD            | Organisation for Economic Co-operation and Development |
| PP              | Phillips-Perron                                        |
| SDG             | Sustainable Development Goals                          |
| SDI             | Sustainable Development Index                          |
| SMEs            | Small and Medium-sized Enterprises                     |
| SPI             | Social Practices Index                                 |
| SSA             | Sub-Saharan Africa                                     |
| TCFD            | Task Force on Climate-related Financial Disclosures    |
| UNDP            | United Nations Development Programme                   |
| VIF             | Variance Inflation Factor                              |

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