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Technological Innovation for Sustainable Development: Evidence from Ten Selected West African Countries

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ABSTRACT

This study assesses the impact of technological innovation on sustainable development in the context of ten selected West African countries. It analyses the simultaneous contribution of technological innovation to economic growth, human development, and environmental quality, using the Generalized Method of Moment and Pairwise causality test on panel data from 2013 to 2022. The study revealed that technological innovations have a significant adverse influence on economic growth. On the other hand, it positively improves human development and enhances environmental sustainability in the short run. Notably, the study shows a bidirectional causality between technological innovation and environmental quality, thus highlighting the complex relationship between these factors. Also, a unidirectional causality runs from human development to economic growth. However, there is no causality between economic growth and technological innovation. Accordingly, this study recommends that West African governments should give adequate incentives to sectors that contribute to immediate economic growth while encouraging investment in research and development. Also, they should ensure balanced technological progress that includes marginalized populations. Lastly, they should promote the adoption of eco-friendly technologies while encouraging a circular economy to create new economic opportunities and mitigate environmental degradation in the countries.

Keywords: Economic growth, Environmental Quality, Human development, Technological innovations, West Africa.

I INTRODUCTION

Global discourse on sustainable development continues to emphasize the need to integrate economic growth, human development, and environmental sustainability (United Nations, 2015). This integration is particularly crucial for West African countries, where socio-economic challenges are closely linked with environmental degradation and limited technological progress (UNDP, 2018). Hence, to address these challenges, innovative approaches are needed to harness technological advancements while ensuring socio-economic and environmental sustainability.

West Africa has witnessed significant economic growth in recent decades, with the region's GDP expanding by 3.94% in 2022, driven largely by agriculture, mining, and services (UNCTAD stats, 2024). However, growth decreased to 2.96%. Meanwhile, the African Development Bank (2024) projected a recovery, with anticipated growth rates of 4.0% in 2024 and 4.4% in 2025. Despite these growth trends, economic growth in the region has not been uniformly inclusive or environmentally sustainable as many countries in the region continue to grapple with high poverty rates, weak infrastructure, and pressing environmental concerns, including deforestation, water scarcity, and pollution (AfDB, 2020).

Technological innovation has emerged as a key driver of sustainable development. It offers potential solutions to many of the challenges faced by developing nations, particularly in West Africa. Innovations in information and communication technologies (ICT), renewable energy, agricultural advancements, and financial technology have shown promise in enhancing economic productivity and environmental sustainability. For instance, mobile technology has significantly improved financial inclusion and access to essential services across Africa (GSMA, 2019). Countries like Nigeria and Ghana are leading in ICT adoption. They are emerging as hubs for technology start-ups, particularly in the FinTech sector.

Meanwhile, nations such as Niger and Mali exhibit lower levels of technological penetration and innovation, primarily due to infrastructural deficits and socio-political challenges. Hence, renewable energy technologies, including solar power and smart grid systems, offer viable solutions for addressing the region's energy shortages and reducing their dependence on fossil fuels (IRENA, 2020). Likewise, advancements in agricultural technology, such as precision farming, drone-based monitoring, and solar-powered irrigation, will aid in productivity and food security in the region. Despite these promising developments, the adoption and impact of technological innovations remain uneven across West Africa, hindered by factors such as limited

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access to capital, inadequate policy frameworks, and a shortage of skilled labour (OECD, 2018).

Empirical studies on the impact of technological innovation on sustainable development have yielded mixed conclusions. Studies such as Emma, Haibo and Isaac (2022); Sunanda (2022); Oyegoke and Aras (2021); Anis (2020); Dominic et al. (2020); Bekhet and Abdul Latif (2018) and Iyoboyi and NaAllah (2014) have found a significant positive relationship between technological innovation, economic growth, environmental quality, and human development. However, a study by Ismaila (2022) suggests that technological innovation has had an adverse effect on economic growth in the ECOWAS region. Accordingly, these studies show conflicting results and ignore the context of West Africa, thus necessitating this study.

This study seeks to bridge this empirical gap by investigating the simultaneous impact of technological innovation on economic growth, environmental quality, and human development in the context of ten selected West African countries. This study focuses on Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal, and Togo. These countries represent a diverse range of socio-economic landscapes within the region. Also, they share common economic structures, which include heavy reliance on natural resource extraction, agricultural dominance, low ICT penetration, limited research and development investment, and weak institutional frameworks.

To achieve this study's objective, Section 1 provides the background, followed by a review of relevant literature in Section 2, while Section 3 includes data sources and methodology. Section 4 presents empirical findings, and Section 5 concludes with policy recommendations.

2 REVIEWS OF RELATED WORKS

The relationship between technological innovation and sustainable development remains a contemporary discourse among scholars, policymakers, and development practitioners. Solow and Swan's (1956) model considers technology as an exogenous factor; the endogenous growth models of Romer (1990) and Lucas (1988) integrate technological progress as an inherent driver of sustained economic growth. Accordingly, these models emphasize the role of technology in driving long-term productivity and economic expansion. Additionally, Schumpeter's (1934) view on creative destruction underscores the disruptive nature of technological innovation, fostering industrial transformation and economic dynamism. This argument is particularly relevant in West Africa, where technological diffusion varies significantly among countries. For instance, digital and mobile technologies have reduced transaction costs and enhanced market efficiencies in Nigeria and Ghana (Aker & Mbiti, 2010; Asongu & Nwachukwu, 2018). However, in countries such as Mali and Niger, political instability and infrastructural deficits hinder similar technological penetration. These differences show that technological progress may not automatically translate into economic prosperity.

Similarly, the link between technological innovation and human capital development is widely debated. According to Becker's (1964) human capital theory, education and skills training enhance productivity, making innovation an indispensable tool for economic growth. While technological advancements, such as e-learning platforms and digital literacy programs, have expanded access to education and skill development (Isaacs, 2007; Garkio, 2006), disparities in digital infrastructure across West African nations exacerbate inequalities. Rogers' (1962) diffusion of innovation theory further suggests that technology adoption is uneven and influenced by social, economic, and institutional factors. For instance, while telemedicine and mobile health applications have improved healthcare access in urban areas (Olu, 2019; Mars & Scott, 2010), rural communities continue to face technological exclusion.

Furthermore, technological innovation also has the potential to foster environmental sustainability. Hajer (1995) and Mol & Spaargaren (2000) argue that modern technologies can decouple economic growth from environmental degradation through sustainable energy solutions. Renewable energy technologies, including solar and wind power, are often cited as essential tools for reducing greenhouse gas emissions (UNDP, 2012; Sovacool & Drupady, 2012). However, the effectiveness of these technologies depends on adequate policy support and financial investment. West Africa's slow transition to renewable energy sources underscores this challenge, as countries remain heavily reliant on fossil fuels despite the region's vast renewable energy potential.

Empirical studies on technological innovation and sustainable development have produced mixed findings. For example, Maha, Pingfeng, and Guihua (2023) found that technological innovation positively influences economic growth in developing countries. Zejiong and Hongmei (2022) suggest that this impact varies based on institutional quality and financial support. Similarly, studies by Oyegoke and Aras (2021) and Iyoboyi and Na-Allah (2014) conclude that technological spillovers enhance economic growth. Meanwhile, Ismaila (2022) reports a negative relationship between technological innovation and economic performance in ECOWAS countries. These contradictions underscore the need for this study. Beyond economic considerations, the role of technological innovation in human development remains contested.

In contrast, some studies argue that research and development investments significantly improve human capital (Dominic et al., 2020; Gyimah-Brempong et al., 2006). Furthermore, green technological innovation and renewable energy adoption have been linked to

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environmental improvements in Africa. Yet, their implementation remains inconsistent (Emma, Haibo & Isaac, 2022). Anis (2022) provides evidence that technological innovation contributes to all three pillars of sustainable development in the long run for both developed and developing countries. Their findings suggest that the short-term costs of technological adoption, including infrastructure investment and policy restructuring, may hinder its immediate effectiveness. While technological innovation holds immense potential for sustainable development in West Africa, addressing the disparities in technological access and fostering regional cooperation will be crucial in ensuring that technological advancements translate into meaningful and sustainable economic, social, and environmental progress.

3 METHODOLOGY

This study examines the impact of technological innovation on sustainable development, including economic growth, environmental quality, and human development, in 10 selected West African countries. The study employed a panel data approach, and the data span was from 2013 to 2022 for each country. The list of selected countries, as well as the descriptions and sources of variables, are presented in Table I. Due to the availability of data, this study empirically examines the contribution of technological innovation to sustainable development in Ten selected West African countries.

TABLE I: LIST OF SELECTED WEST AFRICAN COUNTRIES, DESCRIPTIONS AND SOURCES OF VARIABLES

NO	Countries	NO	Countries
1	Benin	6	Mali
2	Burkina Faso	7	Niger
3	Cote d'Ivoire	8	Nigeria
4	Ghana	9	Senegal
5	Guinea	10	Togo

TABLE II: DESCRIPTIONS AND SOURCES OF VARIABLES.

Acronyms	Descriptions	Sources
EG	GDP per capita (constant 2015 US$)	World Bank Indicators (WDI)
TI	Total number of patent applications (Residents plus non-residents)	World Intellectual Property Organization (WIPO)
HDI	Human development index	United Nations Development Program (UNDP)
CO_2	Carbon emissions (Metric tons per capita)	World Bank Indicators (WDI)

This study estimated the effect of technological innovation and sustainable development in West African countries. The study employed different Generalized Methods of Moment to provide an efficient parameter estimate by exploring the moment conditions while maintaining consistency. Based on the empirical work of Dhahri and Omri (2018) and Anis (2020), the simultaneous equation model for this study is as follows:

Technological Innovation

$$TI_{i,t} = (EG_{i,t}, CO_{2i,t}, \quad HDI_{i,t}) \tag{1}$$

Economic growth

$$EG_{i,t} = (TI_{i,t,}\ CO_{2i,t}, HDI_{i,t}) \tag{2}$$

Human Development

$$HDI_{i,t} = (TI_{i,t}\ EG_{i,t}, CO_{2i,t},) \tag{3}$$

Environmental Quality

$$CO_{2_{i,t}} = (TI_{i,t}, EG_{i,t}, HDI_{i,t}) \tag{4}$$

These equations represent the interrelationships among technological innovation, economic growth, human development and environmental quality in West African countries. The natural log transformation of this model is as follows:

$$logTI_{i,t} = \beta_0 + \beta_1 \log(EG_{i,t}) + \beta_2 \log(CO_{2i,t},) + \beta_3 \log(HDI_{i,t}) + \mu_{i,t} \tag{5}$$

$$logEG_{i,t} = \beta_0 + \beta_1 \log(TI_{i,t}) + \beta_2 \log(CO_{2i,t},) + \beta_3 \log(HDI_{i,t}) + \mu_{i,t} \tag{6}$$

$$logHDI_{i,t} = \beta_0 + \beta_1 \log(TI_{i,t})\ \beta_2 \log(EG_{i,t}) + \beta_3 \log(CO_{2i,t},) + \mu_{i,t} \tag{7}$$

$$logCO_{2,i,t} = \beta_0 + \beta_1 \log(TI_{i,t}) + \beta_2 \log(EG) + \beta_3 \log(HDI_{i,t}) + \mu_{i,t} \tag{8}$$

The general modelling method of GMM estimation method for panel data is as follows:

$$Y_{i,t} = X_{i,t}\beta + Z_i b_i + \varepsilon_i \tag{9}$$

Where $Y_{i,t}$ represents the dependent variable, $X_{i,t}$ is the matrix of explanatory variables that do not include a constant term. $Z_i b_i$ captures the impact of heterogeneity and involves both specific cross-sectional effects and time-specific effects. ε_i It is the error term that incorporates residuals from differences in both cross-section and time series. The subscript i represents cross-sectional units, and t represents data points in time series.

Before conducting the regression analysis, it is imperative to ascertain the stationarity of the variables employed in this study. The order of integration of the variables was determined by the first-generation panel unit root test, including Im, Peseran & Shin (IPS), Levin, Lin & Chu (LLC) t* ADF-Fisher and PP-Fisher panel unit root tests (Peseran, 2007). The result of the panel stationary test revealed that the variables are stationary at level 1(01) and first difference 1(1), respectively, so we examine the long-run effect using the Pedroni panel co-integration test (Pedroni 1999, 2004).

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The co-integration test indicates the absence of co-integration among the variables, indicating that there is no long-run implication among the variables. Therefore, to investigate the short-run impact of technological innovation on economic growth, environmental quality, and human development, we employed the different Generalized Method of Moment. Arellano and Bond (1991) developed this method of estimation, and it is one of the most used estimation models in economics and finance. It is a powerful tool for panel data analysis, especially when dealing with unobserved heterogeneity, dynamic models, and endogeneity. Furthermore, the Pairwise Granger causality test determines the direction of causality among the variables.

4 RESULTS AND DISCUSSION

Stationarity testing is a crucial preliminary step in ensuring the validity of subsequent econometric modelling. Therefore, to determine the order of integration of the variables, the study employed the first-generation panel unit root, including Im, Peseran and Shin Levin. Lin & Chu t*, ADF-Fisher chi-square, and PP-Fisher chi-square as shown in Table III.

TABLE III: PANEL UNIT ROOT TEST RESULTS

	Level				
	LTI	**LEG**	**LHDI**	**CO_2**	**Order**
LLC	0.4815	-2.1679	-4.82437	-3.03554	1(0)
P&S	0.61191	0.93753	-0.38377	0.02068	
ADF	2.79109	16.1275	20.8498	22.0372	
PP	1.4655	12.2761	45.5442	26.2894	1(0)
	First Diff				
LLC	1.51772	-8.80626	-1.11305	-6.16359	1(1)
P&S	-0.13745	-3.25891	-0.16442	-1.72452	1(1)
ADF	4.23498	50.7074	22.5527	37.6778	1(1)
PP	19.9239	48.2213	59.9483	79.8698	1(1)

Source: E-Views 12 Output

The result from Table III indicates that at a 5% significant level, the variables are stationary at level 1(0) and first difference 1(1), respectively. These outcomes indicate a consistent, predictive trend and reliability of the variables to examine the impact of technological innovation on sustainable development in the countries.

TableIV presents the descriptive statistics and the correlation matrix based on annual data from the period between 2013 to 2022. The variables include GDP per capita (LEG), patent application (LTI), carbon emission (LCO_2) and Human Development Index (LHDI). The estimated mean of LEG, LTI, LCO_2 and LHDI is 7.11, 1.28, -1.06 and -0.72 respectively. Similarly, the maximum values are 8.07, 6.11, -0.26 and -0.45, respectively. The standard deviation displays a moderate deviation from the mean across the variables with the values LEG (0.52), LTI (2.058), LCO_2 (0.598), and LHDI (0.124). Also, LEG and LTI are positively skewed, demonstrating a right-skewed distribution, while LCO_2 and LHDI exhibit a left-skewed distribution. LTI, LCO_2 and LHDI have a relatively high kurtosis, indicating a peaked distribution; in contrast, LEG has lower kurtosis, indicating a flatter distribution.

TABLE IV: DESCRIPTIVE STATISTICS AND CORRELATION MATRIX

Variable	**LTI**	**LEG**	**LHDI**	**CO_2**
Mean	1.278119	7.109509	-0.719791	-1.061535
Median	0.500316	7.032172	-0.681219	-0.921197
Max	6.113682	8.071204	-0.446287	-0.263217
Min	-2.302585	6.208663	-0.986177	-2.445884
Std dev.	2.058239	0.517566	0.124462	0.598366
Skewness	0.792422	0.087213	-0.4423	-0.819197
Kurtosis	2.765555	1.748294	2.689102	2.883744
Correlation Matrix				
LTI	1			
LEG	0.642756	1		
LHDI	0.322159	0.798716	1	
CO_2	0.225394	0.706101	0.799662	1

Source: E-Views 12 Output

The correlation matrix test examines the relationships among the variables employed in this study. The outcome shows that LTI correlates with itself, as expected. It also has a positive correlation with GDP per capita, carbon emissions, and the human development index. Although its relationship with carbon emissions and the human development index is relatively weak. Also, the correlation between technological innovation and GDP per capita is moderately high, signifying that technological innovation plays a critical role in enhancing economic growth in the West African region.

As shown in Table 5, the study employed the Pedroni co-integration test to determine the presence of long-run relationships since the variables integrate at different orders of integration. The result from the Pedroni panel co-integration test revealed no co-integration, suggesting that there is no long-run effect among the variables used. Therefore, the study examined the short-run impact of technological innovation on economic growth, human development, and environmental quality.

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TABLE V: PEDRONI PANEL CO-INTEGRATION TEST RESULTS

With-Dimension	Statistic	Prob*
Panel v-Statistic	-0.586750	0.7213
Panel rho-Statistic	1.244215	0.8933
Panel PP-Statistic	1.253714	0.8950
Panel ADF-Statistic	0.406571	0.6578
Between -Dimension		
Group rho-Statistic	1.991877	0.9768
Group PP-Statistic	0.227240	0.5899
Group ADF-Statistic	-0.657014	0.2556

Source: E-Views 12 Output

The Pairwise Granger causality test explores the causal relationships among the variables. The result from Table VI shows that in the short run, there is unidirectional causality from human development to economic growth at a 5% level of significance. This finding indicates that improvement in human development Granger caused economic growth in West African countries. There is no causal relationship between technological innovation and economic growth, Human development and technological innovation. Similarly, there is no causal relationship between carbon emissions and economic growth. Conversely, there is a bidirectional relationship between technological innovation and carbon emission. This outcome revealed a feedback loop between environmental quality and technological innovation in the short run.

TABLE VI: PAIRWISE GRANGER CAUSALITY RESULTS

Null Hypothesis	F-Statistics	Prob
LTI does not Granger Cause LEG	0.62252	0.5428
LEG does not Granger Cause LTI	0.48500	0.6200
LHDI does not Granger Cause LEG	3.06798	0.0524
LEG does not Granger Cause LHDI	0.42216	0.6572
LCO_2 does not Granger Cause LEG	1.66248	0.1991
LEG does not Granger Cause LCO_2	1.13580	0.3286
LHDI does not Granger Cause LTI	0.35052	0.7069
LTI does not Granger Cause LHDI	0.70923	0.4994
LCO_2 does not Granger Cause LTI	4.10472	0.0269
LTI does not Granger Cause LCO_2	5.31561	0.0108
LCO_2 does not Granger Cause LHDI	0.25652	0.7747
LHDI does not Granger Cause LCO_2	2.61663	0.0821

Source: E-Views 12 Output

Taking technological innovation as the dependent variable in model one. The outcome revealed that all things being equal, an increase in past levels of technological innovation would significantly influence the current level of innovation by 0.37 units. This result indicates a cumulative progress of technological innovation in West African countries. The result also shows that economic growth and human development have a negative but insignificant effect on technological innovation. Holding other variables constant, one unit increase in economic growth and human development will result in 1.15 units and 0.298 unit decrease in technological innovation. These findings suggest that higher growth in the West African countries might lead to a reduction in innovation due to a shift towards less innovation-intensive sectors and complacency in the countries. Besides, a one-unit increase in environmental degradation will significantly decrease technological innovation by 4.36 units. This negative impact suggests that higher environmental degradation has a detrimental effect on innovation.

This study used GDP per capita as the dependent variable in model two, and the outcome indicates that holding other variables constant, a one-unit increase in technological innovation will significantly decrease economic growth by 0.02 units. This negative impact suggests a trade-off between technological innovation and economic growth in the short run, as initial investment in innovation may divert resources away from immediate economic productivity in the short run. This finding confirms the recent prior study by Ismaila (2022), whose study revealed that the negative effect of technological innovation in the Ecowas countries was due to weak institutions and poor policy implementation by the government. However, it contradicts the findings by Iyoboyi and Allah (2014), Bujari and Martinez (2016) and Anis (2020), whose empirical studies have shown that technological innovation drives economic growth.

In addition, the result in Table 7 also indicates a significant and positive relationship between past and current economic growth with the value of a 0.42-unit increase. This positive outcome suggests that past economic performance influences the current economic condition in West African countries. Also, the result revealed that economic growth is increased by environmental degradation, and this could lead to long-run negative consequences for the economies. All things being equal, a one-unit increase in carbon emission will significantly increase economic growth by 0.298 units. The coefficient of the human development index indicates that a one-unit increase in the human development index will result in a 0.298-unit increase in economic growth. However, this impact is not statistically significant.

In model three, we take human development as the dependent variable. The result from Table 7 revealed that a one-unit increase in past human development significantly led to a decrease of 0.121 units in the current level. These findings suggest that a higher HDI in the past will likely decrease towards its long-run in the present period. Also, the study found that a one-unit increase in technological innovation will lead to a 0.010-unit increase in human development. However, this effect is only significant at 10%. This result indicates that technological innovation can contribute to improving human development outcomes in West African countries. Thus, an advancement in technology will improve

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society's life expectancy, education, health and well-being. This finding is in line with the previous study by Anis (2020), Dominic, Ejemeyovwi, Adiat and Ayanda (2020). Likewise, the outcome reveals that a one-unit increase in economic growth will lead to a 0.070-unit increase in human development. This positive impact suggests that economic growth is associated with better access to education, health care and other essential services, which significantly contribute to improving human development in the countries. In addition, an increase in carbon emissions will decrease human development by 0.04 units. This outcome implies that environmental degradation has adverse effects on human health, education and the overall well-being of the citizens, which in turn results in a lower level of productivity.

TABLE VII: SHORT_RUN IMPACTS

	Model 1	**Model 2**	**Model 3**	**Model 4**
LTI(-1)	0.3745** (0.0000)			
LTI		-0.0176** (0.0042)	0.0101 (0.0777)	-0.0229 (0.4521)
LEG(-1)		0.4151** (0.0000)		
LEG	-1.1541 (0.1162)		0.0705** (0.0013)	0.2456**(0.0314)
LHDI(-1)			-0.1215** (0.0120)	
LHDI	-0.2988 (0.6348)	0.0211 (0.7979)		-0.0631 (0.8384)
LCO_2 (-1)				0.0897 (0.0562)
LCO_2	-4.3584** (0.0036)	0.2984** (0.0012)	-0.0405 (0.4194)	
J-statistic	5.2379	8.8537	7.1741	6.9824
Prob(J-statistic)	0.5137	0.1819	0.4109	0.3225
Instrument rank	10	10	11	10
Wald Test	7785.3** (0.0000)	2613.8** (0.0000)	12.6915** (0.0000)	3.5340** (0.0177)
AR(1)	-1.2221 (0.2217)			
AR(2)		-0.4555 (0.6488)	-0.000112 (0.9999)	2.7820 (0.254)
Jarque-Bera	1.2939 (0.5236)	1.9108 (0.3846)	44.1930 (0.0000)	0.7995(0.7995)

Source: E-Views 12 Output

Model four shows that taking carbon emissions as the dependent variable, one unit increase in past carbon emissions will increase its present level by 0.089 units. Thus, there is persistence in environmental degradation patterns in West African countries. From the result, a one-unit increase in technological innovation will insignificantly decrease carbon emissions by 0.023 units. Hence, in the long term, advancements in technology will lead to a more efficient and improved production process in West African countries. This outcome confirms the prior study by Kumar and Managi (2010), Omri and Kahouli (2014), and Anis (2020). Also, a one-unit increase in economic growth will significantly increase environmental degradation by 0.25 units. Thus, higher economic growth can be associated with increased industrialization and energy consumption, which results in environmental degradation in West African countries. In addition, a one-unit increase in human development will insignificantly decrease environmental degradation by 0.063 units. Therefore, a higher level of human development creates awareness of environmental issues and the adoption of cleaner technologies, leading to improved environmental quality.

Furthermore, the probability of the J-statistic of all the models shows that the instruments employed are jointly significant at 5%. In contrast, the Jaque-bera test shows that the residuals are normally distributed for model 1, model 2 and model 4, except for model 3. The Wald test result shows that the coefficients in all the models are jointly significant. Also, the Arellano bond serial correlation test reveals the absence of second-order serial correlation in models 2, 3 and 4. In contrast, model 1 results show the absence of first-order serial correlation.

5 CONCLUSION

This study examines the impact of technological innovation on the sustainable development of ten selected West African countries. Using the Generalized Method of Moment and Pairwise Granger Causality test on panel data spanning the period from 2013 to 2022, this study examines the impact and direction of causality between technological innovations and sustainable development in West Africa. The findings revealed that technological innovations have a significant but negative effect on economic growth. Hence, in the short run, technological innovation can disrupt the productivity level of existing industries through job displacement and income inequality, resulting in slow growth. Also, the findings demonstrate that technological innovation is statistically significant and positively improves human development in West Africa. Accordingly, technological advancement will improve education, healthcare and the overall well-being of society. In addition, technological innovation enhances environmental quality, although its impact is insignificant in the short run. Thus, innovation in renewable energy, efficient waste management and sustainable agriculture will aid in influencing a greener future of the West African countries. Furthermore, the study indicates a bidirectional causality between technological innovation and environmental quality, a unidirectional causality from human development to economic growth, and no causality between technological innovation and economic growth, technological innovation and human development.

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Based on the findings, this study recommends that the West African governments and policymakers should implement policies that encourage investment in research and development and give incentives to sectors that contribute to immediate economic growth. Likewise, they should ensure balanced technological progress that includes marginalized populations to promote human development in the countries. In addition, they should also promote the adoption of eco-friendly technologies and encourage a circular economy to create new economic opportunities and mitigate environmental degradation in West African nations.

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