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Foreign Direct Investments and Environmental Quality in Sub-Sahara Africa: The Merits of Policy and Institutions for Environmental Sustainability

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Abstract:

Environmental concerns in today's world cannot be overemphasised. These concerns have interested policymakers and researchers to delve into the causes in order to help mitigate environmental deterioration and support policies and institutions for environmental sustainability. This study, therefore, investigates the association between foreign direct investment (FDI) and environmental quality, taking into account policies and institutions for environmental sustainability across 23 Sub-Sahara Africa (SSA) countries. Employing the generalised method of moment (system-GMM) for the analysis, the results revealed, among others things, that FDI improves environmental quality in the long run, whereas in the short run, FDI diminishes environmental quality when interacted with policies and institutions for environmental sustainability. Furthermore, policies and institutions for environmental sustainability and domestic investment improve environmental quality in SSA in both the long and short run. The study, thus, concludes that policies and institutions for environmental sustainability in SSA are important as they improve environmental quality as well as complement FDI to improve environmental quality in the long run. The study further establishes that domestic investment is important to improve environmental quality in SSA. The study recommends policies for improving environmental quality to policymakers and stakeholders in SSA.

Keywords: Environmental quality. Environmental sustainability. Foreign direct investment. Policy and Institutions. Sub-Sahara Africa

1. Introduction

Environmental conditions, such as pollution (water and air), poor sanitation and depletion of forest reserves and natural resources, in recent years have been a major concern for both developed and developing countries. Poor environmental conditions are detrimental to the health and economic welfare of the citizenry. Baloch and Wang (2019) asserted that the essentials of human life, such as health, natural and physical capital and access to water, food and land are prone to climate change. These environmental concerns have brought about a global movement to combat climate change, with the launch of the Paris Agreement and the Kyoto Protocol. The primary goals of these global movements are to mitigate the effects of carbon dioxide (CO_2) emissions on the environment. The efforts to reduce CO_2 emission, Global Energy and CO_2 Status (2019) reported that, in 2018, carbon dioxide emissions increased by 1.7% globally. The report, again, revealed that the 1.7% increase in global carbon emissions is the highest rate of growth since 2013 and that it is 70% higher, compared to the average increase in carbon emissions since 2010. In Sub-Saharan Africa, carbon emissions (in Kilotons of Co_2) increased from 806,537.52 in 2013 to 853,107.13 in 2016 (World Bank 2020). World Bank (2020) data further shows that carbon emissions in Sub-Saharan Africa (SSA) increased by 1.88% in 2013 and further increased by 7.51% (more than double) in 2014. However, SSA experienced a decline in carbon emissions by 4.11% in 2015 but increased again by 2.6% in 2016. Given the increment in Co_2 emissions in SSA, although a marginal fall in 2015, there is no doubt that CO_2 emissions adversely affect environmental quality in SSA, which has a negative impact on citizenry welfare and, therefore, calls for urgent attention. Less attention will worsen the negative repercussions of climate change on human life, economic growth and climatic and ecological systems (Stern et al. 2006; Baloch and Wang 2019).

Foreign direct investment (FDI) is, generally, argued (both theoretically and empirically) to complement domestic capital to foster economic growth and development, given its benefits (see: Bosworth et al. 1999; Alfaro 2003; Bustos 2007; Sakyi et al. 2015). FDI flows to SSA rose by US\$32 billion in 2018, representing a 13% increase, compared to the preceding two years, which were US\$28.5 billion in 2017 and US\$31.8 billion in 2016 (UNCTAD's World Investment Report 2019). For the past four decades, the average FDI flows to SSA were 12.5, 40.2, 20.0 and 37.2 (billion US dollars) for the periods 1980-1989 and 2010-2019, respectively (World Bank 2020). Based on the neoclassical theory regarding capital flows (like FDI), which asserts that foreign capital complements domestic resources to augment economic growth (Duodu and Baidoo 2020), one can construe that SSA countries are on the verge of developing, given the flow of FDI and its associated benefits. Lee (2013) and Abdouli and Hammami (2017) documented that FDI flows lead to economic stimulation through access to skills and management expertise, exchange of technology and employment creation. Despite the positive impact of FDI on economies (especially Sub-Saharan Africa), FDI, with its interaction with the environment, somehow affects environmental quality. As a result, researchers as well as policymakers are interested in unravelling whether FDI causes Co_2 emissions and depletion of natural resources and forest reserves. A significant amount of literature (Naz et al. 2019; Shahbaz et al. 2019; Udemba 2019; Ma et al. 2019; Ganda 2020; Farooq et al. 2020) points to the fact that FDI deteriorates environmental quality (i.e., increasing Co_2 emission). However, other scholars (Kiviyiro and Arminen 2014; Shahbaz et al. 2015; Saud et al. 2019; Hao et al. 2020; Khan et al. 2020; Ahmad et al. 2020) also argue that FDI can improve environmental quality (that is, reduce Co_2 emissions), making the debate on the subject matter still imperative to help policymakers and other stakeholders settle on policies to improve environmental quality.

In their efforts to unveil the environmental effect of FDI, past studies, especially those on Sub-Saharan Africa (Kiviyiro and Arminen 2014; Ojewumi and Akinlo 2017; Ssali 2019; Ganda 2020; Adams 2020; Asongu and Odhiambo 2020), failed to consider the merit of policy and institutions for environmental sustainability (which reflects the extent to which environmental policies foster the protection and sustainable use of natural resources and the management of pollution), even though policy and institutions for environmental sustainability is an important variable that needs attention when addressing FDI and environmental quality nexus, in the sense that economies with effective policies and institutions for environmental sustainability are likely to implement policies to improve environmental quality. For instance, a country with effective policies and institutions for environmental sustainability is most likely to implement policies that scrutinise the flow of FDI, which enhances environmental quality. This indicates that policy and institutions for environmental sustainability has vital roles to play in the relationship existing between FDI and environmental quality.

In the present study, we contribute to the literature on SSA by incorporating environmental policies and institutions for environmental sustainability as well as their interaction with FDI. The existing literature largely uses the quality of political institutions variable (see: Abid 2016; Abid 2017; Bokpin 2017; Baloch and Wang 2019; Adams et al. 2020; Asongu and Odhiambo 2020; Farooq et al. 2020; Hao et al. 2020). This study uses a measure of policy and institutions index, which focuses directly on the quality of the environment. This is a departure and, therefore, an important contribution. This inclusion allows us to assess the extent to which the implementation of policy and institutions for environmental sustainability affects environmental quality. The interaction variable helps to further assess the complementary effect of policy and institutions for environmental sustainability with FDI on environmental quality. Furthermore, foreign direct investments are channelled to different sectors of the economy, such as manufacturing, mining and other extraction activities, and, therefore, could have various impacts on the quality of the environment, especially on pollution and the depletion of forest reserves and natural resources. However, most past studies considered the impact of FDI on CO_2 emissions but neglected the depletion of forest reserves and natural resources. Most of the studies, especially those on SSA, focused on carbon emissions as a measure of environmental quality (see: Kiviyiro and Arminen 2014; Ojewumi and Akinlo 2017; Ssali 2019; Ganda 2020; Adams 2020; Asongu and Odhiambo 2020). This does not completely depict the depth to which FDI affects environmental quality. We fill this gap by considering the effect of FDI on CO_2 emissions, natural resource depletion and forest reserve depletion individually. Also, we create an environmental quality index, using the three measures of carbon dioxide emission, natural resource depletion and forest reserve depletion to assess the overall impact of FDI on environmental quality.

The general objective of the study is to explore the impact of FDI on environmental quality in SSA, taking into account policy and institutions for environmental sustainability as well as its interaction with FDI. The remaining of the paper is structured as follows: the section that follows is devoted to theoretical and empirical review, and the third and fourth sections focus on the methodological framework employed and the analysis of empirical results, respectively. The final section of the study dwells on conclusion and policy suggestions.

2. Theoretical and Empirical Review

There are divergent theoretical and empirical views about the impact of FDI on environmental quality. In this section, we briefly review some of the theoretical strands and empirical studies relevant to this study. Concerning

the theoretical strands, we review three hypotheses: the Pollution Haven Hypothesis, the Scale Effect Hypothesis and the Pollution Halo Hypothesis.

The Pollution Haven Hypothesis was, initially, proposed by Walter and Ugelow (1979) and, later, confirmed by Baumol et al. (1988) and, then, accepted as an impeccable theory. The Pollution Haven Hypothesis postulates that advanced economies tend to have stringent environmental regulations, making industries, including foreign companies, pay a substantial cost for emitting pollution or degrading the environment. As a result, these multinational companies move to economies with more relaxed environmental regulations because of their goals of maximising profits, resulting in more pollution in these underdeveloped countries. No doubt the World Investment Report (2019) revealed that FDI flows in Africa, including SSA, rose by 11% in 2018. The Pollution Haven Hypothesis, therefore, argues that foreign companies, through FDI, deteriorate environmental quality. With regard to the Pollution Haven Hypothesis, Esty and Dua (1997) documented that economies with less-stringent environmental regulations attract foreign companies, which, in effect, adversely affects environmental quality.

The Scale Effect Hypothesis also explains that foreign or multinational companies, though they increase the output of the industrial sector, heavily consume more energy, which, eventually, leads to pollution in the recipient or host countries (Pao & Tsai 2011). From a different standpoint, the Pollution Halo Hypothesis postulates that investment in underdeveloped countries, like SSA, by foreign companies from well-developed countries improves environmental quality. The theorists are of the view that foreign companies with good management ideas and forward-thinking technology exert a positive impact on the environment. Eskeland and Harrison (2003) posited that foreign (multinational) companies employ clean energy, which leads to more efficient use of energy and which does not expose the environment to any damage.

Turning to empirical studies, the study provides a brief review of some empirical literature on SSA and other parts of the world. Kiviyiro and Arminen (2014) examined the causal links between carbon dioxide emissions, energy consumption, economic growth and foreign direct investment (FDI) in six SSA countries, including Congo, Kenya and Zambia, from 1971-2009. Employing the Autoregressive Distributed Lag (ARDL) and the Granger causality test for their analysis, they revealed that FDI exerts a significantly-positive effect on carbon emissions in Zimbabwe and a significantly negative impact in South Africa, Kenya and the Democratic Republic of Congo, but has an insignificant impact on the rest of the countries. Moreover, energy consumption was found to have a significantly-positive effect on CO_2 emissions in South Africa and Zimbabwe and a significantly-negative impact in the Democratic Republic of Congo with an insignificant effect in the rest of the countries. With regard to the causal links, the results indicate that FDI, energy consumption and economic growth cause CO_2 emissions in Kenya, South Africa and the Democratic Republic of Congo. Ojewumi and Akinlo (2017) also investigated the dynamic interaction among FDI, economic growth and environmental quality, measured by CO_2 emission in 33 SSA countries, including Angola, Benin and Ghana, spanning 1980-2013. Using the Panel Vector Error Correction (PVEC) model as an estimation technique, the study revealed that both FDI and economic growth have a significant positive impact on CO_2 emissions in SSA. Further, the results indicated that a shock to FDI and real per capita income reduces environmental quality with a positive impact on CO_2 emission.

Similarly, Ssali et al. (2019) explored the nexus between environmental quality (measured by CO_2 emission), economic growth and FDI in six (6) selected Sub-Sahara African countries, covering the period 1980-2014. Applying the Panel Autoregressive Distributed Lag model or the Pool Mean Group Estimator, the study shows that FDI has an insignificant impact on environmental quality while Gross Domestic Product (GDP) and energy

use reduce environmental quality. With regard to the causality, the results indicated that there exists a bidirectional causality between energy use and CO₂ emissions in the short run, but only energy use causes carbon emissions in the long run. A unidirectional relationship was found between FDI, economic growth and CO₂ emissions, running from CO₂ emissions to FDI and from economic growth to CO₂ emissions in the long run. Employing the Dynamic Fixed Effect model and the Generalised Method of Moment as estimation techniques, Adams et al. (2020), for the period 1980-2011, examined the link between transport, energy consumption, urbanisation and environmental quality, measured by CO₂ emission, across 19 SSA countries, and the study showed that FDI and regulatory quality improve environmental quality (i.e., they exert a significant negative effect) whereas transport energy consumption, urbanisation, electricity consumption as well as the interaction between regulation and transport energy consumption exert a significant positive effect on CO₂ emissions. Asongu and Odhiambo (2020) also explored trade and FDI thresholds of CO₂ emissions for a green economy among 49 SSA countries. Applying a panel data from 2000-2018 and using the Generalised Method of Moment as an estimation technique, the results indicated that FDI has a significant positive effect on CO₂ emissions while trade has a significant negative effect on CO₂ emissions. The study, further, showed that the minimum FDI and trade threshold for SSA countries to experience green economy are 200 and 100 (as % of GDP), respectively.

Using the Pooled Mean Group (PMG) estimator as well as the Dumitrescu and Hurlin's Granger causality test, Ganda (2020) examined the influence of growth determinants on environmental quality (measured by CO₂ emission) across 44 SSA countries from 1990 to 2014, and the estimated results showed that renewable energy consumption and financial development have a significant negative impact on environmental quality whereas economic growth exerts a positive and significant effect on environmental quality. The study found a bidirectional relationship existing between economic growth, industrial practice, renewable energy consumption, financial development and carbon emissions. In a related study, Aluko and Obalade (2020) investigated financial development and environmental quality among 35 SSA countries from 1985 to 2014. Using the Augmented Mean Group estimator and the Dumitrescu and Hurlin's Granger causality test, the study revealed that population, affluence and technology have a significant positive effect on environmental quality (measured by CO₂ emission) while financial development has a significant negative effect on CO₂ emissions. The interaction between financial development and technology was also found to have significant negative effect on environmental quality. Further, the study observed a bidirectional relationship between financial development and CO₂ emissions.

Turning to past studies beyond Sub-Sahara African countries, Shahbaz et al. (2015) investigated whether FDI impedes environmental quality in 99 high-, middle- and low-income countries, covering the period 1975-2012. Using the Fully Modified Ordinary Least Squares (FMOLS) and the Dumitrescu and Hurlin's causality test, the study revealed that FDI and the square of FDI both improve environmental quality (i.e., they have a significant negative effect on CO₂ emissions) whereas economic growth and energy consumption exert a significant positive effect on carbon dioxide emissions in all countries. However, on the income level, FDI tends to improve environmental quality in high-income countries while it deteriorates environmental quality (i.e., it has significant positive impact) in both middle- and low-income countries. Dumitrescu and Hurlin's causality results revealed that both FDI and energy consumption have a bidirectional causality with CO₂ emissions in all 99 countries. While energy consumption has a bidirectional relationship with CO₂ emissions in high income countries, FDI has unidirectional relationship, running from FDI to CO₂ emissions in high-income countries. In Turkey, Seker et al. (2015), examined the impact of FDI on environmental quality (measured by CO₂ emissions) from 1974 to 2010,

using annual time series data as well as the Autoregressive Distributed Lag model and Vector Error Correction (VEC) Granger causality test for the analysis. The results indicated that FDI, economic growth and energy consumption have a positive and significant impact on CO_2 emissions whereas the square of economic growth exerts a significant negative impact on CO_2 emissions in both the short and long run. Furthermore, the results (VEC causality) revealed that FDI causes (unidirectional) CO_2 emissions in both the short and long run. Similarly, Jiang (2015), applying a static panel estimation method (that is, fixed effect, first difference, random effect and ordinary least squares) examined the effect of FDI, pollution and environmental quality across 28 Chinese provinces from 1997 to 2012. The results in all the estimation methods indicated that FDI, economic growth and human capital have a positive significant effect on pollution emissions.

In Middle East and North Africa (MENA), Abdouli and Hammami (2017) investigated the causality links between environmental quality, FDI and economic growth across 17 countries, including Algeria, Morocco, Jordan and Egypt, spanning 1990 to 2012 and using simultaneous the Equation Panel Vector Autoregressive model for the analysis. The results revealed that FDI has a significant positive effect on CO_2 emissions in all the 17 countries and that there exists a bidirectional relationship between FDI, economic growth and CO_2 emissions. In a related study, Abid (2017), using the Generalised Method of Moment (system-GMM) as the estimation technique, carried out a study in 58 Middle East and North Africa and in 41 European Union countries from 1990 to 2011 to examine whether economic, financial and institutional developments matter for environmental quality. The results, among other things, showed that FDI exerts a significant negative effect on CO_2 emissions (environmental quality) in European Union countries but has a positive and significant impact on CO_2 emissions in MENA countries. However, the interaction between FDI and quality of institutions, namely political stability, government effectiveness, quality of regulation and control of corruption, has a significant negative effect on CO_2 emissions in both MENA and European Union countries. Bokpin (2017) also examined the impact of FDI, institution and governance quality on environmental sustainability in Africa, spanning 1990 to 2013. Using the Fixed and Random Effects model as well as the Panel Corrected Standard Errors and the robust OLS as estimation techniques, the results posited that FDI and quality of institution have a significant positive (that is degrading) and negative (that is improving) effects, respectively, on environmental sustainability. Also, the interaction between quality of institution and FDI was revealed to improve environmental sustainability. In other words, it has significant negative impact.

Employing the Fixed Effect Panel Quantile Regression estimation method, Ma et al. (2019) explored the impact of economic growth, FDI and energy intensity on China's manufacturing industry carbon emissions for the period 2000-2013. The results indicated that FDI, economic growth, urbanisation and energy intensity have a significant positive impact on China's manufacturing industry CO_2 emissions. Similarly, Udemba (2019) studied the triangular nexus between FDI, international tourism, energy consumption and environmental quality in the Chinese economy. Using quarterly data from 1995Q1 to 2016Q4 and applying the Autoregressive Distributed Lag (ARDL) for the analysis, the study revealed that FDI, gross domestic product and tourism arrivals exert a positive impact on CO_2 emissions in both the short and long run. Again, Shahbaz et al. (2019) explored the association between FDI and CO_2 emissions for MENA countries, spanning 1990 to 2015 and employing the Generalised Method of Moment and the Dumitrescu and Hurlin's panel causality test as estimation techniques. The results revealed that FDI and economic growth have a positive and significant effect on CO_2 emissions while the square of FDI and economic growth and biomass energy have a negative significant effect on CO_2 emissions in MENA

countries. The Dumitrescu and Hurlin's causality also indicated a unidirectional relationship, from FDI to carbon emission. Applying the Dynamic Seemingly Unrelated Regression (DSUR) and the Dumitrescu and Hurlin's panel causality test as estimation strategies, Saud et al. (2019) investigated the impact of financial development and economic growth on environmental quality across 59 Belt and Road Initiative (BRI) countries, including Albania, China, Moldova, India and Colombia, from 1980 to 2016. The results showed that FDI, financial development and square of economic growth exert a significant negative effect on CO_2 emissions (promoting environmental quality), but economic growth has a positive significant effect on CO_2 emissions. Also, the study, further, shows that FDI, economic growth, electricity consumption and CO_2 emissions have a bidirectional relationship.

In Pakistan, Naz et al. (2019) examined the impact of renewable energy consumption, FDI and economic growth on carbon emissions from 1975 to 2016 and employed the Robust and Nonlinear Robust Least Squares estimation methods as well as the Vector Autoregressive Granger causality test for the analysis. The results indicated that FDI, GDP and the interaction between FDI and renewable energy consumption exert a significant positive effect on carbon emissions whereas renewable energy consumption has a significant negative impact on carbon emissions in Pakistan. The causality test also indicated that renewable energy consumption causes carbon emissions, but the opposite does not hold. Similarly, Mert et al. (2019) investigated the relationship between CO_2 emissions, FDI and renewable energy in 26 European countries, including Sweden, Denmark, France and Italy, covering 1960-2014, and used the Pooled Mean Group (PMG) estimators as estimation strategy. The outcome shows that FDI, fossil fuel energy consumption and economic growth have significant positive effect on CO_2 emissions whereas renewable energy consumption and square of economic growth exert a significant negative effect on CO_2 emissions in the long run. More recently, Ahmad et al. (2020) examined the effect of FDI and financial development on environmental quality for 90 belt and road countries from 1990 to 2017. Using the Driscoll-Kraay Standard Error Pooled Ordinary Least Squares technique and the Dumitrescu and Hurlin's panel causality test, the findings revealed that FDI and trade openness exert a significant negative effect on CO_2 emissions, but financial development, energy consumption, economic growth and urbanisation have a significant positive effect on CO_2 emissions (promoting environmental quality). The findings from the causality test showed that there exists a bidirectional causality between FDI, financial development, energy consumption, openness, economic growth and CO_2 emissions.

Gunarto (2020), further, explored the relationship between economic growth, FDI and carbon emissions in Asian states from 1970 to 2014, and the results from the Autoregressive Distributed Lag (ARDL) estimation method showed that economic growth and energy consumption significantly exert a positive effect on carbon emissions in both the short and long run. However, the results revealed that FDI has an insignificant effect on carbon emissions in Asian states. Farooq et al. (2020) examined the effect of globalisation and FDI in environmental quality on OIC countries, spanning 1991 to 2017, employing the Generalised Method of Moment for analysis. The results show that globalisation, FDI, institutional quality and industrialisation significantly affect CO_2 emissions positively. However, the interaction between FDI and globalisation has a significant negative impact on CO_2 emissions. Khan et al. (2020) also analysed the repercussions of FDI, renewable energy and health expenditure on environmental decay for 58 Belt and Road Initiative countries, covering the period 1995-2016. The empirical results from the two-step Generalised Method of Moment and the FMOLS showed that FDI and renewable energy consumption have a significant and negative effect on CO_2 emissions whereas income and

health expenditure have a positive and significant impact on CO₂ emissions in both estimators. Employing spatial econometric models and using data for 30 provinces in China from 1998 to 2016, Hao et al. (2020) investigated the impact of FDI and technological innovation on environmental quality and found that FDI and technological innovation have a significant negative effect on environmental pollution.

While a plethora of cross-country studies are found in other parts of the world, there exists relatively fewer studies (see: Kiviyiro and Arminen 2014; Ojewumi and Akinlo 2017; Ssali 2019; Ganda 2020; Adams 2020; Asongu and Odhiambo 2020) on Sub-Sahara Africa, specifically. This, therefore, reveals the essence of further research to complement previous studies to aid policymakers in SSA for effective policy implementation. It was also observed that the past studies, especially those on Sub-Sahara Africa, ignored the relevance of a country's policies and institutions for environmental sustainability to environmental quality and, thus, failed to depict the complementary role of same with FDI and the impact on environmental quality. Although, some studies (see: Abid 2016; Abid 2017; Bokpin 2017; Adams et al. 2020; Asongu and Odhiambo 2020; Farooq et al. 2020; Hao et al. 2020) attempted to use quality of political institutions (measured by government effectiveness, rule of law, control of corruption, political stability and others), which may not have direct effect on environmental quality given its wide scope, the results of those studies may render policy implementation ineffective, compared to policy and institutions for environmental sustainability, which is solely geared towards environmental protection. Furthermore, most studies have virtually focused on CO₂ emissions as a measure of environmental quality in analysing FDI effect on environmental quality, considering the fact that FDI is mostly channelled to different sectors of the economy (mining and other extraction activities), which could have different effects on the environment. In that respect, this study will measure environmental quality by the depletion of natural resources and forest reserves, aside CO₂ emissions, to ascertain the diverse impact of FDI on environmental quality. Again, from the empirical literature reviewed and to the best of the author's knowledge, no studies (see empirical review section) have ever created a composite index to assess the full effect of FDI on environmental quality. Thus, there is limited information for policy implications. In the light of the foregoing, this study further contributes to the extant literature by creating an environmental quality index to deliver adequate information to aid policymakers in Sub-Sahara Africa in the area of environmental quality.

[INSERT TABLE 1 HERE]

3. Methodology and Model Specification

This section focuses on the model specification, data and variable descriptions and estimation techniques employed.

3.1 Theoretical and Empirical Model Specification

The study relies on the STIRPAT model to examine how FDI and policy and institutions for environmental sustainability (PIES) as well as its interaction affect environmental quality. The STIRPAT model builds on the Ehrlich and Holdren (1971) IPAT model, considering the major shortfall of the IPAT model, which is a mathematical identity equation that tends to make hypotheses intolerable (Li and Lin 2015). As a result, Dietz and Rosa (1994) transformed the IPAT model to the STIRPAT (stochastic) model, which accounts for such limitation. The STIRPAT model explains the environmental effect of population, affluence and technology. Equation (1) below is the STIRPAT model specified:

$$I_{it} = aP_{it}^{\beta}A_{it}^{\gamma}T_{it}^{\tau}\varepsilon_{it} \quad (1)$$

where I, P, A and T denote environmental quality, population (proxied by urbanisation), affluence (proxied by economic growth) and technological progress, respectively. a denotes the constant term, and β, γ and τ represent the elasticities of population, affluence and technological progress on environmental quality. Also, i, t and ε denote cross-sectional units, time trend and the stochastic error term, respectively. Technological progress, in this study, is assumed to be influenced by FDI, domestic investment and trade openness, that is $T = f(FDI, DI, TO)$. Equation (1) can, then, be transformed into Equation (2), which is presented as follows:

$$I_{it} = aP_{it}^{\beta}A_{it}^{\gamma}FDI_{it}^{\tau}DI_{it}^{\phi}TO_{it}^{\sigma}\varepsilon_{it} \quad (2)$$

where FDI, DI and TO represent foreign direct investment, domestic investment and trade openness, respectively, and τ, ϕ and σ are their respective elasticities. Equation (2) is, then, linearised into Equation (3), which is presented below:

$$\ln I_{it} = a + \beta \ln P_{it} + \gamma \ln A_{it} + \tau \ln FDI_{it} + \phi \ln DI_{it} + \sigma \ln TO_{it} + \varepsilon_{it} \quad (3)$$

I, P, A, FDI, DI and TO are explained in Equations (1) and (2).

From Equation (3), it is observed that environmental quality is influenced by urbanisation, economic growth, foreign direct investment, domestic investment and trade openness. The general specification of Equation (3) is expressed in Equation (4), which is presented as follows:

$$EQ = f(FDI, DI, TO, URB, EG) \quad (4)$$

where EQ, URB and EG represent environmental quality, urbanisation and economic growth.

Equation (4) is, then, modified to capture other variables, such as policy and institutions for environmental sustainability (PIES) and international tourism (IT). Every economy implements policies and establishes institutions that protect the environment. Therefore, to examine the extent to which such policies and institutions influence environmental quality, it is imperative to include the policy and institutions for environmental sustainability variable in the environmental quality model. Udemba (2019) asserted that international tourism influences environmental quality positively, thus, deteriorating environment quality. In that regard, we also introduce international tourism into the model, considering the significant number of tourist sites that exist in SSA countries, to examine how that influences the environment in SSA. Also, following Abid (2017), Bokpin (2017), Aluko and Obalade (2020), Hao et al. (2020) and Farooq et al. (2020), the study introduces an interaction term between FDI and policy and institutions for environmental sustainability (FDI*PIES) to ascertain how FDI affects environmental quality when policy and institutions for environmental sustainability is improved or is at its mean. From this, the final specification of the generalised model is specified in Equation (5) below:

$$EQ = f(PIES, FDI, DI, IT, TO, URB, EG, FDI * PIES) \quad (5)$$

PIES, IT and FDI*PIES are defined above. Equation (5) is transformed to its panel dynamic estimable form as expressed in equations (6) and (7) below:

$$\ln EQ_{it} = a_1 + \lambda \ln EQ_{it-1} + \beta_1 PIES_{it} + \beta_2 FDI_{it} + \beta_3 \ln DI_{it} + \beta_4 \ln IT_{it} + \beta_5 \ln TO_{it} + \beta_6 \ln URB_{it} + \beta_7 \ln EG_{it} + \gamma_1 (FDI * PIES)_{it} + \varrho_i + \eta_t + \varepsilon_{it} \quad (6)$$

$$EQ_{it} = a_2 + \lambda EQ_{it-1} + \delta_1 PIES_{it} + \delta_2 FDI_{it} + \delta_3 \ln DI_{it} + \delta_4 \ln IT_{it} + \delta_5 \ln TO_{it} + \delta_6 \ln URB_{it} + \delta_7 \ln EG_{it} + \gamma_2 (FDI * PIES)_{it} + \varrho_i + \eta_t + \varepsilon_{it} \quad (7)$$

where a_1 and a_2 are the constant terms. β 's (1, 2, 3, . . . , 7) and δ 's (1, 2, 3, . . . , 7) denote the variable coefficients to be estimated in equations (6) and (7), respectively. $\varepsilon, \ln, \varrho_i$ and η_t represent the stochastic error term, which is, normally, distributed with a mean of zero and constant variance, logarithm country-specific effect and time-

specific effect, respectively. The λ and γ 's (1 and 2) are the coefficients of the lagged dependent variable and the interaction term which captures the impact of FDI on environmental quality, if policy and institutions for environmental sustainability improves. It must be emphasised that equations (6) and (7) are estimated twice and are referred to as models 1 and 2 in Equation (6) and models 3 and 4 in Equation (7). Models 1, 2 and 3 are the estimations with carbon dioxide emission, natural resource depletion and forest reserve depletion, respectively. Model 4 is the estimation with environmental quality index (created using principal component analysis). The difference between models 1 and 2 and models 3 and 4 is that carbon dioxide emissions and natural resource depletion are in their log forms, and this explains why we have equations (6) and (7).

3.2 Data and Variable Description

This study used a balanced panel data of 23 Sub-Sahara Africa countries, spanning 2005 to 2018, and the choice of the study period was as a result of limited data available for an important variable in the model, that is policy and institutions for environmental sustainability. Data for the variables (CO_2 emission, natural resources depletion, forest reserve depletion, policy and institutions for environmental sustainability, FDI, domestic investment, international tourism, trade openness, urbanisation and economic growth) used in this study are extracted from the World Bank's World Development Indicator (World Bank 2020). From the data, we observed that there exist some missing values, and by following Zaman et al. (2016), Bhuiyan et al. (2018), Naz et al. (2019) and Khan et al. (2020), we employed a suitable technique to fill the missing gaps. Table 2 below shows a brief description of the variables used in this study:

[INSERT TABLE 2 HERE]

3.3 Estimation Technique

To empirically delve into how FDI and policy and institutions for environmental sustainability as well as their interaction affects environmental quality, this study employs the dynamic System Generalised Method of Moment (system-GMM) estimation technique. The system-GMM, proposed by Blundell and Bond (1998), is designed to handle and produce reliable estimates when there exist small T and large N, as in our case of 14 years and 23 cross-sectional countries, which makes the system-GMM an appropriate estimator in our study. Furthermore, due to the dynamic nature of equations (6) and (7), which results from the presence of the lagged dependent variable ($\ln EQ_{it-1}$ and EQ_{it-1}), the use of static panel estimators, like the Pooled Ordinary Least Squares, the Fixed Effect, the Random Effect and the rest, makes the estimates biased and inconsistent. The failure of these panel static estimators to produce reliable estimates in a dynamic model is as a result of an endogeneity issue arising from the introduction of the lagged dependent variable, which is correlated with the stochastic error term (ε_{it}) when equations (6) and (7) are transformed to their difference form. The system-GMM, however, overcomes this issue, hence, the choice of the dynamic panel system-GMM estimation method, which is an extension of the differenced-GMM, by Arellano and Bond (1991) and Arellano and Bover (1995). The general GMM specification of our models to be estimated is specified in Equation (8) as follows:

$$EQ_{it} - EQ_{it-1} = \lambda(EQ_{it-1} - EQ_{it-2}) + \beta'(X_{it} - X_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \quad (8)$$

where EQ is the measure of environmental quality, X is a vector of the variables employed and ε is the error term. The accuracy of the system-GMM estimations is diagnosed, using the Hansen (1982) and Sargan (1958) test for instruments validity (overidentification restriction) and the Arellano-Bond tests for second-order [AR(2)] serial correlations. The nonrejection of the null hypothesis of the Hansen and Sargan tests and the AR(2) test indicates that the instruments are valid and lack second-order serial correlation, respectively, hence, the consistency of the

estimates. Given that the long run effect is more vital for policy implications, we adopt the Delta-Method [i.e., $\beta_k/(1 - \lambda)$] by Papke and Wooldridge (2005) to estimate the long run coefficient from the short parameters. This is done by dividing the short run coefficients by one, minus the lagged dependent variable coefficient.

Before using the system-GMM, it is important to consider some preliminary tests, such as cross-sectional dependence test, unit root test and cointegration test, to prevent spurious, bias and inconsistent results (Pesaran, 2007). The study employs the cross-sectional dependence (CD) test proposed by Pesaran (2004) to test whether there exist dependencies in the data from the 23 countries studied. In this test, the null hypothesis of cross-sectional independencies is tested against the alternative hypothesis of cross-sectional dependencies. The test follows the standard normal distribution with a zero mean and a unit variance [i.e., $CD \sim N(0, 1)$] for large cross-section (N) and small-time dimension (T). The CD test is specified in Equation (9) below:

$$CD = \sqrt{2T}/n(n-1) \left[\sum_{i=1}^{N-1} \sum_{j=1+1}^N \rho_{ij} \right] \quad (9)$$

After the cross-sectional dependence test, the study proceeds to establish the stationary properties of the variables. To determine the unit root of the variables, we employ both parametric and nonparametric unit root test as proposed by Wu et al. (2016). Because of statistical weaknesses, we employ Im, Pesaran and Shin (2003), Harris and Tzavalis (1999) and Maddala and Wu (1999)'s Fisher unit root tests and the CIPS unit root test proposed by Pesaran (2007) to account for the cross-sectional dependencies. With respect to these tests, the rejection of the null hypothesis of the panel containing unit roots (nonstationary) implies that the panels are homogenously stationary. However, in the CIPS unit root test, a rejection of the null hypothesis of no homogenous stationarity indicates that there exists heterogenous stationarity. With respect to the panel cointegration test (long run relationship), this study applies Pedroni's (2004) cointegration test, and as a robustness check, we further, use Kao's (1999) cointegration tests to examine whether there exists a panel long-run association among the sample variables. Both the Pedroni and the Kao tests have the null hypothesis of no cointegration (lack of long-run relationship among the variables) as against the long-run relationship (cointegration) of the alternate hypothesis. The rejection (non-rejection) of the null hypothesis implies the presence of a long-run relationship among the variables (no cointegration).

In the attempt to include an interaction between FDI and PIES, Brambor, Clark and Golder (2006) argued that it is imperative to generate the marginal effect and its significance. In spite of that, we generate the marginal effect of FDI in the estimable models by calculating the partial derivatives of environmental quality with respect to FDI and we obtain the standard error of the marginal effects to establish its significance. The general partial derivatives specification for our estimable models is shown in Equation (10) below:

$$\frac{\delta EQ_{it}}{\delta FDI_{it}} = \beta + \gamma PIES \quad (10)$$

Further, to assess the overall impact of FDI and policy and institutions for environmental sustainability as well as their interaction on the environment but not just some aspect of the environment, the study employs the Panel Principal Component (PCA) analysis to create environmental quality index, using the three aforementioned measures of environmental quality (i.e., carbon dioxide emission, natural resource depletion and forest reserve depletion). The environmental quality index is constructed, using the normalised formula below as adopted by Owusu-Ankamah and Sakyi (2020). It is worth noting that the relative standard deviation is used as weight for the sub-indices.

$$EQI_t = \Omega_1 \left(\frac{CO_{2t} - \min CO_2}{\max CO_2 - \min CO_2} \right) + \Omega_2 \left(\frac{NRD_t - \min NRD}{\max NRD - \min NRD} \right) + \Omega_3 \left(\frac{FRD_t - \min FRD}{\max FRD - \min FRD} \right)$$

where EQI, CO_2 , NRD, FRD and Q represent environmental quality index, carbon dioxide emission, natural resource depletion, forest reserve depletion and the relative standard deviation, respectively. The EQI is normalised to zero and one, with zero implying poor (or low) environmental quality and better (or high) environmental quality, as the value is closer to one.

4. Analysis and Discussion of Empirical Results

Under this section, we discuss and analyse the empirical estimation results. We, first, discuss the descriptive statistics and the correlation among the sample variables. After that, we discuss the preliminary (cross-sectional dependence, unit root and the cointegration) test results. Following that, we analyse the long- and short-run results as well as the marginal effect results of the interaction between FDI and policy and institutions for environmental sustainability. Finally, we present and discuss the principal component analysis report.

4.1 Descriptive Statistics and Correlation Analysis

Reported in tables 3 and 4 are the variables descriptive statistics and the correlation matrix results, respectively.

[INSERT TABLE 3 HERE]

It is observed from Table 3 that the average values of carbon dioxide emission, natural resource depletion and forest reserve depletion are about -1.66, 2.01 and 6.17, respectively. It is observed that, on average, there is relatively smaller dispersion around the mean values of the respective variables, as the standard deviation of the variables does not deviate significantly from the average values. It is, further, noticed that the maximum and minimum values of the sample data are 32.26 and -5.10, respectively.

With respect to the correlation among the variables in Table 4, we noticed that FDI and policy and institutions for environmental sustainability (PIES) have a positive association with the environmental quality measures, with the exception of FDI tending to have a negative relationship with forest reserve depletion measure. While domestic investment has a positive correlation with carbon emissions and environmental quality index, the association tends to be negative with natural resource depletion and forest reserve depletion. On average, we observe from the correlation matrix that, the associations among the variables are less than 0.50, with few exceptions, which is an indication that there is less likelihood for multicollinearity to exist in the dataset employed.

[INSERT TABLE 4 HERE]

4.2: Panel Cross-sectional Dependencies Test Results

Table 5 presents the cross-sectional dependencies test results.

Among the variables used in the study, it is revealed from Table 5 that only 3 variables, namely FDI, domestic investment and trade openness, exhibit cross-sectional independencies across the 23 SSA countries. This is because the probability values (0.118, 0.632 and 0.347) of these variables exceed the conventional 5% significance level, implying a non-rejection of the null hypothesis of cross-sectional independencies. Aside these variables, all the other variables give an indication of cross-sectional dependencies, given that the probability values lead to rejection of the null hypothesis at a high significance level (1%). With that, we can say that there exist cross-sectional dependencies across the 23 SSA countries, as majority of the variables indicate cross-sectional dependencies, and with that, policymakers should consider cross-sectional dependencies among countries when implementing policies.

[INSERT TABLE 5 HERE]

4.3 Panel Unit Root Test Results

Table 6 shows the results of the panel unit root test. Despite the cross-sectional dependencies among the variables, we employ the CIPS unit root test by Pesaran [53] to account for the cross-sectional dependencies existing among the variables. A different unit root test is employed for consistency and robustness.

[INSERT TABLE 6 HERE]

From Table 6, it is observed that all the sample variables are stationary. Specifically, all the tests (IPS, H-T, Fisher and CIPS) show that carbon dioxide emission, natural resource depletion, forest reserve depletion, policy and institutions for environmental sustainability and trade openness are stationary at the first difference [$I(1)$] whereas FDI and domestic investment are stationary at the levels [$I(0)$]. While the H-T, Fisher and CIPS (IPS, H-T and Fisher) tests show that the environmental quality index (international tourism) is stationary at the levels (first difference), the IPS (CIPS) shows that the environmental quality index is stationary at the first difference (levels). Also, the Fisher and CIPS tests indicate that urbanisation is stationary at the levels, but the IPS shows that it is stationary at the first difference. With regard to economic growth, all the tests reveal that it is stationary at the first difference, except the Fisher test, which shows that it is stationary at the levels.

After a valid confirmation of panel stationarity among the variables, the study then proceeds to establish whether there exists a long-run relationship between the variables, using both Pedroni's (2004) and Kao's (1999) cointegration tests.

4.4 Panel Cointegration Test Results

Reported in Table 7 is the cointegration test results.

[INSERT TABLE 7 HERE]

From Table 7, it can be seen that there is the validation of a cointegration relationship among the dependent variable (environmental quality) and the explanatory variables in all the estimable models (1, 2, 3 and 4), as shown by the Pedroni's and Kao's cointegration tests. This is because, the test statistics in both tests indicate significance at 1% and 5% error levels. This implies a rejection of no cointegration null hypothesis. Given the presence of a long-run relationship among the variables, the study continues to estimate the long- and short-run results as well as the marginal effect of FDI on environmental quality, using the Generalised Method of Moment (system-GMM) estimation technique.

4.5 Estimation Results and Their Marginal Effect

The long-run results and their marginal effects are reported in Table 8 and Table 9, respectively while the short-run results and their marginal effects are shown in Table 10 and Table 11, respectively. We, first, analyse the long-run results and their marginal effects and, then, followed with the short-run results and their marginal effects. In this analysis, it is important to note that a positive and a negative effect on carbon emission, natural resource depletion, forest reserve depletion and environmental quality index means deterioration of environmental quality and improvement in environmental quality, respectively.

Starting with Model 1, where environmental quality is measured by carbon emission, it is observed that policy and institutions for environmental sustainability is positively and significantly associated with CO_2 emissions, thereby, deteriorating environmental quality. However, we find the effect of policy and institutions for environmental sustainability on natural resource depletion (Model 2) and forest reserve depletion (Model 3) to be negative and significant (improving environmental quality), but its overall impact is insignificant on the environment (Model 4) in the long run. Specifically, the coefficient in Model 1 indicates that an additional improvement in policy and institutions for environmental sustainability worsens environmental quality (increasing

CO_2 emission) by about 0.62 percent at a 1% error level. This outcome can be attributed to the fact that the attitude of policy and institutions towards carbon dioxide emissions in SSA is weak, and this could explain why CO_2 emissions continue to increase in SSA countries. Also, the coefficient in Model 2 (Model 3) reveals that an improvement in policy and institutions for environmental sustainability improves environmental quality in SSA (reducing natural resource and forest reserve depletion) by about 1.01 percent (0.04 points) at a 1% (10%) significance level. These results indicate the significance of policy and institutions for environmental quality in SSA countries, and for that matter, policymakers should pay utmost attention to policies that enhance environmental quality. The negative outcome of policy and institutions for environmental sustainability is in line with Bokpin (2017), Abid (2017) and Adams et al. (2020) whereas the positive effect is consistent with Hao et al. (2020), Farooq et al. (2020) and Asongu and Odhiambo (2020).

[INSERT TABLE 8 HERE]

With regard to FDI, it is noticed that the unconditional effect (when there exists no policy and institutions for environmental sustainability) of FDI (Table 8) improves environmental quality in models 1 and 3, that is, it decreases carbon emissions and forest reserve depletion. It, however, tends to worsen environmental quality (increasing natural resource depletion) in Model 2 but has insignificant effect on the overall environment (Model 4). To understand the real effect of FDI on environmental quality, it is prudent to account for the conditional impact of FDI on environmental quality, that is the marginal effect from the interaction term. This is because the partial derivatives in the estimable models show how FDI affects environmental quality when policy and institutions for environmental sustainability is at its mean (i.e., $\frac{\delta EQ_{it}}{\delta FDI_{it}} = \beta + \gamma PIES$). We estimate the long-run marginal effect in Table 9 and we observe that an additional increase in FDI improves environmental quality in models 1, 3 and 4, but the effect is insignificant in Model 4. However, FDI worsens environmental quality (depleting natural resources) in Model 2. Specifically, the coefficients in Model 1 show that if policy and institutions for environmental sustainability in SSA is at its mean (or improves), FDI will improve environmental quality (and reduce carbon emission) by about 0.65 and 1.02 percent at the 50th-95th percentiles, respectively, if FDI flows in SSA increase by one point and are significant at 5% error level, holding all other variables constant. In Model 3 (that is forest reserve depletion), the coefficients indicate that a single increase in FDI will improve environmental quality by approximately 0.20, 0.13 and 0.08 points at all percentile levels, respectively, if policy and institutions for environmental sustainability in SSA is at its mean (or improves) and is significant at 1% error level when all other covariates are constant. These results are consistent with the pollution halo hypothesis, which argues that foreign companies use modern technology and, hence, improve environmental quality.

[INSERT TABLE 9 HERE]

The coefficient in Model 2 (that is, natural resource depletion), however, reveals that FDI will deteriorate environmental quality by about 0.70 percent at the 50th percentile for any additional increase in FDI when policy and institutions for environmental sustainability in SSA is at its mean (or improves) and is significant at 10% error level, holding all other variables constant. This outcome supports the pollution haven hypothesis and the scale effect hypothesis. Overall, we notice that FDI improves environmental quality by 0.07 points at the 5th and 25th percentiles, respectively, even though, it tends to degrade the environment from the 50th-95th percentile by about 0.19 and 0.46 points, respectively, for an additional increase in FDI, if policy and institutions for environmental sustainability in SSA is at its mean (or improves), holding all covariates constant but is insignificant, and this

could be because the measures for environmental quality do not move in tandem, as shown by the different signs in Table 8.

Moving to the control variables in the long-run results, it is found that domestic investment in the long run improves environmental quality, specifically, reducing carbon emissions and natural resources depletion, in models 1 and 2 as well as in Model 4 (the overall effect), but the effect is insignificant in Model 4 (environmental quality index). Domestic investment's impact on environment quality tends to be positive (deteriorating the environment) in Model 3 (forest reserve depletion). The coefficient in models 1 and 2 shows that, all other things held constant, a one-percent increase in domestic investment in SSA countries will enhance environmental quality by about 0.23 percent at 1% and 5% significance levels, respectively. This outcome could be attributed to the fact that domestic firms, knowing very well how poor environmental quality will harm their welfare, are less likely to engage in activities that will deteriorate the environment. Bokpin (2017) reported similar results. However, the coefficient in Model 3 (forest reserve depletion) indicates that environmental quality will be worsened by about 1.33 points and is significant at 1% significance level, if domestic investment in SSA countries rises by one percent, when all other variables are held constant. Citizens, in their quest to undertake businesses, may damage or destroy the forest reserve, leading to poor environmental quality. This result is in line with Abid (2017).

Further, we observe that, while international tourism improves environmental quality, that is it has a negative effect on natural resource depletion and the environmental quality index, in models 2 and 4, it tends to worsen environmental quality in models 1 and 3, though we find the effect on environmental quality index to be insignificant. The coefficient shows that a one-percent rise in international tourism will enhance environmental quality by about 0.12 percent, significant at 1% error level, and 0.74 points in models 2 and 4, respectively, but will deteriorate environmental quality by about 0.04 percent and 0.76 points in models 1 and 3, respectively, at a 5% and 1% significance levels, respectively. The positive effect of international tourism on environmental quality is consistent with findings by Udemba (2019). Trade openness in all the estimation models, though insignificant in Model 4, is observed to deteriorate environmental quality. The coefficients, specifically, reveal that environmental quality will deteriorate by about 0.61 percent, 0.53 percent and 1.68 points in models 1, 2 and 3, respectively, at a 1% and 5% significance levels, if trade openness increases by one percent, holding all other variables constant. This result agrees with the scale effect of the trade openness concept, which argues that trade openness increases carbon emissions and, thus, deteriorates environmental quality, due to heavy consumption of energy and natural resources. Abid (2017) and Asongu and Odhiambo (2020) reported similar findings, but this result contradicts those of Ansari (2019) and Ahmad et al. (2020).

With respect to urbanisation, we observe that urbanisation deteriorates or has positive and significant effect on environmental quality and, thus, increases natural resource depletion in Model 2, and its effect on other measures on environmental quality is insignificant. Specifically, the coefficient depicts that a one-percent rise in urbanisation induces poor environmental quality by about 0.44 percent at 1% significance level, holding all other variables constant. Pressure on the environment as population tends to grow can lead to poor waste disposal as well as depletion of natural resources, resulting in bad environmental quality. While economic growth deteriorates environmental quality by increasing carbon emission in Model 1, the effect is revealed to enhance environmental quality as it decreases natural resource and depletes forest reserve in Model 2 and Model 3, respectively. The coefficient indicates that a one-percent increase in economic growth will deteriorate environmental quality by about 1.26 percent in Model 1, that is 0.61 percent and 0.07 points in Model 2 and Model 3, respectively, which

are all significant at 1% significance level. The negative effect is in line with findings by Bokpin (2017) whereas the positive impact on carbon emissions conforms with studies by Gunarto (2020), Aluko and Obalade (2020), Khan et al. (2020), Ganda (2020) and Hao et al. (2020).

Turning to the short-run results reported in Table 10, though there exist some differences in the signs, magnitudes and significance, the short-run results do not differ much from the long-run results.

The short-run results in Table 10 reveal that the lagged environmental quality measures, that is carbon emission, natural resource depletion, forest reserve depletion and the index, all have a significant positive effect on environmental quality, except natural resource depletion, which is insignificant. The coefficients depict that a previous one-percent increase in carbon emissions, that is forest reserve depletion and the environmental quality index, induces carbon emissions (forest reserve depletion and the environmental quality index) to rise by about 1.58 percent (2.20 and 0.87 points, respectively) at a 1% error level when all other factors are constant. This outcome indicates that there exists no convergence as the positive coefficient indicates a drift. This estimate confirms findings by Abid (2017), Farooq et al. (2020), Khan et al. (2020), Asongu and Odhiambo (2020) and Adams et al. (2020). In the short run, we observed that policy and institutions for environmental sustainability enhances environmental quality, specifically, decreases carbon emissions and natural resource depletion, in models 1 and 2. The coefficient shows that, if all other things are controlled, a one-percent improvement in policy and institutions for environmental sustainability decreases carbon emissions and natural resource depletion by about 0.36 percent and 0.85 percent, respectively, at 1% significance level. However, its effect on forest reserve depletion (which differs from the long-run results) and environmental quality index is insignificant. The short-run effect of policy and institutions for environmental sustainability also emphasises the vital role of policy and institutions geared towards environmental protection and the need for it to be given keen attention in SSA countries to improve environmental quality. This effect is consistent with Abid (2017), Bokpin (2017) and Adam et al. (2020).

Contrary to the long-run results, we notice that the unconditional and conditional impacts of FDI deteriorate environmental quality in the short run in all the models (1, 2, 3 and 4). Specifically, the marginal effect, that is the conditional effect of FDI, in Table 11 reveals that, all other variables held constant, a single increase in FDI will deteriorate environmental quality (increasing carbon emission, natural resource depletion and forest reserve depletion and decreasing the index value closer to zero) by about 0.38 and 0.59 percent at the 50th-95th percentile, respectively, in Model 1, 0.59 percent at the 50th percentile in Model 2, 0.23, 0.17 and 0.10 points at the 5th-95th percentile in Model 3 and 0.02 and 0.06 points at the 50th-95th percentile, respectively, in Model 4, if policy and institutions for environmental sustainability is at its mean (or improves) and are all significant at the 5%, 10%, 1% and 10% significance levels in models 1, 2, 3 and 4, respectively.

[INSERT TABLE 10 HERE]

This outcome could be that policies and institutions that protect the environment in SSA countries are less stringent in the short run to monitor or scrutinise the FDI flows properly, assessing foreign companies with modern technology, and, in turn, cause FDI to deteriorate the environmental quality in SSA. These short-run results, therefore, validate the pollution haven hypotheses, which holds that there exists environmental pollution in developing countries because of less stringent policies. Jiang (2015) and Naz et al. (2019) reported similar outcomes. The results, however, contradict the findings of Abid (2017) and Bokpin (2017).

With respect to domestic investment in the short run, we realise that domestic investment enhances environmental quality in models 2, 3 and 4. However, its impact in Model 1 (carbon emission) deteriorates environmental quality, which differs from that of the long-run results. The coefficient indicates that a percent (or single) increase in domestic investment improves environmental quality by approximately 0.19 percent (1.59 and 0.89 points) in Model 2 (Model 3 and Model 4, respectively) and is significant at 1% and 5% significance levels in models 2, 3 and 4 whereas the coefficient in Model 1 shows that environmental quality will deteriorate by about 0.13 percent at 5% significance level, if domestic investment increases by one percent, holding all covariates constant. As argued earlier, in the case of the long-run results, domestic investors concerned about their welfare are less likely to engage in activities that harm the quality of the environment, and that could explain why domestic investment improves environmental quality in models 2, 3 and 4. This effect contradicts Bokpin (2017) and Hao et al. (2020), but the positive impact on carbon emissions in Model 1 supports the findings of Bokpin (2017).

[INSERT TABLE 11 HERE]

Unlike the results in the long run, we observe from the short-run results that international tourism improves, that is has a negative impact on, environmental quality in all the models, though its effect in Model 4 is observed to be insignificant. The coefficient indicates that, all things being equal, a percent rise in international tourism is associated with 0.03 and 0.10 percent (0.91 points) in models 1 and 2 (Model 3) at a 5% and 1% (10%) significance levels, respectively. This result contradicts the study by Udemba (2019). Compared to the long run, we notice that trade openness in the short run improves environmental quality in Model 1 (Model 2). To the contrary, its effect is insignificant in models 3 and 4. Precisely, a percent increase in trade openness induces environmental quality to improve by about 0.36 and 0.45 percent in Model 1 and Model 2, respectively, and are significant at 1% significance level, when controlled for all other variables. While the long run supports the scale effect concept of trade openness, the short run only supports it in Model 2. Further, economic growth is observed to improve environmental quality in SSA in models 1 and 2 (models 3 and 4), but the impact is insignificant in Model 4. The coefficient reveals that quality of environment in SSA countries will improve by about 0.73 and 0.52 percent (0.08 points) in models 1 and 2 (Model 3), respectively, if economic growth increases by a percent and is significant at 1% (5%) significance level in both models 1 and 2 (Model 3) and when all other factors are held constant. The negative effect of economic growth is in line with Bokpin (2017), but Ojewumi and Akinlo (2017) and Ahmad et al. (2020) reported positive effects. Just like we observe in the long run, urbanisation tends to have a positive significant effect, that is deteriorates environmental quality, only in Model 2, and the coefficient depicts that, all things being equal, a percent increase in urbanisation is associated with 0.37 percent deterioration of environmental quality in SSA countries. Adams et al. (2020) and Ahmad et al. (2020) reported similar results.

The second order [AR(2)] serial correlation and the overidentification tests in Table 10 indicate that there is the lack of a second order serial correlation and there exist valid instruments, respectively, in all the estimable models (1, 2, 3 and 4). This is because, the probability values of the AR(2) [0.098, 0.231, 0.974 and 0.145] and the Hansen test (0.753, 0.073, 0.269 and 0.194) fail to reject the null hypothesis of no second order serial correlation and instruments validity at a 5% significance level. This reveals the accuracy and consistency of the estimable models' parameters.

4.6 Principal Component Analysis Report

Table 12 shows the report of the principal component analysis.

[INSERT TABLE 12 HERE]

It is observed from Table 12 that all the components (carbon emission, natural resource depletion and forest reserve depletion) have a strong positive association with the environmental quality index. Further, we notice that carbon dioxide emissions and natural resource depletion are the predicted variables for the index, since its eigen values (1.4809 and 1.08470) are greater than one and also show higher proportion (about 0.50 and 0.36) of the environmental quality index created. The report from Table 12 may be an indication that carbon emissions and natural resource depletion are key environmental issues in SSA countries and should be a concern, when implementing policies for environmental protection. Given that the Bartlett's probability value is significant at 1% percent, we conclude that the three variables used for the index are intercorrelated.

5. Conclusion and Policy Suggestion

With environmental issues being a major concern globally, with SSA countries not an exception to this phenomenon, this study examines the association links between FDI, policy and institutions for environmental sustainability and environmental quality, using a balanced panel data across 23 SSA countries from 2005 to 2018. The study employs the Generalised Method of Moment (system-GMM precisely) as an estimation technique for the analysis. The results reveal that foreign direct investment (FDI) improves environmental quality in the long run (models 1, 3 and 4) whereas in the short run, FDI deteriorates environmental quality in all the models, when it interacted with policy and institutions for environmental sustainability. Policy and institutions for environmental sustainability, in this study, is observed to improve environmental quality in SSA in both the long run (models 1 and 3) and the short run (models 1 and 2). With regard to the control variables, the GMM results indicate that domestic investments in SSA improve environmental quality in both the long run (models 1, 2 and 4) and the short run (models 2, 3 and 4). Further, international tourism is revealed to improve environmental quality in the short run but deteriorate environmental quality in the long run. Also, trade openness deteriorates environmental quality in all the models in the long run, but the effect improves environmental quality only in Model 1, in the short run. While urbanisation in both the long run (Model 2) and the short run (Model 2) deteriorates environmental quality, economic growth, on the other hand, improves environmental quality in both the long run (models 2 and 3) and the short run (models 1 and 2). The study, therefore, concludes, based on the outcome, that policy and institutions for environmental sustainability in SSA is worthy, as it improves environmental quality and complements FDI to improve environmental quality in the long run. The study, further, concludes that domestic investment is also important to improve environmental quality in SSA.

On the policy front, the study, based on the impact of policy and institutions for environmental sustainability, suggests that governments, policymakers and other stakeholders in SSA implement more stringent policies that focus on environmental protection. This can be accomplished if policies and institutions that are geared towards environmental quality are free from political interferences and corruption. This will ensure that companies, especially foreign ones, adopt technologies that do not harm environmental quality in SSA. Also, on the outcome of domestic investment on environmental quality, the study suggests that governments and other stakeholders in SSA implement policies that enhance domestic investment to improve environmental quality. This can be attained if governments and stakeholders ensure a more friendly business environment in SSA. Doing so will enhance domestic investments and, hence, improve environmental quality, according to the results and, in turn, improve citizenry welfare and, to larger extent, foster economic growth and development in SSA.

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LIST OF TABLES

Table 1: Summary of Related Past Literature

Author (Year)	Country (Duration)	Title	Methodology	Key Findings
Kiviyiro and Arminen (2014)	6 SSA countries (1971-2009)	Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: A causality analysis	ARDL and Granger causality test	FDI exerts a significant positive effect on carbon emissions in Zimbabwe and a negative effect on South Africa, Kenya and Democratic Republic of Congo.
Ojewumi and Akinlo (2017)	33 SSA countries (1980-2013)	Foreign direct investment, economic growth and environmental quality	PVEC	FDI has a significant positive impact on CO_2 emissions.
Ssali et al. (2019)	6 SSA countries (1980-2014)	Investigating the nexus among environmental pollution, economic growth, energy use, and foreign direct investment.	PMG	FDI has insignificant impact on environmental quality.
Adams et al. (2020)	19 SSA countries (1980-2011)	Transport energy consumption and environmental quality: Does urbanization matter?	DFE model and GMM	FDI improves environmental quality.
Asongu and Odhiambo (2020)	49 SSA countries (2000-2018)	Trade and FDI Thresholds of CO_2 Emissions for a Green Economy.	GMM	FDI has a significant positive effect on CO_2 emissions.
Ganda (2020)	44 SSA countries (1990-2014)	The influence of growth determinants on environmental quality.	PMG and Dumitrescu and Hurlin's causality test	Financial development has a significant negative impact on environmental quality.
Aluko and Obalade (2020)	35 SSA countries (1985-2014)	Financial development and environmental quality: Is there a technology effect?	Augmented mean group estimator and Dumitrescu and Hurlin's causality test	Financial development has a significant negative effect on CO_2 emissions.

Shahbaz et al. (2015)	99 high, middle- and low-income countries. (1975-2012)	Does foreign direct investment impede environmental quality?	FMOLS and Dumitrescu and Hurlin's causality test	FDI and the square of FDI both improve environmental quality.
Seker et al. (2015)	Turkey (1974-2010)	The impact of foreign direct investment on environmental quality	ARDL and VEC causality test	FDI has a positive and significant impact on CO_2 emissions.
Jiang (2015)	28 Chinese provinces (1997-2012)	Foreign direct investment, pollution, and the environmental quality	FE, FD, RE and OLS	FDI has a positive significant effect on pollution emissions (environmental quality).
Abdouli and Hammami (2017)	17 MENA countries (1990-2012)	Investigating the causality links between environmental quality, foreign direct investment and economic growth.	Simultaneous equation panel VAR model	FDI has a significant positive effect on CO_2 emissions.
Abid (2017)	58 MENA and 41 EU countries (1990-2011)	Do economic, financial and institutional developments matter for environmental quality?	System-GMM	FDI exerts a significant negative effect on CO_2 emissions in European Union countries and a positive significant impact on CO_2 emissions in MENA countries.
Bokpin (2017)	Africa (1990-2013)	Foreign direct investment and environmental sustainability in Africa: The role of institutions and governance	FE and RE model as well as panel corrected standard errors and the robust OLS	FDI and quality of institution has a significant positive and negative effect, respectively, on environmental sustainability.
Ma et al. (2019)	China (2000-2013)	The Impact of economic growth, FDI and energy intensity on China's manufacturing industry's CO_2 emissions	Fixed effect panel quantile regression	FDI has a significant positive impact on China's manufacturing industry CO_2 emissions.
Udemba (2019)	Chinese economy (1995Q1-2016Q4)	Triangular nexus between foreign direct investment, international tourism, and energy consumption	ARDL	FDI exerts a positive impact on CO_2 emissions in both the short and long run.
Shahbaz et al. (2019)	MENA (1990-2015)	Foreign direct Investment- CO_2 emissions nexus in Middle East and North African countries	GMM and Dumitrescu and Hurlin's causality test	FDI has a positive significant effect on CO_2 emissions while the square of FDI has a negative significant effect on CO_2 emission.

Saud et al. (2019)	59 BRI countries (1980-2016)	Impact of financial development and economic growth on environmental quality.	DSUR and Dumitrescu and Hurlin's causality tests	FDI exerts a significant negative effect on CO_2 emissions (environmental quality).
Naz et al. (2019)	Pakistan (1975-2016)	Moderating and mediating role of renewable energy consumption, FDI inflows, and economic growth on carbon dioxide emissions	Robust and non-linear robust least squares	FDI and the interaction between FDI and renewable energy consumption exert a significant positive effect on carbon emission.
Mert et al. (2019)	26 European countries (1960-2014)	Interrelationships among foreign direct investments, renewable energy, and CO ₂ emissions for different European country groups	PMG	FDI has significant positive effect on CO_2 emission.
Ahmad et al. (2020)	90 Belt and Road countries (1990-2017)	Does financial development and foreign direct investment improve environmental quality?	Driscoll-Kraay standard error pooled OLS and D&H panel causality test	FDI exerts a significant negative effect on CO_2 emissions. Bidirectional causality exists between FDI and CO_2 emissions.
Gunarto (2020)	Asian States (1970-2014)	Effect of Economic Growth and Foreign Direct Investment on Carbon Emission	ARDL	FDI exhibits an insignificant effect on carbon emissions in Asian states.
Farooq et al. (2020)	OIC countries (1991-217)	How do globalization and foreign direct investment affect environmental quality?	GMM	FDI and institutional quality significantly affect CO_2 emissions positively.
Khan et al. (2020)	58 BRI countries (1995-2016)	The repercussions of foreign direct investment, renewable energy and health expenditure on environmental decay	System GMM and FMOLS	FDI has a significant and negative effect on CO_2 emissions.
Hao et al. (2020)	30 provinces in China (1998-2016)	How do FDI and technical innovation affect environmental quality?	Spatial econometric models	FDI has a significant negative effect on environmental pollution.

Note: SSA, MENA, EU, BRI, OIC, ARDL, PVEC, PMG, D&H, DFE, GMM, FMOLS, VEC, FE, RE, FD, OLS, VAR and DSUR represent Sub-Saharan Africa, Middle East and North Africa, European Union, Belt and Road Initiatives, Autoregressive Distributed Lag, Panel Vector Error Correction, Pooled Mean Group, Dumitrescu and Hurlin's, dynamic fixed effect, Generalized Method of Moment, Fully Modified Ordinary Least Squares, Vector Error Correction, fixed effect, random effect, first difference, ordinary least squares, Vector Autoregressive And Dynamic Seemingly Unrelated Regression, respectively.

Table 2: Brief Description of Variables

Variable	Measurement/Proxy	Definition	Notation	Source
Carbon dioxide emission	Metric tons per capita	Emissions stemming from the burning of fossil fuels and the manufacture of cement. They include those produced during consumption of solid, liquid and gas fuels and gas flaring	CO_2	WDI (2020)
Natural resource depletion	Natural resources depletion (% of GNI)	The sum of net forest depletion, energy depletion and mineral depletion	NRD	WDI (2020)
Forest reserve depletion	Net forest depletion (% of GNI)	The product of unit resource rents and the excess of roundwood harvest over natural growth	FRD	WDI (2020)
Policy and institutions for environmental sustainability	Policy and institutions for environmental sustainability rating (1=low to 6=high)	Assess the extent to which environmental policies foster the protection and sustainable use of natural resources and the management of pollution	PIES	WDI (2020)
Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	The net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor	FDI	WDI (2020)
Domestic investment	Gross fixed capital formation (% of GDP)	Formerly gross domestic fixed investment. It includes land improvements, plant, machinery and equipment purchases and the construction of roads, railways, and others	DI	WDI (2020)
International tourism	Number of arrivals	The number of tourists who travel to a country other than that in which they usually reside, and outside their usual environment, for a period not exceeding 12 months	IT	WDI (2020)
Trade openness	Trade (% of GDP)	The sum of exports and imports of goods and services as a share of GDP	TO	WDI (2020)
Urbanisation	Urban population	Urban population refers to people living in urban areas as defined by national statistical offices	URB	WDI (2020)
Economic growth	GDP per capita (constant 2010 US\$)	Gross domestic product divided by midyear population	EG	WDI (2020)

Note: WDI denotes World Development Indicators Source.

Table 3: Descriptive Statistics

Variable(s)	Mean	Standard Deviation	Minimum	Maximum
lnCO ₂	-1.6640	1.0552	-5.9985	0.5097
lnNRD	2.0138	1.0165	-1.4554	4.4046
FRD	6.1689	5.3364	-0.4778	32.2574
EQI	0.0003	0.8290	-1.8618	1.8311
FDI	-0.0001	0.3116	-0.3960	0.6040
PIES	0.0002	0.4610	-0.4829	0.5171
lnDI	2.9949	0.4017	0.7728	3.9946
lnIT	12.3859	1.4277	8.5172	15.6259
lnTO	4.0443	0.4245	2.9497	5.0869
lnURB	15.0564	1.4518	12.0464	18.4067
lnEG	6.7140	0.6908	5.3509	8.2541

Note: CO₂, NRD, FRD, EQI, FDI, PIES, DI, IT, TO, URB and EG denote carbon dioxide emission, natural resource depletion, environmental quality index, forest reserve depletion, foreign direct investment, policy and institutions for environmental sustainability, domestic investment, international tourism, trade openness, urbanisation and economic growth, respectively.

Table 4: Correlation Matrix

	$\ln CO_2$	$\ln NRD$	$\ln FRD$	EQ index	FDI	PIES	$\ln DI$	$\ln IT$	$\ln TO$	$\ln URB$	$\ln EG$
$\ln CO_2$	1.										
$\ln NRD$	-0.337	1									
FRD	-0.602	0.439	1								
EQI	0.001	0.299	0.236	1							
FDI	0.021	0.044	-0.135	0.034	1						
PIES	0.038	0.036	0.043	0.234	0.071	1					
$\ln DI$	0.307	-0.155	-0.282	0.039	0.158	0.097	1				
$\ln IT$	0.296	-0.054	-0.134	0.069	0.078	0.076	0.242	1			
$\ln TO$	0.361	-0.007	-0.127	0.127	0.101	0.059	0.349	-0.095	1		
$\ln URB$	-0.025	0.507	-0.046	0.124	0.072	-0.031	0.056	0.493	-0.201	1	
$\ln EG$	0.835	-0.398	-0.750	-0.061	0.093	0.033	0.388	0.337	0.179	0.076	1

Note: CO_2 , NRD, FRD, EQI, FDI, PIES, DI, IT, TO, URB and EG denote carbon dioxide emission, natural resource depletion, forest reserve depletion, environmental quality index, foreign direct investment, policy and institutions for environmental sustainability, domestic investment, international tourism, trade openness, urbanization and economic growth, respectively.

Table 5: Cross-section Dependence Test Results

Variable(s)	CD Test	P-values
$\ln CO_2$	17.44	0.000
$\ln NRD$	9.17	0.000
FRD	19.50	0.000
EQI	11.87	0.000
FDI	1.56	0.118
PIES	7.83	0.000
$\ln DI$	0.48	0.632
$\ln IT$	18.91	0.000
$\ln TO$	0.94	0.347
$\ln URB$	59.47	0.000
$\ln EG$	36.39	0.000

Note: CO_2 , NRD, FRD, EQI, FDI, PIES, DI, IT, TO, URB and EG denote carbon dioxide emission, natural resource depletion, forest reserve depletion, environmental quality index, foreign direct investment, policy and institutions for environmental sustainability, domestic investment, international tourism, trade openness, urbanisation and economic growth, respectively.

Table 6: Unit Root Test Results

Variable	IPS		H-T		Fisher		CIPS	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
lnCO ₂	-1.299	-2.054***	0.965	0.345***	36.647	69.952**	-1.558	-2.788***
lnNRD	-1.573	-2.060***	0.764	0.167***	58.281	62.074*	-1.585	-2.405***
FRD	-1.377	-2.457***	0.768	-0.031***	57.203	60.934*	-1.421	-3.135***
EQI	-1.768	-2.397***	0.632***	0.022***	74.040***	112.068***	-2.372***	-3.413***
FDI	-2.448***	-3.259***	0.285***	-0.295***	69.490**	116.397***	-2.312**	-3.819***
PIES	-1.738	-2.614***	0.779	-0.035***	21.402	80.546***	-2.042	-3.281***
lnDI	-1.970**	-2.797***	0.595***	-0.023***	67.364**	134.421***	-2.165*	-3.371***
lnIT	-1.606	-2.830***	0.775	-0.149***	47.516	97.139***	-2.532***	-3.328***
lnTO	-1.480	-2.680***	0.749	-0.087***	38.834	79.861***	-1.611	-3.462***
lnURB	-1.524	-1.860**	0.998	0.782	468.590***	85.041***	-2.364***	-1.062
lnEG	-1.461	-2.584***	0.911	0.206***	62.539*	172.770***	-1.319	-2.910***

Note: CO₂, NRD, FRD, EQI, FDI, PIES, DI, IT, TO, URB and EG denote carbon dioxide emission, natural resource depletion, forest reserve depletion, environmental quality index, foreign direct investment, policy and institutions for environmental sustainability, domestic investment, international tourism, trade openness, urbanisation and economic growth, respectively. ***, ** and * represent 1%, 5% and 10% significance levels, respectively. -2.34, -2.17 and -2.07 are the critical values at 1%, 5% and 10%, respectively, for the CIPS test.

Table 7: Cointegration Test Results

Pedroni Cointegration				
	Model 1	Model 2	Model 3	Model 4
Panel v	-3.105***	-2.713***	-2.632***	-3.28***
Panel rho	5.335***	5.538***	5.72***	5.673***
Panel P-P	-8.183***	-7.686***	-6.362***	-7.981***
Panel ADF	3.533***	6.194***	5.249***	1.3
Group rho	7.35***	7.643***	7.582***	7.509***
Group P-P	-9.251***	-8.411***	-6.864***	-8.739***
Group ADF	5.705***	6.646***	4.693***	3.563***
Kao Cointegration				
ADF	3.0643***	-3.0871***	-1.6612**	-3.4139***

Note: *** and ** denote significance levels at 1% and 5%, respectively. Models 1, 2 and 3 represent the estimated model with CO_2 emission, natural resources depletion and forest reserve depletion as a measure of environmental quality, respectively, whereas Model 4 denotes the estimated model with environmental quality index as dependent variable.

Table 8: The GMM Long-Run Estimates

	Model 1	Model 2	Model 3	Model 4
PIES	0.6153*** (0.1378)	-1.0062*** (0.2413)	-0.0355* (0.0188)	0.0133 (0.0460)
FDI	-0.6421** (0.2971)	0.7075* (0.3618)	-0.1401*** (0.0367)	0.1843 (0.4181)
FDI*PIES	-0.7361 (0.8463)	-0.3900 (0.7890)	0.1138** (0.0567)	0.5254 (1.1928)
lnDI	-0.2301*** (0.0799)	-0.2252** (0.0890)	1.3276*** (0.5050)	-0.0692 (0.1458)
lnIT	0.0449** (0.0182)	-0.1209*** (0.0192)	0.7607*** (0.2183)	-0.7364 (1.5846)
lnTO	0.6116*** (0.0653)	0.5322*** (0.0839)	1.6789* (0.9702)	0.1682 (1.7918)
lnURB	-0.0004 (0.0185)	0.4434*** (0.0170)	-0.0507 (0.1795)	0.2945 (0.5897)
lnEG	1.2552*** (0.0317)	-0.6139*** (0.0317)	-0.0671*** (0.0029)	0.3905 (1.5831)

Note: ***, ** and * denote 1, 5 and 10 percent significance levels, respectively. Standard errors are in the parenthesis. Models 1, 2 and 3 represent the estimated model with CO_2 emission, natural resources depletion and forest reserve depletion as a measure of environmental quality, respectively, whereas Model 4 denotes the estimated model with environmental quality index (EQI) as dependent variable.

Table 9: Long Run Marginal Effect of FDI on Environmental Quality as Policy and Institutions for Environmental Sustainability Improves (or Is at Its Mean).

Percentiles	Percentile Values	Coefficient	Standard Error	Confidence Interval (95%)	
Model 1					
5%	-0.4829	-0.2867	0.5434	-1.3518	0.7784
25%	-0.4829	-0.2867	0.5434	-1.3518	0.7784
50%	0.0171	-0.6547**	0.2950	-1.2329	-0.0765
75%	0.5171	-1.0227**	0.4867	-1.9767	-0.0688
95%	0.5171	-1.0227**	0.4867	-1.9767	-0.0688
Model 2					
5%	-0.4829	0.8958	0.5848	-0.2504	2.0420
25%	-0.4829	0.8958	0.5848	-0.2504	2.0420
50%	0.0171	0.7008*	0.3589	-0.0026	1.4042
75%	0.5171	0.5058	0.4763	-0.4277	1.4393
95%	0.5171	0.5058	0.4763	-0.4277	1.4393
Model 3					
5%	-0.4829	-0.1951***	0.0619	-0.3164	-0.0738
25%	-0.4829	-0.1951***	0.0619	-0.3164	-0.0738
50%	0.0171	-0.1382***	0.0358	-0.2084	-0.0680
75%	0.5171	-0.0812***	0.0185	-0.1174	-0.0451
95%	0.5171	-0.0812***	0.0185	-0.1174	-0.0451
Model 4					
5%	-0.4829	-0.0694	0.1752	-0.4129	0.2740
25%	-0.4829	-0.0694	0.1752	-0.4129	0.2740
50%	0.0171	0.1933	0.4382	-0.6656	1.0521
75%	0.5171	0.4560	1.0318	-1.5664	2.4784
95%	0.5171	0.4560	1.0318	-1.5664	2.4784

Note: ***, ** and * denote 1, 5 and 10 percent significance levels, respectively. Model 1, 2 and 3 represent the estimated model with CO_2 emission, natural resources depletion and forest reserve depletion as a measure of environmental quality, respectively, whereas Model 4 denotes the estimated model with environmental quality index as dependent variable.

Table 10: The GMM Short-Run Results

	Model 1	Model 2	Model 3	Model 4
L.lnEQ1 (CO_2)	1.5805*** (0.1226)			
L.lnEQ2 (NRD)		0.1600 (0.2096)		
L.lnEQ3 (FRD)			2.2011*** (0.5089)	
L.EQ4 (EQI)				0.8715*** (0.2348)
PIES	-0.3572*** (0.0827)	-0.8452*** (0.1825)	0.0427 (0.0367)	0.1711 (0.5991)
FDI	0.3727** (0.1660)	0.5942* (0.3457)	0.1683*** (0.0433)	2.3689* (1.2593)
FDI*PIES	0.4272 (0.4862)	-0.3276 (0.7081)	-0.1367** (0.0573)	0.0675* (0.0358)
lnDI	0.1336** (0.0542)	-0.1891*** (0.0677)	-1.5946*** (0.5386)	-0.8891** (0.3458)
lnIT	-0.0261** (0.0128)	-0.1015*** (0.0292)	-0.9137* (0.4808)	-0.0947 (0.0682)
lnTO	-0.3550*** (0.0814)	0.4471*** (0.0946)	-2.0166 (1.6101)	0.0216 (0.2436)
lnURB	0.0002 (0.0108)	0.3725*** (0.0931)	0.0609 (0.2271)	0.0379 (0.0850)
lnEG	-0.7286*** (0.1513)	-0.5156*** (0.1291)	0.0805** (0.0334)	0.0502 (0.1664)
Constant	7.2479*** (1.4724)	-0.4207 (0.4200)	-0.3880** (0.1825)	0.0273 (0.0287)
No. of Observations	299	299	299	299
No. of Groups	23	23	23	23
No. of Instruments	19	19	19	19
AR(2) P-value	0.098	0.231	0.974	0.145
Hansen P-value	0.753	0.073	0.269	0.194

Note: ***, ** and * denote 1, 5 and 10 percent significance levels, respectively. Standard errors are in the parenthesis. Models 1, 2 and 3 represent the estimated model with CO_2 emission, natural resources depletion (NRD) and forest reserve depletion (FRD) as a measure of environmental quality, respectively, whereas Model 4 denotes the estimated model with environmental quality index (EQI) as a dependent variable.

Table 11: Short-Run Marginal Effect of FDI on Environmental Quality as Policy and Institutions for Environmental Sustainability Improves (Is at Its Mean).

Percentiles	Percentile Values	Coefficient	Standard Error	Confidence Interval (95%)	
Model 1					
5%	-0.4829	0.1664	0.3154	-0.4517	0.7845
25%	-0.4829	0.1664	0.3154	-0.4517	0.7845
50%	0.0171	0.3800**	0.1644	0.0579	0.7022
75%	0.5171	0.5937**	0.2698	0.0649	1.1224
95%	0.5171	0.5937**	0.2698	0.0649	1.1224
Model 2					
5%	-0.4829	0.7524	0.5871	-0.3983	1.9031
25%	-0.4829	0.7524	0.5871	-0.3983	1.9031
50%	0.0171	0.5886*	0.3404	-0.0785	1.2557
75%	0.5171	0.4248	0.3711	-0.3026	1.1522
95%	0.5171	0.4248	0.3711	-0.3026	1.1522
Model 3					
5%	-0.4829	0.2343***	0.0658	0.0978	0.3708
25%	-0.4829	0.2343***	0.0658	0.0978	0.3708
50%	0.0171	0.1659***	0.0427	0.0775	0.2544
75%	0.5171	0.0976***	0.0309	0.0335	0.1616
95%	0.5171	0.0976***	0.0309	0.0335	0.1616
Model 4					
5%	-0.4829	-0.0089	0.0108	-0.0314	0.0135
25%	-0.4829	-0.0089	0.0108	-0.0314	0.0135
50%	0.0171	0.0248*	0.0131	-0.0023	0.0520
75%	0.5171	0.0586*	0.0294	-0.0024	0.1197
95%	0.5171	0.0586*	0.0294	-0.0024	0.1197

Note: ***, ** and * denote 1, 5 and 10 percent significance levels, respectively. Models 1, 2 and 3 represent the estimated model with CO_2 emission, natural resources depletion and forest reserve depletion as a measure of environmental quality, respectively, whereas Model 4 denotes the estimated model with environmental quality index as a dependent variable.

Table 12: Principal Component Analysis Report

Environmental Quality Index	Eigen Value	Proportion Explain	Primary Variables	Eigen Vectors	Correlation Coefficient	Bartlett's P-value
Component 1	1.4809	0.4936	CO_2	-0.1277	0.8473	0.000
Component 2	1.0847	0.3616	NRD	0.3560	0.5311	
Component 3	0.4344	0.1448	FRD	0.6695	0.6495	

Note: The eigen value greater than one, based on the Kaiser criterion, is selected for the principal components. The null hypothesis of no intercorrelation between the variables for the Bartlett's sphericity test is tested against the alternate of variables intercorrelation. CO_2 , NRD and FRD denote carbon dioxide emission, natural resource depletion and forest reserve depletion, respectively.

Table 13: List of SSA Countries

Angola	Comoros	Guinea	Mali	Sudan
Burkina Faso	Congo, Dem. Rep.	Guinea-Bissau	Niger	Togo
Burundi	Ethiopia	Kenya	Nigeria	Uganda
Cabo Verde	Gambia, The	Lesotho	Rwanda	
Chad	Ghana	Malawi	Sierra Leone	

Declarations

- **Data availability**

The data is available on request from corresponding author.

- **Compliance with ethical standards Ethical approval and consent to participate**

This study did not use any kind of human participants or human data, which require any kind of approval.

- **Consent to publish**

Our study did not use any kind of individual data such as video and images.

- **Ethics approval and consent to participate**

This study did not use any kind of human participants or human data, which require any kind of ethical approval or consent to participate.

- **Consent for publication**

Not applicable.

- **Availability of data and materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

- **Competing interests**

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- **Authors Contributions**

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