ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

Impact of Climate Commitment on the Nexus between Institutional Quality and Private Investment in off-Grid Renewable Electricity in Sub-Saharan Africa (SSA)

Authors: Akono Etienne B. and Mandjeng Bekima Paul A.
Faculty of Economics and Applied Management of the University of Douala
Corresponding Author: Mandjeng Bekima Paul A.

Abstract:- This study examines the impact of institutional quality on private investment in off-grid renewable electricity in Sub-Saharan Africa (SSA), and analyses how climate commitment affects the relationship between the two factors. The analysis covers the period 2010 to 2022 and uses Generalised Method of Moments estimation to deal with endogeneity on a panel of SSA countries divided into five samples: Sub-Saharan, Central, Southern, East and West Africa. Firstly, our results indicate that institutional quality acts as an obstacle to private investment in off-grid renewable electricity, but the effect is not significant in all samples. Secondly, in some cases, they provide significant evidence for the existence of an interaction effect between institutional quality and climate commitment in promoting private investment in off-grid renewable electricity. A 1% increase in the interaction effect increases private investment by 11.7% in SSA, 3.3% in the East and 20% in the West. These findings have important policy implications, particularly the need for SSA countries to strengthen their climate action through electricity sector decarbonisation plans and energy efficiency policies that are attractive to climate finance.

Keywords:- *Off-Grid Renewable Electricity, Private Investment, Institutional Quality, Climate Commitment, Interaction Effect, Dynamic Panel Data Models.*

I. INTRODUCTION

Between 2010 and 2020, sub-Saharan Africa (SSA) received 57% of global private investment in decentralized renewable energy solutions, totalling USD 1.419 billion (Wood Mackenzie, 2021). This investment has resulted in more than 1.7 million households gaining access to electricity through stand-alone systems and over 140,000 households being connected to mini-grids from 2016 to 2020 according to International Renewable Energy Agency (IRENA, 2021b). However, this level of investment falls short of meeting the electrification needs of the region's 116 million rural households. As of 2020, decentralized systems were only able to serve 12 million households (IRENA, 2021b). This highlights the necessity for greater investment in off-grid systems to fully utilize the potential of renewable resources such as solar, wind, geothermal, and bioenergy, in order to achieve universal and affordable electrification by 2030. An estimated $20 billion per year in renewable energy investment is needed by 2030, according to a report by the International Energy Agency (IEA, 2011). The most notable observation is that East and West Africa received 94% of the investment captured in SSA between 2010 and 2020, of which 52% was allocated to six countries, namely Nigeria, Kenya, the United Republic of Tanzania, Rwanda, Côte d'Ivoire and Uganda, as reported by Wood Mackenzie (2021).

The low mobility of capital to developing countries is typically explained by the standard neoclassical model in terms of diminishing returns and weak market dynamics. However, the New Economics of Institutions argues that the quality of institutions plays a crucial role in attracting private investment. Strong institutions reduce transaction costs and ensure the profitability of investments (North, 1990), whereas institutional inefficiency acts as a tax that alters the risk-return profile (Smarzynska & Wei, 2002). Moreover, in countries with poorly protected property rights, there is a risk of expropriation (Henisz & Williamson, 1999). The United Nations Environment Programme conducted a survey in 2012 (UNEP, 2012), which identified ineffective enforcement of legislation, unreliable policies and support mechanisms, and political instability as significant barriers to investment in renewable energy in SSA. Overall, empirical studies on the relationship between institutional quality in general, or governance in particular, and private investment in renewable energy in SSA show that institutional inefficiency is a major challenge for renewable energy development (Diallo & Ouoba, 2023 ; Haldar and al., 2023 ; Wilson and al., 2022).

The role of climate change commitments in attracting green capital to developing countries has been suggested by some studies. Research by Brunnschweiler (2010) and Pfeiffer & Mulder (2013) shows that the Kyoto Protocol's Clean Development Mechanism (CDM) has stimulated renewable energy (RE) projects in developing countries. Additionally, Stadelmann & Castro's (2014) study shows that climate commitments stimulate RE deployment in emerging and developing countries. In contrast, Da Silva et

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

al.'s (2018) study on the determinants of renewable energy investment in sub-Saharan Africa finds that climate commitments do not have a significant impact. Green finance is crucial in supporting renewable energy projects by providing the necessary funds to invest in clean energy infrastructure. According to some studies, promoting regional and international cooperation on climate issues can help overcome political barriers by attracting green funds to local actors (Schwerhoff & Sy, 2017; Taghizadeh-Hesary & Yoshino, 2020; Chelminski, 2022; Mungai and al., 2022). According to Climate Policy Initiative (CPI, 2020) report, Africa has made progress in climate finance, with global flows increasing from an average of $8 billion annually in 2015-2016 to $34 billion in 2017-2018. This is a significant increase, although further progress is needed.

Although there is general evidence in the literature of the negative impact of low institutional quality on RE development in Africa, the role of climate commitment in RE development in the context of institutional inefficiency is not well understood. Our study brings some light to enrich the knowledge on that issue considering the interaction between institutional quality and climate commitment to explain the lack of private investment in renewable energy in the majority of SSA countries.

Our aim is twofold: to investigate the impact of institutional quality on private investment in off-grid renewable electricity in SSA and to examine how climate commitment affects this relationship between the two factors. We investigate whether institutional quality and climate commitment have a joint influence on private investment in off-grid renewable electricity, in addition to their individual effects. The paper addresses these questions using the dynamic two-steps difference GMM approach, which addresses endogeneity issues, on a panel of 48 SSA countries organised into five samples (SSA, Central, Southern, Eastern and Western Africa) over the period 2010-2022. We analyse private investment in off-grid renewable electricity in these samples using a synthetic index of governance indicators, a measure of climate commitment and an interaction variable, as well as two control variables. Firstly, our results indicate that institutional quality has a negative but not significant effect on private investment in off-grid renewable electricity in all samples. Secondly, in some cases, they provide significant evidence for the existence of an interaction effect between institutional quality and climate commitment in promoting private investment in off-grid renewable electricity.

The remainder of the document is structured as follows: Section 2 gives an overview of off-grid renewable electricity in SSA sub-regions. Section 3 presents a theoretical and empirical framework of the relationship between governance, climate commitment and private investment in RE. Section 4 describes the empirical strategy and data, while Section 5 reports and discusses the empirical results of our baseline model as well as robustness checks. Finally, Section 6 presents our main conclusions and policy implications.

II. OVERVIEW OF OFF-GRID RENEWABLE ELECTRICITY IN SUB-SAHARAN AFRICA

This section provides an overview of the decentralised renewable energy sector in SSA. Installed capacity of off-grid RES is based on IRENA data (2023), while technical potential is based on IRENA assessment (2021b) and Hoes (2014). Private investment in off-grid RES is based on Wood Mackenzie data (2021).

From 2010 to 2020, the world will invest $2.485 trillion in off-grid renewables. Sub-Saharan Africa (SSA) was the biggest beneficiary, receiving $1.419 billion. More than half of this ($822m) went to East Africa, mainly Kenya and Tanzania, while West Africa, mainly Nigeria, was the second largest recipient ($509m). Investment in off-grid renewables remained low in Central and Southern Africa, at 2.5% and 3.9% respectively. Southern Africa received $36m invested, with Zambia and Mozambique receiving the most. In Central Africa, 38% of the region's total investment went to the Democratic Republic of Congo, Chad and Cameroon. Figure 1 shows that 98% of investments were committed after 2016, indicating that the sector is still in its early stages of developing.

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

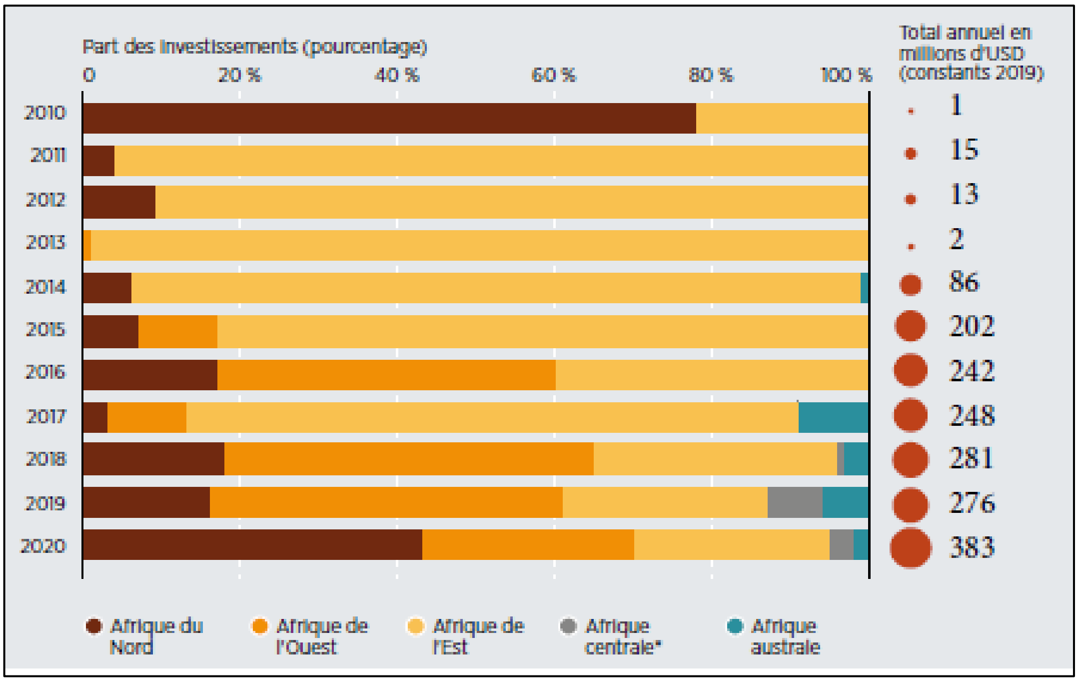

Fig 1. Annual Investment in Off-Grid Renewable Energy by Sub-Region, 2010-2020
Source: Wood Mackenzie (2021)

In sub-Saharan Africa (SSA), there is a mismatch between energy demand and renewable energy potential, particularly in rural areas. Although regions in SSA have the potential for solar, wind and hydropower generation, the installed capacity of decentralised electricity systems in 2022 is estimated to be only 1,445 MW. In West Africa, the installed capacity is 257 MW, while the technical potential is much higher, with 1,956 GW for solar, 106 GW for wind and 162 GW for hydro. East Africa has an installed capacity of 498 GW, with a technical capacity of 1,067 GW for solar, 47.2 GW for wind and 263 GW for hydro. The installed capacity in Central Africa is 226MW, but the technical capacity is estimated to be 1055GW of solar, 767GW of hydro and 31GW of wind. Southern Africa has the lowest installed capacity of 164 MW, while the technical potential is 908 GW for solar, 447 GW for hydro and 53 GW for wind. Figure 2 shows that the development of decentralised systems was greatest in East Africa (445.6 MW) between 2010 and 2022, followed by West Africa (238.2 MW), the Southern sub-region (144.4 MW), and Central Africa (111.8 MW).

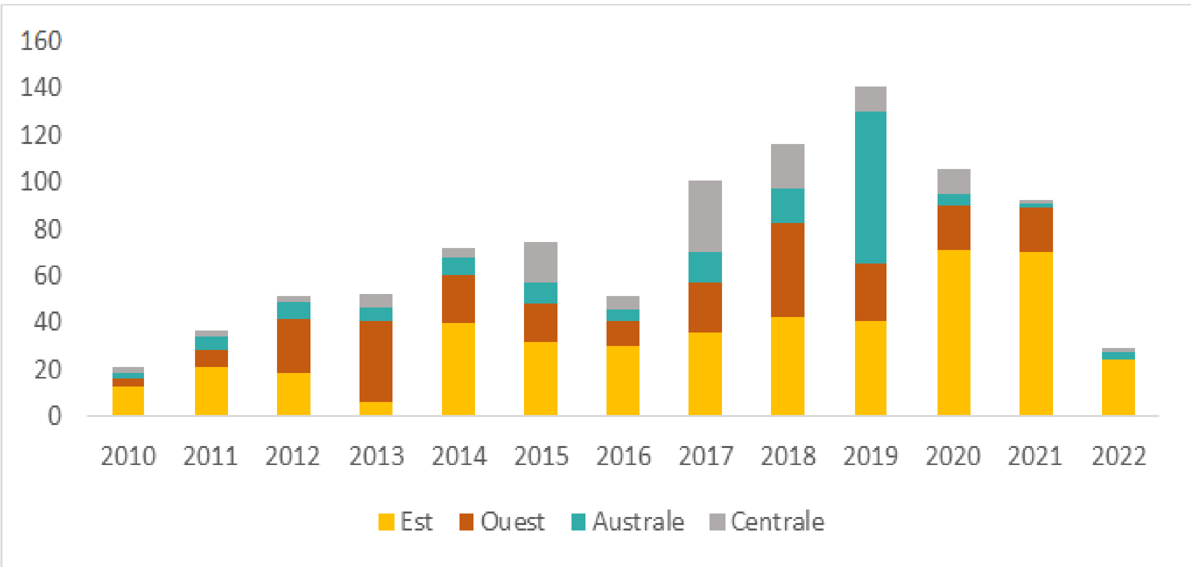

Fig 2. Annual Installed Capacity of Off-Grid Renewable Electricity (MW)
Source: IRENA (2023)

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

III. LITERATURE REVIEW

A. Renewable Energy Finance–Institutions Nexus

African countries face a challenge in financing their renewable energy potential due to a lack of capital, despite the increasing cross-border capital flows (IRENA & AfDB, 2022; Wood, 2021). New Institutional Economics (NEI) emphasizes that the quality of institutions plays a crucial role in attracting investment by reducing transaction costs and uncertainty (North, 1990). Protecting investors' rights and ensuring efficient institutions increases the appeal of private funds and promotes innovation (La Porta and al., 1997; Globerman & Shapiro, 2002). Conversely, institutional inefficiencies can discourage private investment by creating additional transaction costs that alter the risk-return profile of projects (Smarzynska & Wei, 2002) and exposing investors to the risk of expropriation due to weak property rights protection (Henisz & Williamson, 1999). The NEI's findings align with empirical literature, which suggests that institutional quality needs improvement to attract more investment in Africa's renewable energy sector. Panel data analysis and governance indicators such as regulatory quality, political stability, absence of violence, control of corruption, government effectiveness, rule of law, and voice and accountability are commonly used to measure institutional quality.

Fischer and al (2011) identified transaction costs and energy market structure as the main barriers to renewable energy investment in sub-Saharan Africa. More recently, Bellakhal and al. (2019) in the Middle East and North Africa (MENA) countries and Hussain and al. (2021) in the Belt and Road Initiative (BRI) countries found that political stability, rule of law, regulatory quality and corruption are barriers to private investment in renewable energy. Baumli and Jamasb (2020) found that improving policy instruments and building private investor confidence are essential to attracting private investment in renewable energy by analysing the financial and non-financial factors influencing renewable energy investment decisions in Africa. Research conducted by Amoah and al. (2022), Ren and al. (2021), Sovacool (2021), and Imam and al. (2019) demonstrates that corruption impedes electricity reforms and diminishes the energy sector's contribution to economic growth in sub-Saharan Africa. These studies suggest that the negative effects of corruption can be mitigated by, among other things, establishing independent regulatory institutions and implementing privatisation. The study by Wilson and al. (2022) on the role of institutional quality in explaining investment in renewable electricity in sub-Saharan Africa finds that improving the quality of economic and political institutions leads to substantial increases in installed renewable electricity capacity. They suggest that policy choices should focus on strengthening existing laws to ensure better property rights, financial freedom, fiscal freedom, civil liberties, political rights and labour laws, which will encourage investment in renewable electricity. Diallo and Ouoba (2023) find a strong correlation between renewable energy and economic growth in sub-Saharan Africa between 2002 and 2018. The study's conclusion is that institutional quality plays a critical role in the amplification of the impact of renewable energy on economic growth above a certain threshold. Improving institutional quality, particularly through good governance, significantly increases the contribution of renewable energy to economic growth in sub-Saharan Africa. The relationship between institutional quality and renewable energy capital flows to Africa has been examined by Dube and Horvey (2023). The results show that institutional quality has favoured renewable energy capital flows in some countries. These results highlight the importance of institutional quality in promoting renewable energy investment in Africa. The study suggests that implementing reforms aimed at reducing policy uncertainty is recommended to attract domestic and foreign private capital to develop renewable energy. Haldar and al. (2023) argue that the building of strong institutions and the provision of transparent governance are important factors in the fight against energy poverty in sub-Saharan Africa. Olaniyi and Odhiambo (2024) analyse how institutions affect natural resource wealth's contribution to renewable energy transitions in African countries, and find that many resource-rich African countries fall below this institutional bar. In summary, inefficient institutions represent a major challenge for the promotion of renewable energy in Africa countries.

B. Climate Commitment and Renewable Energy Investment Funds

African countries have regularly ratified international climate agreements since the creation of the United Nations Framework Convention on Climate Change (UNFCCC, 1994), demonstrating their commitment to implementing renewable energy and climate policies at national level. West Africa and Southern Africa have set themselves ambitious targets for increasing the share of renewable energy in their electricity mix, to 48% and 39% respectively by 2030. In August 2021, 28 countries, mainly in West Africa, had renewable energy targets for rural electrification, mainly focusing on off-grid solar photovoltaic energy. Central Africa was the least involved in renewable energy-based rural electrification plans. By mid-November 2021, 40 of the 53 African countries that had submitted nationally determined contributions (NDCs) had included renewable energy targets, particularly for the electricity sector.

Several climate funds supporting renewable energy projects in Africa. Notable examples include: The Green Climate Fund is an important component of the UNFCCC (Cancun, 2010), investing in distributed energy resources to help the least developed nations meet their climate goals. The Kyoto Protocol's Clean Development Mechanism (CDM) (2005) allows developing countries to participate in climate change mitigation through financial flows from developed countries. The Clean Technology Fund offers financing and technical assistance for programmes relating to clean technology, energy access, climate resistance and sustainable forestry (CIF, 2021a). The United Nations Climate Change Conference (COP26) led to the creation of several climate funds, including the Rockefeller Foundation. The United Arab Emirates and IRENA have announced the creation of the Energy Transition Accelerator financing platform. This platform will mobilise more than USD 1

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

billion to finance climate action in developing countries, with a focus on renewable energy.

Research shows that climate change engagement is an important way to attract private capital to developing countries, particularly green finance, for renewable energy development. Brunnschweiler's (2010) study, which looked at potential impacts of Kyoto's CDMs on renewable energy deployment in 119 developing and transition countries over 1980-2006, found that renewable energy production in transition and developing countries had increased significantly since Kyoto's adoption. This was attributed to increased environmental awareness and the growing number of renewable energy projects stimulated by the CDM. Considering the potential impact of the Kyoto Protocol, Pfeiffer and Mulder (2013) investigated the factors affecting renewable electricity generation in 108 developing countries from 1980-2010, and found a positive impact on renewable energy technology adoption. Stadelmann and Castro (2014) investigated domestic and international determinants of renewable energy adoption in 112 developing countries over 1998-2009. Focusing on climate policy diffusion, they found that countries' climate commitments were among the international factors influencing renewable energy adoption in developing countries. However, in their analysis of RE deployment determinants in sub-Saharan Africa over 1990-2014, Da Silva and al. (2018) considered environmental concerns represented by Kyoto Protocol ratification and found no significant contribution of climate commitments to RE deployment.

Schwerhoff and Sy (2017) argue that climate finance plays a crucial role in supporting renewable energy projects in Africa by providing the capital necessary for investment in clean energy infrastructure. This financial support helps African countries overcome high upfront costs of renewable energy technologies and facilitates sustainable energy deployment (Taghizadeh-Hesary & Yoshino, 2020; Tolliver and al., 2019). By leveraging climate finance, African countries can accelerate the transition to renewable energy, advance their sustainable development goals and contribute to global climate action (Chelminski, 2022). According to Mungai and al. (2022), promoting regional and international cooperation on climate change issues can help overcome political obstacles and channel climate-smart investments to local actors. This, in turn, can ensure a better climate impact and increase access to electricity for a larger population.

C. Research Gaps and Hypothesis of the Study

While the literature offers evidence of the negative impact of low institutional quality on RE development in Africa in terms of policy and governance, little is known about the role of climate commitment on RE development in the context of institutional inefficiencies. This paper contributes to fill this gap by examining how climate commitment can affect the relationship between institutional quality and private investment in RE. Therefore, the aim of our study is to examine the interaction between institutional quality and climate commitment in explaining private investment in off-grid renewable electricity in sub-Saharan Africa. Our findings may shed light on the disparities in renewable energy investment in the region. We have formulated the following hypothesis:

- **H1:** Institutional quality negatively affects private investment in off-grid renewable electricity in sub-Saharan Africa.
- **H2:** The impact of institutional quality depends on the translation of climate commitment into renewable energy policy.

IV. MATERIALS AND METHODS

This section first presents the theoretical model, then discusses the selection and construction of variables and data sources, and finally the empirical model and estimation.

A. Theoretical Model and Empirical Specification

This study investigates the relationship between institutional quality, climate commitment and investment in off-grid renewable electricity in Sub-Saharan Africa, following a strand of literature (Inglesi-Lotz, 2024; Bellakhal and al., 2019; Cadoret and Padovano, 2016) that explains renewable investment levels based on political and governance, energy and environmental, and economic factors. In the generic model (Eq. 1), institutional quality stands for politics and governance, climate commitment for energy and environment, and X for economic factors:

$$RE\ Investment = f\ (Institutional\ quality\ ;\ Climate\ commitment\ ;\ X)\ (1)$$

Assessing off-grid renewable electricity investments in terms of existing generation infrastructure (Dube & Horvey, 2023; Killinc & Dolmotov, 2023; Abban & Hasan, 2021; Bourcet, 2020), Eq. (1) becomes (Eq. 2):

$$ER\ Installed\ capacity = f\ (Institutional\ quality\ ;\ Climate\ commitment\ ;\ X)\ (2)$$

The installed capacity of off-grid renewable electricity is the dependent variable, while institutional quality and climate commitment are the independent variables and X is a vector of control variables.

B. Data Description and Variables Selection

The study aims to examine the effect of institutional quality on private investment in off-grid renewable electricity in SSA and how climate change commitments may affect this relationship. The study analyses a panel dataset of 48 countries in the region from 2010 to 2022. The sample of SSA countries is divided into four sub-regions according to the African Union classification (see Annex A): East (14), Central (10), Southern (9) and West (15). SSA was chosen because it has abundant renewable resources but lags behind in achieving universal electrification, especially in rural areas (IEA, IRENA et al., 2021). Both the SSA panel and sub-regional panels are used in the analysis. The choice of sub-regional analysis is due to the fact that SSA is the recipient of over half of global private investment in off-grid renewable electricity between 2010 and 2020, with

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

notable differences between sub-regions (Wood Mackenzie, 2021). This choice was made to ensure that the results are robust and the policy recommendations relevant. Regarding time period selection, off-grid DERs in Africa began in the early 2000s, but investment in the region only expanded after 2010 (Wood Mackenzie, 2021). Data sources, selected variables, their definitions and units of measurement are presented in Table 1.

Table 1. Data Sources and Measurement of Variables

Variables	Indicators	Unit of measurement	Data sources
Installed cumulative decentralized capacity (DREC)	Private investment in decentralize renewable electricity	*Cumulative, in MW*	IRENA
Institutional quality (INSQ)	Control of Corruption Rule of law Political stability and no violence Government effectiveness Regulatory quality Voice and accountability	Estimate	World Bank
Climate commitment (CCOM)	Degree of involvement in the fight against climate change	Dummy variable	CCNUCC
GDP per capita (GDPPCG)	level of development	*In Percentage %* (%)	World Bank
Rural population (RPOP)	Market size	In % of total population	World Bank

Source : by authors

The variable studied is the installed capacity of off-grid renewable electricity (DREC), measured in megawatts (MW), which includes solar photovoltaic, hydro, wind and liquid biofuels.

➢ *Institutional Quality*

The main variable of interest is institutional quality, as it is expected to significantly affect private investment in the SSA region (Olaniyi & Odhiambo, 2014; Diallo & Ouoba, 2014; Dube & Horvey, 2014; Inglesi-Lotz, 2014; Haldar and al., 2014; Wilson and al., 2014). Our research uses institutional quality as a composite measure of six governance indicators provided by the Worldwide Governance Indicators (WGI) database and developed by Kaufmann et al. (2010): control of corruption, regulatory quality, rule of law, government efficiency, political stability, and voice and responsibility (See Annex B for defining these indicators). Each WGI indicator represents a specific aspect of governance, ranging from -2.5 (lowest governance) to +2.5 (highest governance). However, including all indicators in one model could lead to multicollinearity and reduce the relevance of each governance indicator (Mauro, 1995). The creation of an aggregate governance component (INSTQ) by adding the weighted average index of individual governance indicators is proposed by Daude and Stein (2007) and Peres and al. (2018). Thus, institutional quality can be assessed on a scale ranging from -15 (weakest level) to +15 (strongest level).

➢ *Climate Engagement*

In addition to the indicator of institutional quality described above, we include engagement in international climate action (CCOM) in the specification, not only to control for a potentially positive effect on RE development in line with previous studies (da Silva et al., 2018; Stadelmann & Castro, 2014; Pfeiffer & Mulder, 2013; Brunnschweiler, 2010), but also to detect a potential interaction with institutional quality. A simple way to measure a country's commitment to climate change is to look at its participation in international climate agreements, which is available in the United Nations Framework Convention on Climate Change (UNFCCC) database. The climate commitment variable (CCOM) is constructed for the period 2010-2022, using the Framework Convention on Climate Change, the two phases of the Kyoto Protocol, and the Paris Climate Agreement, covering the period from 2010 to 2022. CCOM is a binary indicator, taking the value 1 if an SSA country has committed to a climate agreement, and 0 otherwise.

➢ *Control Variables*

Given the limited sample size, we included a few control variables. We used two weakly correlated variables that are commonly used in the literature as primary determinants of private investment in renewables. The first important factor is the level of development of a country (GDPPG), measured by the growth rate of GDP per capita. Hillman (1994), Grossman and Krueger (1995) and Damania and al. (2003) argue that more affluent societies tend to be more demanding in terms of cleanliness, increasing the demand for renewable energy. The second control variable is market size or potential demand (RPOP), which is a measure of population size (Dube & Horvey, 2023; Peres and al., 2018; Billington, 1999). It is expected to have a positive and significant impact on private investment in RE. Data for the GDPPCP and RPOP variables are taken

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

from the World Bank's World Development Indicators (WDI) database.

C. Empirical Specification and Estimation Strategy

➢ *Empirical Specification*

In this paper, we examine the relationship between institutional quality, climate change commitment and investment in renewable energy in the countries of the SSA region. Applying a time dimension to Eq. 2 and taking into account the interaction effects between institutional quality and climate change commitment, we obtain the following explicit form (Eq. 3):

$$lnDREC_{it} = \alpha + \beta.\mathrm{INSQ}_{it} + \delta.\mathrm{CCOM}_{it} + \varphi.(\mathrm{INSQ}_{it} * \mathrm{CCOM}_{it}) + \gamma.\mathrm{X}_{it} + \varepsilon_{it} \qquad (\mathbf{3})$$

For each country i at time t, lnDRECit represents the natural logarithm of the cumulative installed off-grid renewable electricity capacity. INSQit is a composite governance indicator, while CCOMit is a measure of climate commitment. The interaction term between the governance index and the climate commitment variable is represented by INSQit × CCOMit. Xit represents a set of control variables traditionally used as determinants of private investment in renewable energy. Finally, εit represents the error term. The equation is εit = ui + νt + ωit, where ui represents country-specific effects that account for significant heterogeneity across countries, while νt represents time effects that capture all dynamic factors affecting private investment in renewable energy. The term ωit represents the independent and identically distributed error terms. It is important to note that ui and νt must be orthogonal to ωit and the regressors.

Parameters β and φ are key to answering our questions: whether institutional quality affects private investment in off-grid renewables, and whether this effect depends on climate commitment. The derivative of **Eq.3** with respect to institutional quality shows how our model tests this relationship (**Eq.4**).

$$\frac{\partial lnDREC_{it}}{\partial \mathrm{INSQ}_{it}} = \beta + \varphi.\mathrm{CCOM}_{it} \qquad (\mathbf{4})$$

If φ is significant, we can say that the impact of institutional quality on private investment in off-grid renewable electricity depends on which the climate commitment is translated into energy and climate policy terms. Furthermore, the hypotheses tested in this paper are that β < 0 and φ > 0. In other words, weak institutions (β < 0) harm private investment in off-grid renewable electricity, but climate commitment can reduce (φ > 0) this negative effect. The effect of weak institutions on private investment in off-grid renewable electricity should therefore be significantly lower in countries that are relatively more engaged in international climate action.

➢ *Estimation Strategy*

This study uses Arellano and Bond's (1991) two-step difference generalised moments (GMM) dynamic panel approach to examine the relationship between institutional quality, climate commitment and renewable energy investment in SSA countries. The two-step difference GMM model was chosen for several reasons. First, it is designed for a small time dimension and a large cross-section (Siddiqui & Ahmed, 2013). Second, it does not require many assumptions and starts from the moment relationships that exist in the model (Ahn and al., 2001). Third, data differencing in the General Method of Moments (GMM) controls for both unobserved static heterogeneity and dynamic endogeneity problems (Ullah and al., 2018). Finally, in terms of robustness and consistency of estimates, two-step difference GMM coefficients are more efficient and consistent in balanced panels than unbalanced panels (Arellano & Bover, 1995). Since our panel is balanced, the two-step difference GMM model is used in this study. Thus, according to Eq. 3, the two-step difference GMM model can be described as follows, taking into account the lagged value of the dependent variable (Eq. 5):

$$\Delta lnDREC_{it} = \alpha + \rho.\Delta DREC_{i,t-1} + \beta.\Delta\mathrm{INSQ}_{it} + \delta.\Delta\mathrm{CCOM}_{it} + \varphi.(\Delta\mathrm{INSQ}_{it} * \Delta\mathrm{CCOM}_{it}) + \gamma1.\Delta\mathrm{GDPPCG}_{it} + \gamma2.\Delta\mathrm{RPOP}_{it} + \varepsilon_{it} \qquad (\mathbf{5})$$

In order to remove unobserved country-specific effects, Eq. 5 takes a differential form. By including lagged past investment (DRECi,t-1) among the explanatory variables, we assume that private investment at time t in country i also depends on past investment, and transform Eq. 3 into a dynamic model (Eq. 5).

The STATA syntax "xtabond2" (Roodman, 2009) is used to obtain the regression results. Following Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998), two types of post-estimation diagnostics are required to check overall specification and result validity. First, under the null hypothesis that the instruments are exogenous as a group, Sargan and Hansen test the overall validity of the instruments. Consequently, a non-significant p-value is preferred (accepting hypothesis H0). The second type is testing for the absence of first and second order serial correlation in the Arellano-Bond error term (AR (1) and AR (2)). Accepting the null hypothesis is also preferable. The STATA command xtabond2 is used to obtain the two tests and the GMM model estimates. The Wald test of the simple and compound linear hypotheses was performed in each sample to check that the GMM estimates obtained are statistically non-zero overall (rejection of the H0 hypothesis). The output is the p-value associated with a chi-squared test with two degrees of freedom.

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

V. RESULTS AND DISCUSSION

This section presents the results in three parts: descriptive statistics for the variables used (subsection 'Descriptive statistics'), analysis of the correlation between the variables (subsection 'Correlation analysis'), and the econometric results of the dynamic two-step GMM difference model (subsection 'Econometric results').

A. *Descriptive Statistics*

The characteristics of the variables used in the analysis are shown in the descriptive statistics. Table 2 provides a summary of the means and variances.

Table 2. Summary Statistics of Variables

Variables	Full sample		Central Africa		East Africa		Southern Africa		West Africa	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
drec	1.373	1.805	0.701	2.276	1.924	1.798	1.379	1.516	1.377	1.442
instq	-4.017	3.802	-6.602	2.332	-4.243	4.855	-1.689	3.332	-3.509	2.710
ccom	0.744	0.436	0.692	0.463	0.782	0.414	0.752	0.433	0.743	0.437
Instq×ccom	-2.805	3.704	-4.546	3.644	-2.847	4.590	-1.220	3.007	-2.562	2.746
gdppcg	1.162	4.649	-0.808	5.179	1.911	4.619	1.428	4.334	1.791	4.114
rpop	56.419	17.731	46.536	22.497	62.873	16.236	60.181	17.005	55.588	11.799

Source : the authors

The presentation in Table 2 refers to the sample as a whole as well as to the different sub-regions of sub-Saharan Africa: Central, East, West and Southern. For the full sample, the DREC averaged 1.373. Central Africa averaged 0.701, East Africa 1.924, Southern Africa 1.379 and West Africa 1.377 over the period. The dispersion around the mean for the full sample is 0.1805 for Central Africa, 1.778 for East Africa, 1.516 for Southern Africa and 1.442 for West Africa. This implies: East Africa has been the main recipient of private investment in SSA. On the other hand, more countries in West Africa were beneficiaries of these investments than in the other SSA sub-regions. The lowest relative contribution of off-grid renewable energy to electricity supply was in Central Africa.

On average over the period, the quality of institutions (INSTQ) is low in SSA (-4.017). However, it is much better in Southern Africa (-1.689) compared to West Africa (-3.332), followed by East Africa (-4.243) and Central Africa (-6.602), where institutions are the least effective. The disparities between countries are highest in East Africa (standard deviation: 4.855) and Southern Africa (3.332), as opposed to West Africa (2.710) and Central Africa (2.332), where there are many similarities. For the sample as a whole, the average climate change commitment is 0.744. This is an indication that many SSA countries are translating international climate change commitments into the development of renewable energy policies. East Africa is the sub-region where climate change commitment is most reflected in renewable energy policy development (0.782). The description of the variable INSTQ*CCOM shows that climate commitment improves the mean of institutional quality and reduces the dispersion. For the whole sample, the mean is -2.805 with a dispersion of 3.704. This represents an improvement of +25% in average institutional quality. This is more than 30% in Central Africa (-4.546), more than 31% in the East (-2.847), +25% in the West (-2.562) and +24% in Southern Africa (-1.220).

With regard to the control variables, GDPPCG has an average of +1.162% for the whole sample, with large differences in income levels between sub regions and countries (4.649) over the period studied. In the Eastern sub region (+1.911%), the level of per capita income increased the most, in contrast to Central Africa, where the level of income fell (-0.808%) and income disparities were higher (5.179). As regards the proportion of the population living in rural and peri-urban areas, the average for SSA over the period is 56.419%, with a dispersion of 17.731 between countries. The average is 46.536% in Central Africa, 62.873% in East Africa, 55.588% in West Africa and 60.181% in Southern Africa. The description of these two variables assumes that potential demand is high in all sub regions of SSA, but that the capacity of households to consume innovation is very low in Central Africa and encouraging in the other sub regions.

B. *Correlation Analysis*

The correlation matrices (Tables 3a, 3b, 3c, 3d, 3e) indicate potential linear relationships between variables, while the variance inflation factor (VIF) provides information about multicollinearity.

Table 3a. Correlation Matrix and Variance Inflation Factors (V.I.F.s) - Full Sample (SSA Countries)							
	lndrec	instq	ccom	instq×ccom	gdppcg	rpop	**V.I.F.s**
drec	1.0000						
instq	-0.1511***	1.0000					**5.02**
ccom	0.0700	0.0743	1.0000				**2.47**
instq×ccom	-0.1594***	0.7688	-0.4341	1.0000			**6.02**
gdppcg	-0.0071	0.1556	0.0536	0.0843	1.0000		**1.06**
rpop	0.2569***	-0.1939	-0.0169	-0.1471	0.1369	1.0000	**1.07**
Table 3b. Correlation matrix and Variance Inflation Factors (V.I.F.s) - Central Africa Countries							
drec	1.0000						
instq	-0.2085*	1.0000					**4.08**
ccom	0.0613	0.0231	1.0000				**7.18**
instq×ccom	-0.0576	0.4544	-0.7348	1.0000			**7.05**
gdppcg	0.0810	0.1035	0.1860	-0.1515	1.0000		**1.11**
rpop	0.0926	-0.6344	-0.0509	-0.2575	0.0647	1.0000	**1.74**
Table 3c. Correlation matrix and Variance Inflation Factors (V.I.F.s) - East Africa Countries							
drec	1.0000						
instq	-0.4218***	1.0000					**8.31**
ccom	0.0202	0.1103	1.0000				**2.39**
instq×ccom	-0.3993***	0.7730	-0.2711	1.0000			**8.10**
gdppcg	-0.1746**	0.1730	-0.1215	0.2473	1.0000		**1.09**
rpop	0.5147***	-0.0677	-0.0743	-0.0464	0.1042	1.0000	**1.02**
Table 3d. Correlation matrix and Variance Inflation Factors (V.I.F.s) - Southern Africa Countries							
drec	1.0000						
instq	-0.1605*	1.0000					**5.06**
ccom	0.0540	0.0352	1.0000				**1.35**
instq×ccom	-0.1229	0.7448	-0.2339	1.0000			**5.06**
gdppcg	-0.1526	-0.0771	-0.0240	-0.1092	1.0000		**1.02**
rpop	-0.0086	-0.6587	-0.1193	-0.5408	0.0451	1.0000	**1.80**
Table 3e. Correlation matrix and Variance Inflation Factors (V.I.F.s) - West Africa Countries							
drec	1.0000						
instq	-0.1782**	1.0000					**3.77**
ccom	0.1695**	0.0394	1.0000				**2.71**
instq×ccom	-0.2501***	0.6859	-0.5494	1.0000			**5.11**
gdppcg	-0.0725	0.0763	0.0411	0.0604	1.0000		**1.03**
rpop	0.1848***	-0.4567	-0.0178	-0.3261	0.0839	1.0000	**1.29**

***, **, * significant at 1%, 5% and 10% respectively

Source: Authors calculation

Tables 3a, 3b, 3c, 3d and 3e show the results of the correlation tests between the explanatory variables and the variable of interest, in the full sample (SSA) and in the sub-regions. A negative and significant correlation between DREC and INSTQ and INSTQ*CCOM can be seen in Table 3a. DREC and CCOM are assumed to be insignificant. Overall, institutional quality negatively affects private investment in off-grid renewable electricity. The direct effect of climate commitment on private investment is small, but its effect on the relationship between institutional quality and private investment levels is not negligible. Moreover, market size (RPOP) is an attracting factor, but not income levels. Tables 3b, 3c, 3d and 3e show the correlations between INSTQ, DREC, GDPPCG and CCOM in central, eastern, western and southern Africa. The results indicate a negative correlation between INSTQ and DREC in central and southern Africa, while in eastern Africa DREC is negatively related to INSTQ and GDPPCG. The results indicate a negative correlation between INSTQ and DREC in central and southern Africa, while in eastern Africa DREC is negatively related to INSTQ and GDPPCG. In addition, CCOM may affect the relationship between DREC and INSTQ in the East. In the west, DREC is negatively

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

correlated with INSTQ. It is positively correlated with CCOM.

To overcome the problem of multicollinearity, the correlation between the independent variables must be low. Multicollinearity occurs when the correlation between the explanatory variables is greater than or equal to 80 per cent (Tabachnick & Fidell, 2007). It is important to note that the language used in this text is clear, objective and value-neutral, and that technical terms are used consistently throughout the text. In the full sample (Table 3a), the highest correlation is found between the INSTQ and the lINSTQ*CCOM, with a value of 76%. Table 3b shows that in Central Africa the correlation between CCOM and lINSTQ*CCOM is the highest at 73%. Similarly, the East (Table 3c) has the highest correlation between INSTQ and lINSTQ*CCOM, 77%. In the West (Table 3e), the highest correlation between INSTQ and lINSTQ*CCOM is 68%. The highest correlation between INSTQ and lINSTQ*CCOM is 74% in Southern Africa (Table 3d). These results suggest that there is no unhealthy association between any of the variables in the model. The Variance Inflation Index (VIF) is used to validate the correlation test. The average VIF values are 3.13 in SSA, 4.23 in Central Africa, 4.18 in East Africa, 2.78 in West Africa and 2.85 in Southern Africa. All the VIFs in our regression are below the threshold of 5 prescribed by Chatterjee and Price (1991). This indicates that multicollinearity does not affect the outcome of the estimates. Therefore, it was appropriate to do the regression model analysis for hypothesis testing.

C. Dynamic Panel Regression Results (Two-Steps Difference GMM)

Table 4 presents the two-step GMM estimators and the results of the post-estimation tests for the SSA region and its four sub-regions (central, eastern, southern and western).

Table 4. Climate Commitment, Institutional Quality and Renewable Electricity Private Investment

Variables	**SSA countries**	**Central Africa**	**East Africa**	**Southern Africa**	**West Africa**
$drec_{t-1}$	**+ 0.053***	- 0.052	**+ 0.260****	+ 0.014	**+ 0.211*****
instq	- 0.423	- 0.171	- 0.200	- 0.069	- 0.150
ccom	+ 0.985	+ 0.091	**+ 0.376***	**- 0.316***	**+ 0.148***
instq×ccom	+ 0.117	+ 0.004	**+ 0.033***	- 0.084	**+ 0.201****
gdppcg	**- 0.014***	- 0.032	**+ 0.007*****	**+ 0.017****	+ 0.005
rpop	+ 0.048	**+ 1.173***	**+ 1.568***	- 0.089	+ 0.975
Observations	442	100	102	90	150
Wald test	3.35***	5.71***	17.21***	81.20***	118.88***
AR(1)	- 3.30***	- 2.04**	- 1.69*	- 2.05**	- 2.39**
AR(2)	- 0.87	- 0.92	0.11	- 0.09	0.75
Sargan test	3.73	4.06	8.53	3.87	11.00
Hansen test	9.35	6.31	4.63	2.61	11.86

***, **, * significant at 1%, 5% and 10% respectively
Source: Authors calculation

For each sample, AR(1) is significant and AR(2) is insignificant according to the autocorrelation or serial correlation test of the Arellano-Bond error term. The null hypothesis is therefore accepted. This implies that the error term is not serially correlated and moment conditions correctly specified. The Sargan and Hansen tests reject over-identifying restrictions, suggesting that all instruments are valid to explain the model. Wald test statistics produce significant Chi-square values at the 1% level, rejecting the null hypothesis that the estimated coefficients are jointly and significantly zero, indicating that the model is predictive.

With regard to the estimation results in Table 4, the lagged dependent variable (DRECt-1) is statistically significant at 10% for SSA countries, 5% for East Africa and 1% for West Africa in the dynamic model. The choice of the dynamic model specification is justified by the significance of the results: the positive association suggests that infrastructure improvements in previous years are a factor in attracting private investment in SSA in general and East and West Africa in particular. The DRECt-1 coefficient was 0.053, 0.211 and 0.260 in each of the three samples where existing infrastructure contributed significantly to private investment, indicating a moderate degree of private investment attraction. These results are similar to the findings of Çevis & Camurdan (2007) and Siani and al. (2018), which suggest that some developing countries are attractive destinations for foreign investment inflows due to supportive policies and business environments.

In general, the relationship is as expected between the control variables and private investment in off-grid renewable electricity. Rural population size (RPOP) has a positive, albeit insignificant, effect on private investment in

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

off-grid renewable electricity in SSA and West Africa. The effect is positive and significant at the 10% threshold in Central and East Africa. The effect of income level (GDPPCG) on private investment in off-grid renewable electricity is negative and statistically significant at the 10% threshold in SSA, but positive and significant at the 1% and 5% thresholds in Eastern and Southern Africa. Overall, these results are consistent with the specific nature of our sample, which consists mainly of low- and middle-income countries with a rural population estimated at 56.42% of the total population over the period 2010-2022 (World Development Indicators, World Bank).

One of the most important results of our study concerns the relationship between institutional quality and private investment in off-grid renewable electricity. From Table 4, it appears that lower institutional quality is detrimental to private investment in off-grid renewable electricity, as in most cases in our samples institutional quality is negatively associated with private investment, although not significantly. Some aspects of institutional quality would have a negative influence on private investment. For example, low institutional quality ($\beta < 0$) tends to be associated with less private investment in off-grid renewable electricity (Hypothesis 1). This result is consistent with the literature on institutional barriers to RE development in SSA (S. Diallo & Y. Ouoba, 2023; Dube & Horvey 2023; K. Baumli & T. Jamasb, 2020; UNEP, 2012).

The question at the heart of our study concerns the existence of a positive interaction effect ($\varphi > 0$) between institutional quality and climate commitment (instq×ccom) on private investment in off-grid renewable electricity (Equation 2). According to Table 4, overall (in SSA) the coefficient (φ) associated with the interaction term (instq×ccom) is positive, but not significant. On the other hand, this coefficient is positive and significant in East and West Africa. Table 4 shows that in cases where the coefficient (δ) of the climate commitment is positive ($\delta > 0$), the coefficient of the interaction effect (φ) is also positive, and a negative coefficient of the climate commitment is associated with a negative φ. This implies that in SSA countries, when climate commitment is translated into renewable energy and climate policies, the impact of institutional quality on private investment in off-grid renewable electricity is weaker. The relationship between institutional quality and private investment in decentralised renewable electricity therefore depends on the level of consideration given to international climate concerns (Hypothesis 2). This observation is consistent with the literature which argues that climate engagement through the implementation of RE and climate policies promotes the attraction of green investments and that climate finance mechanisms can help to ease financial and non-financial barriers to RE development in Africa (Chelminski, 2022; Taghizadeh-Hesary & Yoshino, 2020; Tolliver et al., 2019; Schwerhoff & Sy, 2017).

VI. CONCLUSION AND POLICY IMPLICATIONS

In this study, we explore the relationship between institutional quality and private investment in off-grid renewable electricity in sub-Saharan Africa. They specifically investigate how the interaction between institutional quality and climate commitment influences sub-regional differences in investment. The study utilises a panel of 48 sub-Saharan African countries, divided into five samples based on geographical regions, and examines data from 2010 to 2022. To address endogeneity concerns, a two-step difference GMM estimation technique is employed. The findings of this study contribute to the existing literature by shedding light on the importance of institutional quality and climate commitment in promoting private investment in decentralised renewable electricity in sub-Saharan Africa.

The analysis indicates that the quality of institutions has a negative impact on private investment in off-grid renewable electricity, with a few exceptions. However, this relationship is influenced by the way in which climate commitment is implemented at the local level. In countries with poor institutional quality, climate commitment mitigates the negative impact on private investment (e.g. East Africa), whereas in countries with better institutions, climate commitment enhances private investment (e.g. West Africa). These findings suggest that in most Sub-Saharan African countries, low institutional quality acts as a deterrent to private investment in off-grid renewable electricity. However, the effect of poor institutional quality is less severe in countries that actively implement renewable energy and climate change policies, attracting green funds.

Our findings suggest a number of important policy implications and point policymakers to the efforts and reforms needed to encourage private investment in off-grid renewable electricity in SSA. First, the results suggest that greater governance efforts are needed to change the perceptions of local and foreign investors. Second, countries need to strengthen their commitment to climate change through energy system decarbonisation plans and energy efficiency policies in order to attract climate finance. Third, the level of per capita income suggests that private investment should be encouraged through policies such as feed-in tariffs and tax breaks.

To conclude, meeting the challenge of financing universal access to electricity requires a concerted effort by SSA governments and the private sector. Governments will need not only to provide financing, but also to create an enabling environment for the private sector and to support innovative approaches by collaborating, learning and sharing experiences.

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14576656

REFERENCES

[1]. Ahn SC, Lee YH, Schmidt P (2001) GMM estimation of linear panel data models with time-varying individual effects. Journal of Econometrics 101(2):219–255.

[2]. Amoah, A., R. K. Asiama, K. Korle, and E. Kwablah. 2022. Corruption: Is it a bane to renewable energy consumption in Africa? Energy Policy 163:112854.

[3]. Arellano, M. & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies, 58(2), 277–297.

[4]. Arellano, M. & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. Journal of Econometrics, 68(1), 29–51.

[5]. Baumli K, Jamasb T (2020) Assessing private investment in African renewable energy infrastructure: a multi-criteria decision analysis approach. Sustainability 12(9425):1–19.

[6]. Bellakhal, R., S. B. Kheder, and H. Haffoudhi. 2019. Governance and renewable energy investment in MENA countries: How does trade matter? Energy Economics 84:104541.

[7]. Bhattacharyya, S. C. (2013). Financing energy access and off-grid electrification: A review of status, options and challenges. Renewable and Sustainable Energy Reviews, 20, 462-472.

[8]. Blundell, R. & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics, 87(1), 115–143.

[9]. Brunnschweiler, C. N. 2010. Finance for renewable energy: An empirical analysis of developing and transition economies. Environment and Development Economics 15 (3):241–74.

[10]. Çevis, Đ., & Camurdan, B. (2007). The economic determinants of foreign direct investment in developing countries and transition economies. The Pakistan Development Review, 46(3), 285-299.

[11]. Chelminski, K. (2022). Climate finance effectiveness: a comparative analysis of geothermal development in indonesia and the philippines. The Journal of Environment & Development, 31(2), 139-167.

[12]. CIF (Climate Investment Funds) (2021a), "Climate Investment Funds: Donors & MDBs", Climate Investment Funds, www.climateinvestmentfunds.org/finances.

[13]. CPI (Climate Policy Initiative) (2020), Updated View on the 2019 Global Landscape of Climate Finance, Climate Policy Initiative, London.

[14]. Cuervo-Cazurra, A. (2006). Who cares about corruption? Journal of International Business Studies, 37(6), 807–822.

[15]. da Silva, P. P., Cerqueira, P. A., & Ogbe, W. (2018). Determinants of renewable energy growth in sub-Saharan Africa: Evidence from panel ARDL. Energy, 156, 45–54.

[16]. Diallo, S., & Ouoba, Y. Effect of renewable energy on economic growth in sub-Saharan Africa: Role of institutional quality. Sustainable Development.

[17]. Dube, A., & Horvey, S. S. (2023). Institutional quality and renewable energy capital flows in Africa. Future Business Journal, 9(1), 55.

[18]. Fischer, R., Lopez, J., & Suh, S. (2011). Barriers and drivers to renewable energy investment in sub-Saharan Africa. J. Environ. Invest, 2(1), 54-80.

[19]. Globerman, S., & Shapiro, D. (2002). Global foreign direct investment flows: The role of governance infrastructure. World Development, 30(11), 1899–1919.

[20]. Haldar, A., Sethi, N., Jena, P. K., & Padhan, P. C. (2023). Towards achieving Sustainable Development Goal 7 in sub-Saharan Africa: Role of governance and renewable energy. Sustainable Development, 31(4), 2446-2463.

[21]. Henisz, W., & Williamson, O. (1999). Comparative economic organization – within and between countries. Business and Politics, 1(3), 261–276. doi:10.1515/bap.1999.1.3.261

[22]. Hussain, J., Zhou, K., Muhammad, F., Khan, D., Khan, A., Ali, N., & Akhtar, R. (2021). Renewable energy investment and governance in countries along the belt & Road Initiative: Does trade openness matter? Renewable Energy, 180, 1278-1289.

[23]. IEA (2011). Energy for all: financing access for the poor, special early excerpt of the World Energy Outlook 2011, International Energy Agency, Paris.

[24]. Imam MI, Jamasb T, Llorca M (2019) Sector reforms and institutional corruption: evidence from electricity industry in Sub-Saharan Africa. Energy Policy 129:532–545.

[25]. IRENA (2021b), IRENA Off-Grid Statistics Database, International Renewable Energy Agency, Abu Dhabi.

[26]. IRENA (2023), Renewable energy statistics 2023, International Renewable Energy Agency, Abu Dhabi.

[27]. IRENA and AfDB (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan.

[28]. La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (1997). Legal determinants of external finance. The journal of finance, 52(3), 1131-1150.

[29]. Mihaela Peres, Waqar Ameer & Helian Xu (2018). The impact of institutional quality on foreign direct investment inflows: evidence for developed and developing countries, Economic Research-Ekonomska Istraživanja, 31:1, 626-644.

[30]. Mungai, E. M., Ndiritu, S. W., & Da Silva, I. (2022). Unlocking climate finance potential and policy barriers—A case of renewable energy and energy efficiency in Sub-Saharan Africa. Resources, Environment and Sustainability, 7, 100043.

[31]. North, D. C. (1990). Institutions, institutional change and economic performance. Cambridge: Cambridge University Press.

[32]. Olaniyi, C. O., & Odhiambo, N. M. (2024). Do natural resource rents aid renewable energy transition in resource-rich African countries? The roles of institutional quality and its threshold. In Natural Resources Forum. Oxford, UK: Blackwell Publishing Ltd.

[33]. Pfeiffer, B., and P. Mulder. 2013. Explaining the diffusion of renewable energy technology in developing countries. Energy Economics 40:285–96.
[34]. Rafiq, S., Paramati, S. R., Alam, M. S., Hafeez, K., & Shafiullah, M. (2024). Does institutional quality matter for renewable energy promotion in OECD economies? International Journal of Finance & Economics, 1–16.
[35]. Ren, S., Hao, Y. & Wu, H. (2021). "Government corruption, market segmentation and renewable energy technology innovation: Evidence from China". Journal of Environmental Management, vol. 300, 113686.
[36]. Roula Inglesi-Lotz (2024) Exploring the impact of institutional quality to South Africa's transition to renewables, Energy Sources, Part B: Economics, Planning, and Policy, 19:1, 2291433.
[37]. Roodman, D. (2006) How to do xtabond2: An introduction to ''difference'' and ''system'' GMM in Stata, Center for Global Development Working Paper No. 103.
[38]. Saini, N., & Singhania, M. (2018). Determinants of FDI in developed and developing countries: A quantitative analysis using GMM. Journal of Economic Studies, 45(2), 348-382.
[39]. Siddiqui DA, Ahmed QM (2013). The effect of institutions on economic growth: a global analysis based on GMM dynamic panel estimation. Struct Chang Econ Dyn 24:18–33
[40]. Sovacool, B K. (2021). "Clean, low-carbon but corrupt? Examining corruption risks and solutions for the renewable energy sector in Mexico, Malaysia, Kenya and South Africa". Energy Strategy Review, vol. 38, 100723.
[41]. Smarzynska, B. K., & Wei Shang-Jin. (2002). Corruption and cross-border investment: firm-level evidence. William Davidson Institute Working Paper No. 494:1-29.
[42]. Stadelmann, M., & Castro, P. (2014). Climate policy innovation in the South–Domestic and international determinants of renewable energy policies in developing and emerging countries. Global Environmental Change, 29, 413-423.
[43]. Schwerhoff, G., Sy, M. (2017). Financing renewable energy in Africa – Key challenge of the sustainable development goals. Renew. Sustain. Energy Rev. 75, 393–401.
[44]. Taghizadeh-Hesary, F. and Yoshino, N. (2020). Sustainable solutions for green financing and investment in renewable energy projects. Energies, 13(4), 788.
[45]. Tabachnick, B. G., & Fidell, L. S. (2007). Experimental designs using ANOVA (Vol. 724). Belmont, CA: Thomson/Brooks/Cole.
[46]. Ullah S, Akhtar P, Zaefarian G (2018). Dealing with endogeneity bias: the generalized method of moments (GMM) for panel data. Ind Mark Manage 71:69–78
[47]. UNEP (2012). Financing renewable energy in developing countries: drivers and barriers for private finance in Sub-Saharan Africa, United Nations Environment Programme Finance Initiative, Geneva, Switzerland.
[48]. Wilson, J., Twerefou, D. K., Bekoe, W., & Akpalu, W. (2022). Institutional quality and investment in renewable electricity in Sub-Saharan Africa. Ghanaian Journal of Economics, 10(1), 34-50.
[49]. Wood Mackenzie (2021), "Off-Grid Renewable Investment (database)", https://datahub.woodmac.com/app/main#/dashboards/5d3a1511d249d18c0f001758

APPENDIX A. List of Countries by Sub-Region

Central Africa (10)	**East Africa (14)**	**Southern Africa (9)**	**West Africa (15)**
Angola	Djibouti	Botswana	Benin
Burundi	Eritrea	Eswatini	Burkina Faso
Cameroon	Ethiopia	Malawi	Cape Verde
Central Africa Republic	Kenya	Lesotho	Ivoiry cost
Chad	Madagascar	Mozambique	Gambia
Congo Democratic	Mauritania	Namibia	Ghana
Congo Republic	Mauritius	South Africa	Guinea
Equatorial Guinea	Rwanda	Zambia	Guinea Bissau
Gabon	Seychelles	Zimbabwe	Liberia
Sao Tome Principe	Somalia		Mali
	Sudan		Niger
	South Sudan		Nigeria
	Tanzania		Senegal
	Uganda		Sierra Leone
			Togo

APPENDIX B. Dimensions of Institutional Quality

Indicators	Measures	Estimate
Regulatory Quality	measure perception of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	-2,5 to +2,5
Political Stability and Absence of Violence/Terrorism	measure perception of the likelihood of political instability and/or politically-motivated violence, including terrorism.	-2,5 to +2,5
Control of Corruption	measure perception of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	-2,5 to +2,5
Government Effectiveness	measure perception of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	-2,5 to +2,5
Rule of Law	measure perception of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	-2,5 to +2,5
Voice and Accountability	measure perception of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	-2,5 to +2,5

Source: Worldwide Governance Indicators (WGI) database